# Can you 3D print a gasket?

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**Abstract.** Yes, in TPU for low-pressure, low-heat joints: 95A, 1.5 to 2.5 mm thick, 15 to 25% squeeze. Prusa's printed gaskets all leaked, so pressure needs a stock O-ring.

**Keywords:** tpu, waterproofing, watertight

## 1 Can you 3D print a gasket?

Yes, in TPU (thermoplastic polyurethane) filament, for low-pressure, low-temperature joints. MarineLab3D's design rules call for 95A TPU squeezed 15 to 25 percent. Prusa Research's printed flexible gaskets all leaked, so a joint that must hold pressure or heat needs a stock rubber O-ring in a printed groove.

### 1.1 TPU hardness against O-ring rubber

Flexible filaments are sold by Shore A hardness, the same durometer scale O-ring makers use. The common grades bracket ordinary O-ring rubber:

**Table 1.** TPU hardness against O-ring rubber

| Material | Shore A hardness | Source |
|---|---|---|
| Recreus Filaflex 70A | 70A | Recreus product page |
| NinjaTek NinjaFlex | 85A | NinjaFlex data sheet (ASTM D2240) |
| Polymaker PolyFlex TPU95 | 95A | Polymaker data sheet (ISO 7619-1) |
| Bambu Lab TPU 95A HF | 95A grade | Bambu Lab data sheet |
| Parker N0674-70 nitrile O-ring compound | 70 | Parker O-Ring Handbook |
| Parker's range for most O-ring applications | 70 to 80 | Parker O-Ring Handbook |

The Parker O-Ring Handbook calls 70 to 80 durometer "the most suitable compromise" for most seals. In moving seals, 90 durometer or harder "often allow a few drops of fluid to pass with each cycle", and 50 durometer wears and extrudes quickly. A 95A TPU sits above that window, while 70A and 85A filaments fall in or near it.

### 1.2 Can you 3D print rubber seals that hold water?

Sometimes; the two published sources disagree. Prusa Research printed gaskets in Flexfill 98A, Flexfill 92A, FilaFlex40 and a flexible SLA (stereolithography) resin for underwater housings. None held water, even when screwed down "with a force that damaged the threads". Prusa could not find a printable material "soft enough to work as a proper seal between two 3D-printed surfaces".

MarineLab3D, which designs printed boat fittings, uses TPU gaskets on flanges, hatches, cap rims and inspection ports "where no off-the-shelf O-ring fits". It credits them with handling vibration and thermal cycling better than a rigid joint. Neither source gives a pressure rating for a printed gasket. MarineLab3D keeps printed fittings away from below-waterline, fuel and gas jobs unless an engineer has assessed them.

Hardness is one likely reason for the split. Prusa's two graded filaments, 98A and 92A, sit above Parker's 70 to 80 window, and Parker notes that a harder ring needs far more compressive load to reach the same squeeze. No source here tested a 70A or 85A filament as a gasket.

Squeeze is the other lever. Parker puts the minimum squeeze for any seal at about 0.2 mm, because below that almost every elastomer soon takes a 100 percent compression set and stops pushing back.

### 1.3 TPU seal: the design numbers for a printed flat gasket

MarineLab3D's rules for a printed gasket:

- **Material:** TPU at Shore 95A, "soft enough to conform, stiff enough to print cleanly".
- **Thickness:** 1.5 to 2.5 mm. Thinner prints poorly; thicker squeezes out sideways.
- **Compression:** 15 to 25 percent. Below 10 percent it will not seal reliably; above 35 percent the gasket extrudes out of the joint.
- **Infill:** 100 percent, with concentric or aligned top and bottom layers. "Any infill pattern is a leak path straight through the gasket."
- **Printing:** flat, on a smooth plate. A textured plate leaves a surface that weeps.
- **Retention:** a shallow groove or lip in the flange, because "free-floating gaskets migrate".

Say your lid gasket is 2 mm thick. At 15 to 25 percent compression, the lid should close it down to 1.5 to 1.7 mm. Design a hard stop at that height so tightening the screws cannot crush it thinner.

Prusa's alternative for a custom flat seal skips the filament: print a two-piece mold, fill it with silicone caulk, and demold

**Table 2.** O-ring seal: print the groove, buy the ring

| O-ring cross-section | Parker sizes | Groove depth | Groove width (liquids) | Squeeze |
|---|---|---|---|---|
| 1.78 mm (0.070 in) | 2-004 to 2-050 | 1.27 to 1.37 mm (0.050 to 0.054 in) | 2.57 to 2.72 mm (0.101 to 0.107 in) | 19 to 32 % |
| 2.62 mm (0.103 in) | 2-102 to 2-178 | 1.88 to 2.03 mm (0.074 to 0.080 in) | 3.45 to 3.61 mm (0.136 to 0.142 in) | 20 to 30 % |
| 3.53 mm (0.139 in) | 2-201 to 2-284 | 2.57 to 2.72 mm (0.101 to 0.107 in) | 4.50 to 4.75 mm (0.177 to 0.187 in) | 20 to 30 % |
| 5.33 mm (0.210 in) | 2-309 to 2-395 | 3.86 to 4.11 mm (0.152 to 0.162 in) | 6.86 to 7.37 mm (0.270 to 0.290 in) | 21 to 30 % |

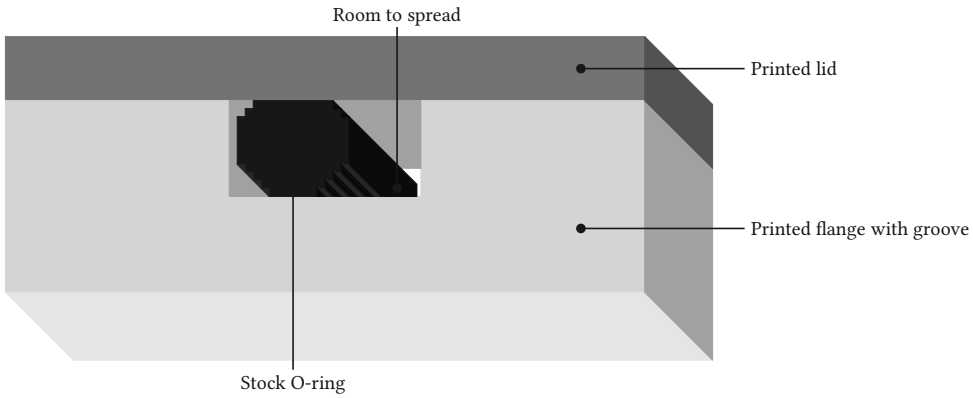



**Figure 1.** The groove is shallower than the ring is thick, so closing the lid flattens the ring, and the empty space beside it gives the rubber room to spread.

once it cures. Prusa found it messy. Its molded silicone seals held in a threaded flashlight housing at 30 m but leaked in a camera housing however hard they were squeezed.

### 1.4 O-ring seal: print the groove, buy the ring

Prusa calls a stock O-ring "the best, easiest, and most proven method", with silicone grease on the sealing surface before every use. The printed part only has to hold the ring at the right squeeze. Parker's face-seal chart, for an O-ring clamped between a flat lid and a groove, gives the groove for each standard cross-section (inch figures from the handbook, millimeters converted):

The rest of Parker's static-seal rules:

- **Squeeze:** 30 percent maximum for most elastomers in a static seal.
- **Gland fill:** the ring should fill 60 to 85 percent of the groove volume, 75 percent at best, and never more than 90 percent.
- **Surface:** a 32 microinch RMS (root mean square) finish on the groove for liquids. Layer lines leave a printed groove rougher than that, so grease the ring and test the joint.

The lid and flange are still printed walls, so they need watertight settings of their own. The box and enclosure page covers the housing around the seal.

### 1.5 Can you print an O-ring?

You can print a ring shape in TPU, but no source here reports a printed O-ring holding water. Prusa's advice ends at bought O-rings, which it says diving shops, car parts stores and some hobby markets stock. Buy the ring and print the groove.

### 1.6 When TPU is the wrong gasket material

Heat rules TPU out first. NinjaTek gives NinjaFlex a heat deflection temperature of 60 °C at 0.07 MPa and 44 °C at 0.45 MPa. Parker rates polyurethane O-ring rubber, the family TPU belongs to, for water only up to 50 °C.

Oil matters less. Bambu Lab rates TPU 95A HF resistant to most oils and greases, and NinjaTek rates NinjaFlex highly resistant to ASTM oils, gasoline and kerosene. Both rate TPU poorly against acids. NinjaFlex also fares poorly with alcohols, so keep isopropyl alcohol off a NinjaFlex seal.

**Table 3.** When TPU is the wrong gasket material

| Seal material | Heat limit | Handles | Avoid | Source |
|---|---|---|---|---|
| TPU (NinjaFlex) | Heat deflection 60 °C at 0.07 MPa | Water, ASTM oils, gasoline | Acetone, alcohols, acids | NinjaTek |
| Polyurethane O-ring rubber | About 82 °C; water to 50 °C | Mineral oil and grease | Hot water, steam, acids | Parker |
| Nitrile (NBR) | 100 °C, shorter life at 121 °C | Oils, fuels, water | Ozone, weather, brake fluid | Parker |
| EPDM (ethylene propylene diene rubber) | 150 °C | Hot water and steam, brake fluid | Mineral oil, grease, fuel | Parker |
| Silicone | About 204 °C | Ozone, weather | Wear, tearing | Parker |
| Fluorocarbon (FKM) | 204 °C | Oils, fuels, solvents | Glycol brake fluid, steam | Parker |

### 1.7 What to do

1. **Joint under pressure, under water or hot:** buy an O-ring. Nitrile covers cold water, oil and fuel; EPDM covers hot water and steam; silicone or FKM covers higher heat. Print the groove from the Parker table and grease the ring.
2. **Flat, low-pressure joint with no stock ring that fits:** print a 95A TPU gasket to MarineLab3D's numbers, at 100 percent infill on a smooth plate, with a hard stop setting the squeeze.
3. **Either way, test it:** run the leak test before relying on the seal. For a part that goes underwater or holds pressure, the pressure results show what printed housings have survived.

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