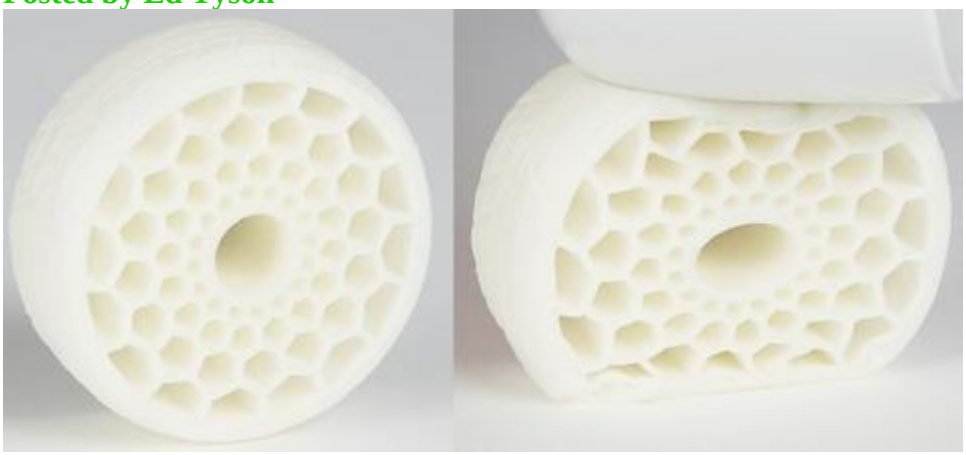
What is the difference between TPE and TPU Flexible Filament?

Posted by Ed Tyson



Open your world, print flexible stuff like this airless tire concept.

This article will clear up the confusion surrounding TPU vs TPE, how they're best used for printing and take you through the steps to **achieving best results**.

Ironically, flexible filaments don't *have* to be hard to print.

You want to start using 3D printer flexible filaments? But with all the choice out there, it can be a bit daunting deciding which one to go for. TPE and TPU are both popular **flexible, rubber like** filament.

There are other filaments like Flexible or Soft PLA, but the two serious players (TPU and TPE) in the market are **harder wearing and more elastic** – so they're suitable for a much greater range of uses.

What's difference between TPE and TPU? While we'll explain the intricacies shortly, it's worth getting out of the way that TPU is a form of TPE. Confusing, right? Well, in the 3D printing industry the terms TPU and TPE have been interchanged loosely, but they are in the same family.

For the sake of avoiding confusion in this article, we're going to assume TPE is the more common, softer variant that's been available for a few years now. While the name TPU more commonly used for the slightly newer, firmer variant that's more recently become available.

Many people believe that TPE and TPU are different materials, when in reality these names don't differentiate. It's actually the grade of TPU and shore hardness that actually determine the differences between flexible PolyUrethane filaments.

To clear this up, you need to know what they stand for:

TPE = ThermoPlastic Elastomer

TPU = Thermoplastic PolyUrethane, which is a type of ThermoPlastic Elastomer

Why can't I use actual rubber 3D printer filament? Well, rubber itself in a thermoset form cannot actually be re-melted due to the cross-linking that occurs in the original setting process.

In short, we could make the filament – but you wouldn't be able to re melt it to print with it.

So you want all the end-use properties of rubber, like high elasticity, great compression strength and hard wearing durable flexibility – but in a form that's easy to print? We hear you.

Let's delve into the key differences between these two thermoplastic elastomers so you can decide what's right for your application.

First up, the original contender: What is TPE filament?

To avoid confusion, it's worth noting that nearly all "TPE" filaments are in fact a grade of "TPU" as we've shown above.

For the purposes of this article we're going to call TPE as the original, softer material first brought to the market a few years ago, and TPU as the newer variant, with slightly different properties.

As we mentioned above, TPE (ThermoPlastic Elastomer) is what these flexible filaments we commonly called when first entering the marketplace.

Until recently, the softer TPE has been the more commonly available material of choice for flexible printing (think Ninjaflex, SemiFlex, Filaflex and similar). It's essentially a plastic that has rubber-like qualities.

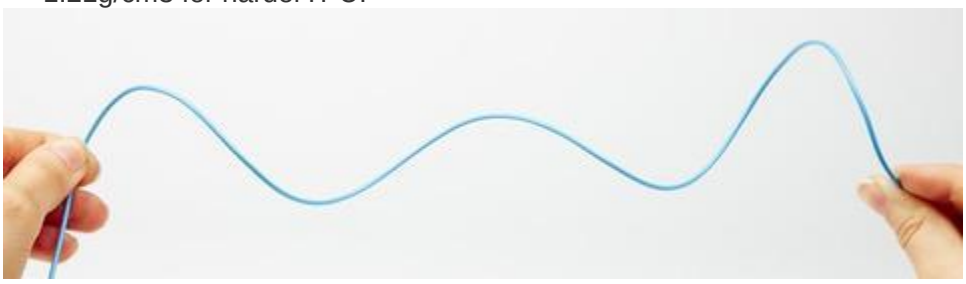
Wait, but isn't Ninjaflex a TPU? Yes - however when NinjaTek entered the market a few years ago, their core product NinjaFlex was at the time referred to as a TPE. In recent years they've switched to calling it the correct name, TPU.

Typically prints made with TPE flexible filament are **really elastic** – you can stretch them up to twice their original length and return to their original state, without permanent deformation.

It's really soft, with a typical shore hardness of just 85A. Very soft flexible filaments have a history of causing difficulties in some printers when printing - depending on the type of extruder you're using.

While both materials we're covering here have slightly different properties, here are the main similarities they share:

- They're generally regarded as safe and contain non-toxic raw materials.
- Layer to layer adhesion is excellent, helped by their make-up and very soft nature of the printing. This means very durable end-use prints.
- You can print both filaments at between **210C – 240C**, with a heated bed around **20-70C**
- Printing at **15mm/sec speed is recommended**, but you can print up to 30mm/sec with good results. This tends to be depending on your printer.
- Both can be used to print objects that need to bend or flex to suit their environment, typically; belts, springs, door stoppers or phones cases.
- The densities are near-identical at 1.20g/cm3 for materials like NinjaFlex and similar and 1.21g/cm3 for harderTPU.



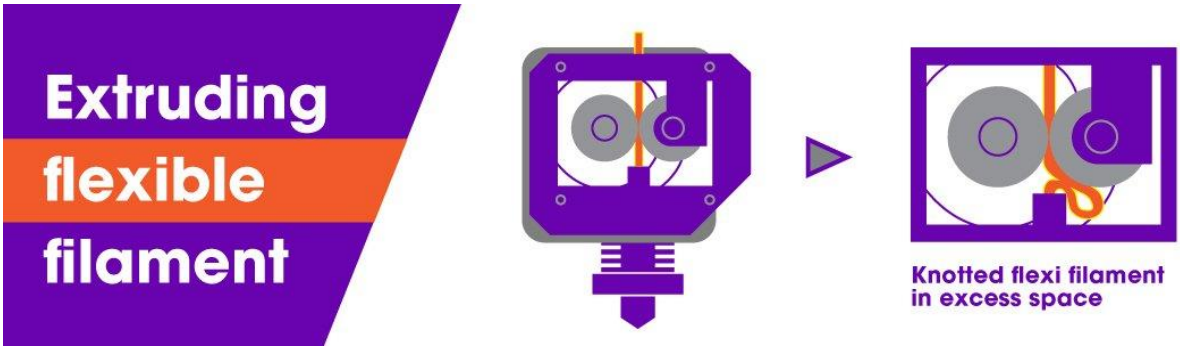
Now, what's this new TPU 3D Printer Filament?

Although technically classed under the ThermoPlastic Elastomer spectrum, the full name for TPU is ThermoPlastic Polyurethane. This isn't especially new in industry, but until recently wasn't commonly available in 3D printing.

However recently it's growing a lot more popularity among printers. While on the surface very similar to TPE, but TPU 3D printing has some notable differences.

TPU is very similar in elasticity and other mechanical properties to TPE. Although it is very slightly more rigid, at Shore 94A-95A. This makes it a little **easier to print** in printers that don't usually print the original, softer TPE 3D printing filament well, as the slight more rigidity is easier for the extruder mechanism to handle.

See our diagram below (you get the idea…)



Does this happen when using very soft filaments? Avoid it by using slightly more rigid filaments, like TPU or Flexible PLA.

Sometimes this issue can be caused by simply having the wrong, or poorly designed flexible filament extruder. More extruders are being designed with this in mind.

Still, as we say - if your extruder isn't working with your current flexi filament, try using a **stiffer version and it should print fine**.

Apart from being a little easier to print, what are the other benefits? Well TPU material has a higher abrasion resistance, usually making it longer lasting in working parts. It also retains its elastic properties in lower temperatures – so if you need it to still be soft in cold conditions, it's still going to perform.

Another notable difference is that modern TPU naturally has a **higher resistance to oils, greases and a variety of solvents** – making it more favorable in industry applications.

Shrinkage is usually hard to accurately measure, but for TPE it's around 1.2 – 3.0 % and TPU has a lower shrinkage at around 0.8 – 1.8%. So if you need accurate measurements post-printing, you may be better with a harder TPU. If you wanted to get really technical on TPU materials, here's the Wiki.

What can I print with flexible filament?

You may be sold on the benefits of using the best flexible filament, but what can you actually print with it?

While it can be tricky to work out what you'd want to print before actually having a reason - we'll provide a couple of examples below that our customers have used.

After you understand the types of prints that would be useful to make with these soft materials, you'll start to see possibilities everywhere.

These are some flexible brackets that Jason Cannon printed for his custom photography diffusers. Printed flat, he then simply bends them over to secure, forming a durable, long lasting strap.

In this example you could vary the stiffness of the strap if required by changing the cut outs (eg size of the holes) or the thickness of the strap.

The following example is an excellent demonstration as to the chemical resistance and extreme durability of our TPU.

Phillip's automotive bushings here take a real hammering. If a member of our exclusive Facebook group, you'll see his various TPU prints for a range of applications.

Here are some more examples of stuff that's better not-stiff:

- Anything you might wear, like a belt, watch strap, custom wallet or bag.

- Anything that needs a snug push fit. You'll get a much tighter seal using flexible materials. Including grommets, bushings, washers, dust caps and some clip fit mechanisms.
- Custom phone cases, the density provides a great level of protection.
- Anything you need to hand-hold. Increase ergonomics of your prototypes with molded soft grips.
- Where indestructibility is the aim of the game. Think high-impact components, living hinges or even handcuffs.
- RC car tyres or wheels. Build flexibility into your projects organically, instead of using springs and traditional dampening techniques.
- Custom stamps
- Replacement feet for household items.

So there you have it, all the main differences between these ThermoPlastic Elastomers. Which you decide to print with will depend on your application. Below is a handy table to make a quick direct comparison. If you want to view our range of high-grade flexible TPU filament 1.75, feel free to browse them here.

Or if you're interested in our easy-to-print, biodegradable Flexible PLA, you can view it here. Due to it's slightly more rigid nature and low friction (meaning it won't stick in the bowden tube) our 2.85mm version is a great Ultimaker 2 flexible filament.

In summary it's important to ignore the branding of whether the material is actually called TPU or TPE, and instead focus on the actual properties of the material you desire for that specific project. The bellow table should help clear any confusion.

You may require softer materials, like an 85A (or lower) Shore hardness, or ease of 3D printing may be more important to you and it might pay off to go with a harder variant. Often you can achieve many of the properties of a softer material by changing the design of your part.

If you found this article useful, please share it to allow it to be used by others looking for assistance choosing a flexible printing material.

Filament	Shore A Hardness:	Density:	Print temps:	Chemical Resistance:	Abrasion Resistance:	S
TPE	85A (very soft)	1.20g/cm^3	245-255C HB~90C	Med	Med-Low	1
TPU	94A (pretty soft)	1.21g/cm^3	245-255C HB~90C	Med-High	High	0