ADARSH AUSTRALIA

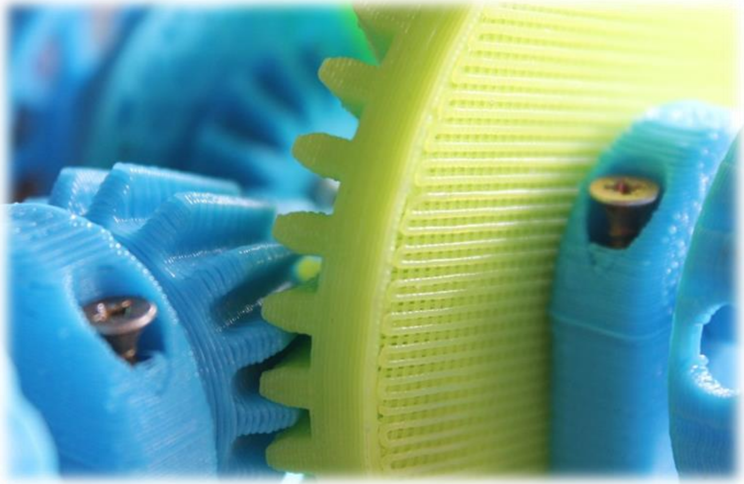
AFARIDAN PLASTICS PTY LTD

A DIVISION OF ADARSH AUSTRALIA

3D PRINTING MATERIAL & PROCESS SELECTION GUIDE

Choosing the Correct 3D Printing Material and Process

With all different kinds of plastics on the market manufactured under different processes such as traditional plastics injection and 3D printing processes like Fused Deposition Modelling (FDM), Stereolithography (SLA) and Selective Laser Sintering (SLS), how do you know which material and process is right for your application?



The following document highlights the key differences in material properties between traditional manufacturing methods and our 3D printing solutions – helping you choose the correct material for your project.

Important Mechanical Properties To Consider

Material Property	What is it?	Why is it needed?
Tensile Strength	Ability for a material to resist breakage under tension.	Determines at what load failure will occur.
Hardness	Resistance to permanent deformation (scratching/indentation) under a compressive load.	Indicates the effectiveness of tooling and resistance to wear and scratches.
Toughness	The ability for a material to undergo plastic deformation before fracturing.	Relates to how much a material can be bent or shaped before fracturing.
Young's Modulus	Resistance to strain (elongation / deformation) under stress.	Measures how much force can be applied before bending or deformation occurs.
Elongation	The ability for a material to stretch before fracturing.	Compares how flexible materials are, and whether they will break suddenly or stretch before breaking.
Flexural Strength	Resistance to fracture from an applied bending force.	Measures how much force can be applied while bending before fracture occurs.
Flexural Modulus	Material's stiffness in relation to bending direction.	Useful for comparing the flexibility of different materials.
Impact Strength	Amount of energy absorbed from a sudden force without fracture.	Shows the ability to absorb sudden impacts and shocks.
Compression Set	Permanent deformation remaining after a compressive force has been released.	Shows how much a material will return to its original shape after a load has been lifted off.
Tear Strength	Material's resistance to the growth of fractures and tears.	Measures how resilient a material is to the spreading of cracks after an initial fracture has occurred.

Important Thermal and Absorption Properties

Material Property	What is it?	Why is it needed?
Water Absorption	Water absorbed under different conditions	Useful in determining what conditions the plastic can be under, as absorption results in poor material performance.
Heat Deflection Temperature	Deformation under a load dependant on temperature.	Shows whether a material can perform under high temperatures.
Vicat Softening Point	Softening of a material due to temperature.	Since some plastics have no definitive melting point, a softening point can be used to determine the point at which mechanical properties change.
Thermal Expansion	Shrinkage or expansion of a material due to a change in temperature.	Since some processes involve a rapid cooling of material, changes in geometry can occur which will impact the planned dimensions of the design.

The following data has been collected through standardized tests published through ASTM International and other sources utilizing similar testing. It abides by their testing conditions, and allows a comparison between materials to be made. Like with all prints, material properties will vary due to the design chosen and printing properties, and the environment in which the print takes place. If objects are to be load bearing, ALWAYS test your materials under the specific conditions of your application before permanent installation.

What The Numbers Mean

The figure below aims to explain the meaning behind the variance in some material properties.

Material Property	A higher number…	A lower number…
Tensile Strength [MPa]	The material will require a high amount of stress before failure occurs.	The material will break with a lower load.
Young's Modulus [GPa]	High stress is required to cause any deformation or change in geometry.	The material can be easily bent.
Elongation [%]	The material can stretch far beyond its original geometry before breaking.	The material will fracture if a small stretch occurs.
Flexural Strength [MPa]	High amount of bending force required before fracture.	Little bending force will result in failure.
Flexural Modulus [GPa]	The material is stiff, and is unlikely to bend before breaking.	The material is more flexible.
Thermal Expansion Coefficient [μm/m/°C]	Material is prone to expansion and contraction effects with varying temperature.	Temperature variance will have little effect on the geometry of the material.
Hardness (Shore A)	The material is harder and less flexible. Harder to machine.	The material is softer and more flexible. Easier to machine.

Comparison Between Traditional and 3D Printed Methods

Below shows a table summarising the differences in material properties between traditional plastic manufacturing and 3D printed methods. It is important to note that due to the difference in manufacturing processes, even using the same material can yield different properties for your part.

Traditional Methods						3D Printed Methods			
Material Property	**Material Type**								
	ABS	Nylon	Polypropylene	Pine Wood	Stainless Steel 17-4 PH	ABS (FDM)	Formlabs Tough Resin (SLA)	Nylon (SLS)	PLA (FDM)
Tensile Strength [MPa]	40	70	40	40	1,090	30-33	55.7	48	37-39
Young's Modulus [GPa]	2.3	1.8	1.9	11	280	1.65-2.1 (axis dependant)	2.7	1.65	2.8-3.1 (axis dependant)
Elongation (%)	30	90	100	9	5	6	24	18	6
Flexural Strength [MPa]	30	117	40	60	1,100	35-38 (axis dependant)	60.6	48	36

Comparison Between Traditional and 3D Printed Methods

	Traditional Methods					3D Printed Methods			
Material Property	**Material Type**								
	ABS	Nylon	Polypropylene	Pine Wood	Stainless Steel 17-4 PH	ABS (FDM)	Formlabs Tough Resin (SLA)	Nylon (SLS)	PLA (FDM)
Flexural Modulus [GPa]	2.5	1.8	1.5	8	210	1.65-2.1 (axis dependant)	1.6	1.5	2.4-2.6 (axis dependant)
Impact Strength [J/m]	400	64	64	19	-	106	38	32	47
Water Absorption [%]	0.05-1.8	0.7-1.6	0.01-0.1	-	-	0.14	0.21	0.2	0.01-0.1
Heat Deflection Temperature [°C at 0.45 MPa]	200	160	210	-	-	96	-	177	60
Vicat Softening Point [°C]	100	125-165	143-152	-		99	230	163	63
Thermal Expansion Coefficient [µm/m/°C]	63	90	80-100	-	-	88.2	87.2	82.6-179.2	80

Hardness

Hardness requires a different form of measurement to reflect a material's resistance to permanent shape change. The Shore A scale is used to measure soft, elastic materials like rubber and plastics. Various examples of traditionally manufactured items aims to contextualise the hardness of elastic 3D printed materials. Since the elongation for materials such as ABS and PLA are low, they should not be used in this context, as they are generally brittle.

Traditional Methods						**3D Printed Methods**		
Material Property	**Material Type**							
	Rubber Band	Door Seal	Automotive Tire Thread	Hydraulic O-Ring	Hard wheel of roller skate	NinjaFlex (FDM)	Formlabs Flexible Resin (SLA)	Tango (PolyJet)
Hardness (Shore A)	25	55	70	70-90	98	85	70-85 (depending on curling)	27-95 (depending on raw material)

Compression Set & Tear Strength

Compression set is used to describe the deformation remaining after a compressive force is removed, and measured as a percentage – representing the ability of the material to match its original geometry.

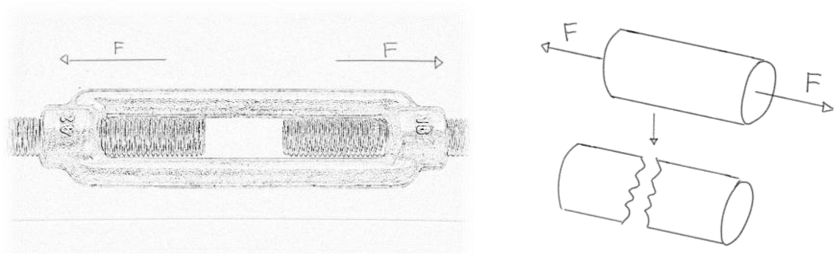
Tear strength is measured by the amount of force required to create tears and cuts within the material after being stretched.

Traditional Methods					**3D Printed Methods**	
Material Property	**Material Type**					
	Soft Silicone	Hard Silicone	Silicone Sponge	Urethane	Formlabs Flexible Resin (SLA)	Tango (PolyJet)
Compression Set (%)	1	<1	5	5	0.4	0.5-5 (depending on material composition)
Tear Strength (kN/m)	9.8	49	-	12-26	9.5-14.1 (dependning on curing)	3.3-10 (depending on material composition)

Properties to Look For

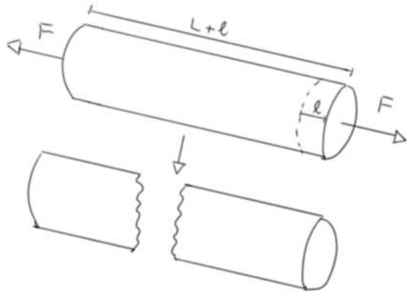
Tensile Strength

One of the most important properties to consider is tensile strength. This property measures the maximum pulling load a material can take before breaking and is the most basic reflection of how strong a material is. When considering designs that include any load bearing aspects, consider the tensile strength of the material you want to use.



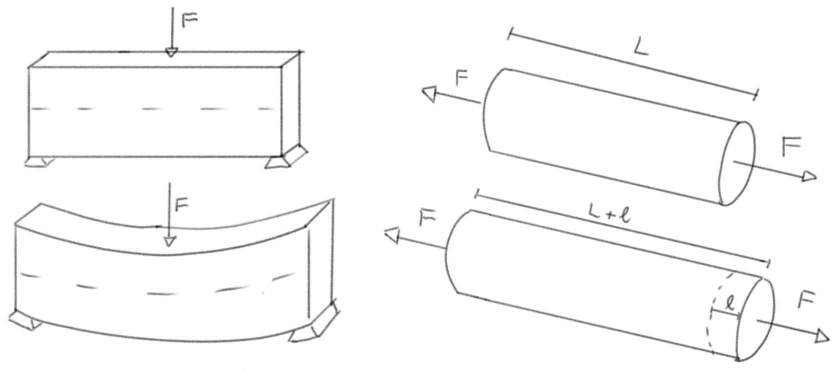
Elongation

If you are looking for your product to have flex, then elongation is an important property to consider. If you are looking for a rigid product, minimal elongation should be inherent in the material. Below shows elongation in action – after stretching so far, elongation measures at what point fracturing will occur.



Young's Modulus

Usually accompanied by a stress-strain curve, the Young's modulus of a material shows a material's behaviour when under stress. The numerical value of Young's modulus shows how much stress is required before bending and breaking occurs. A stress-strain curve can be used to identify the amount of stress associated with the elasticity of the material and at what point non-recoverable deformation occurs. The diagrams show how Young's Modulus can affect a workpiece – through bending moments and axial stress.



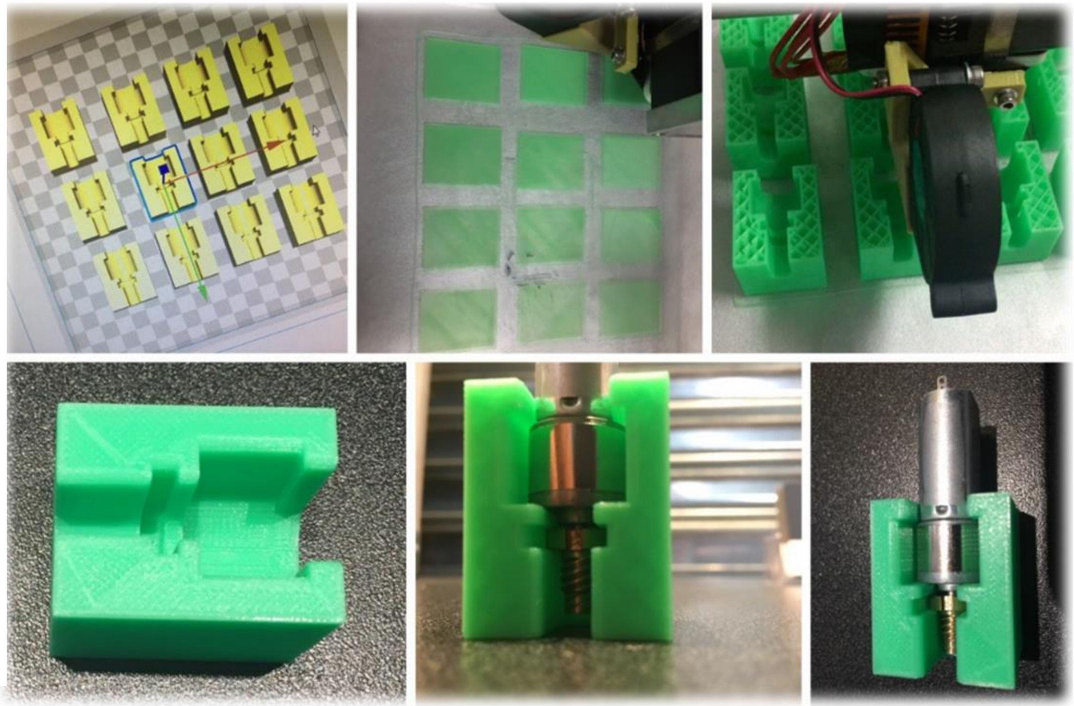
Which Printing Process Do I Need?

Many different kinds of 3D printing exist, with FDM, SLA and SLS being the most popular forms among designers and prototyping enthusiasts.

Fused Deposition Modelling (FDM)

By far the most common form of additive printing and the cheapest to produce parts and models, FDM extrudes hot plastic layer by layer to form a 3-dimensional part. Since the bond strength between layers isn't as strong as solid plastic, the FDM method can vary in material strength depending on printing conditions and material used. A variety of thermoplastics can be used with FDM methods, such as ABS, PLA, PETG, Nylon and many others, each with different advantages.

FDM printing offers accessible and affordable prototyping solutions with good surface finishes.



Stereolithography (SLA)

SLA uses laser to produce models of high precision, complexity and superior surface finish, involving curing a lifting bed of UV-sensitive resin. Since the accuracy of FDM printing can be limited by nozzle diameter, the reliance on the optical spot size of the laser gives SLA models a more accurate print. SLA printing is restricted in terms of materials – only select resins sensitive to UV can be chosen, however many different kinds of resins are available serving a variety of applications.

Due to the costs of the laser, specific materials and post-processing required, the cost of SLA printing is higher than FDM methods, though will yield a more accurate print and allows for complex geometries not possible with FDM.

Selective Laser Sintering (SLS)

On par with the complexity offered by SLA printing, the benefit of SLS methods is in the use of a wide range of powdered materials. Since materials used in SLA methods are UV-sensitive, light can degrade the quality of the material if special coatings are not applied. SLS works by using a laser to sinter powder, layer by layer. The downside of SLS is in the surface quality, where depending on the material, parts can be porous and thermal distortion can be an issue when using different polymers. In terms of materials, however, SLS can work with metallic powders whereas SLA cannot.