	Test Report	Date
	Gluing of PA12 SLS parts	2021/09/15

Goal of the test

Gluing selective laser sintered (SLS) PA12 parts is sometimes unavoidable. Suggestions for various types and brands of glue can be found for this purpose, however, comparison data is hard to find. This test compares a number of these suggested gluing options. The test measures the maximum tensile strength for a PA12 to PA12 glued connection.

Materials and sample preparation

Following glues have been selected for this test:



Glue	Characterisation	Max tensile strength ¹ and open time	Advantages
Uhu Plus Endfest 300	Dual-component epoxy	12 N/mm ² , more at higher temperatures Open time 90 minutes	For a variety of materials, good filling capacity, long open time life, color is yellowish
Araldite 2028-1	Dual-component polyurethane	11 N/mm ² Open time 6 minutes	Transparent, fast curing, UV stable, for a variety of metals and plastics
Technicoll 9411	Dual-component MMA	21-24 N/mm ² Open time 6 minutes Used with primer 9603-1 for PA	Fast curing and handling, gap filling up to 10 mm, high flexibility, black
Bison Kombi Plastic	Dual-component MMA	Up to 30N/mm ² Open time 3 minutes	For a variety of materials, including metals, fast curing, filling, beige
Ruplo 1505 VN	Cyanoacrylat ("Super Glue")	10-25N/mm ²	Transparent, very fast, high strength, for a variety of materials, transparent
+PLUSerie Composite 1 Minute	Dual-component urethane	No strength information Open time 1 minute	High strength and fatigue, often used in orthopaedic applications

¹ These are general maximum values claimed (online or data sheet) for the glue, not for gluing PA12.

For each test, two PA12 samples are used. By design, an identical gluing surface is guaranteed for every sample. Inside the sample, there is a hole to align the samples with a 4 mm pin.

Properties of samples	
Material	PA12 (PA2200 EOS white)
Tensile strength	42 (Z-Axis) to 48 N/mm ²
Glue surface outer diameter	Ø 12 mm
Alignment hole diameter	Ø 4.1 mm
Resulting glue surface	~100 mm ²
Attachment for test bench	Ø 12 mm
Finishing	polished (most common SLS finishing procedure)



Sample preparation

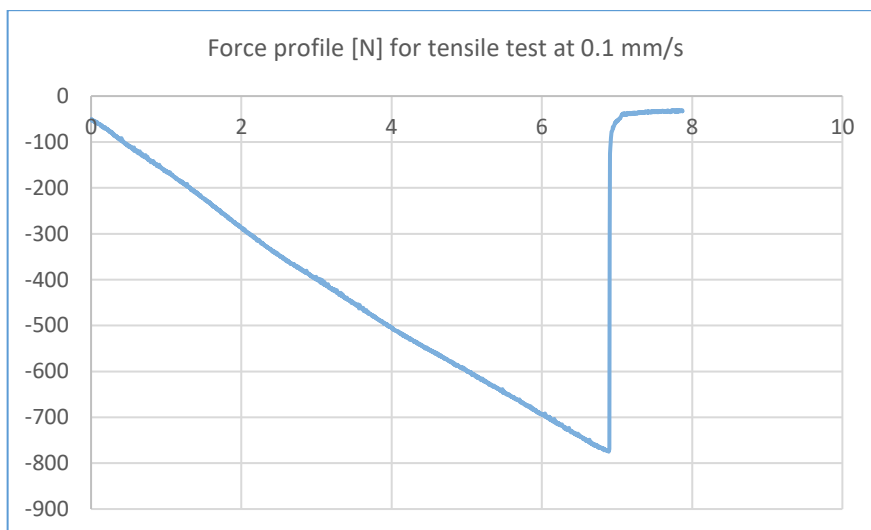
1. Dual-component glue mixed using the correct gluing pistole and mixer or mixed thoroughly with a spatula. First few cm of glue out of the cartridge remain unused to guarantee correct mixing ratio. *
2. Glue applied one-sided (1S) or two-sided (2S) and if needed evenly distributed with a glue spatula within the open time recommended by the manufacturer. **
3. Samples glued and left for >24 hours at room temperature in a horizontal position.

* Many manufacturers use their own cartridge system for 50ml cartridges. Make sure to order the correct cartridge gun and mixer nozzles for your glue of choice! Follow the manufacturer recommendations regarding ventilation and protection equipment!

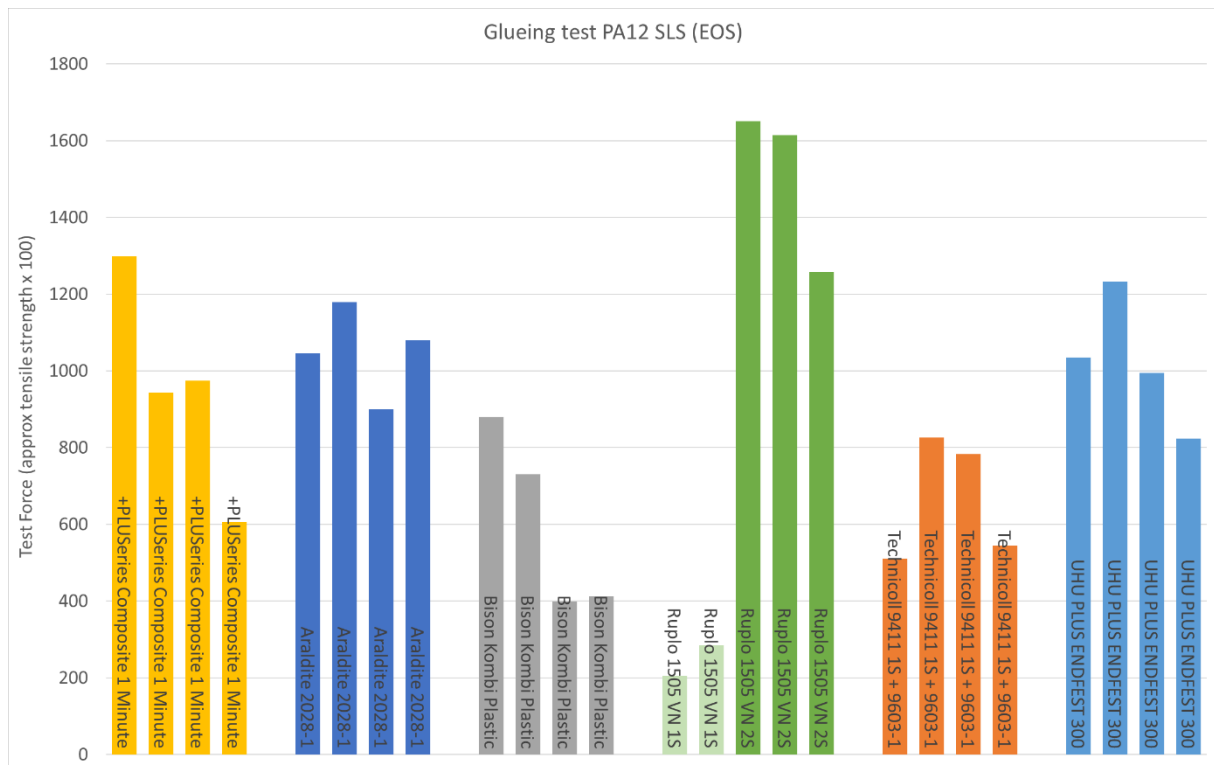
** The four two-sided samples of the +PLUSeries composite 1 minute were finished partly outside the open time recommended.

Testing

In the test bench, samples have been preloaded at 50N (=0.5 N/mm²) and then loaded at constant test bench speed (0.1 mm/s) till failure



Results



Discussion

All samples remain well below the tensile strength of SLS printed PA12 (around 48N/mm² in the printed direction). No damage to any of the PA12 samples has been seen in the test.

+PLUSeries Composite 1 minute	This glue performs well. The 4 th sample showed reduced strength. Most likely this is due to the short open time. So fast working is important.
Araldite 2028-1	Average tensile strength of this glue is close to data sheet. Most likely the capillary effect of this low-viscosity glue supports the propagation of the glue into the porous 3D printed material. Open time is sufficient for four samples.
Bison Kombi Plastic	This dual-component MMA glue comes in a 25 ml consumer cartridge, so no special glue pistol is needed. Mixing thoroughly with a spatula and preparing four samples takes more time compared to a cartridge gun. This might explain the lower values of the later samples.
Ruplo 1505 VN:	When applied one-sided, the samples remain far below the glue data sheet value (See samples indicated with 1S). Could the capillary effect lead to good propagation of the glue into the printed PA12, leaving insufficient glue for the other side? The test with two-sided application indeed showed much better strength, the highest in the test.
Technicoll 9411	Samples were prepared with 9603-1 primer, applied 90 minutes before gluing the samples together. Tests without the primer resulted in lower strength, but as this is not recommended on PA, we have not included the values.
Uhu Plus Endfest 300	This glue performs close to the data sheet value of 12N/mm ² . It has a long open time of 90 minutes. Strength can be increased by applying heat (not tested).

Conclusion

The Ruplo 1505 VN cyanoacrylate shows the highest strength of the tested glues, about 12-16 N/mm², but **only** when applied to both sides of the sample. It seems the glue propagates quite well in the PA12 due to the capillary effect. The effect seems to create optimal strength if the glue is applied to both sides.



The +PLUSeries Composite 1 Minute, Araldite 2028-1 and UHU Plus Endfest 300 all offer good strength as well, typically 8-12 N/mm², when used one-sided and within the open time of the glue. It seems that towards the end of the open time (with two-sided samples) the final strength rapidly reduces (except for the UHU Plus Endfest 300, with its 90 minutes open time).

The MMA based glues do not perform as well as the polyurethane based ones on the PA12 SLS parts in this test. With the Bison Kombi Plastic, this might be caused by a short open time. The Technicoll 9603-1 primer increased the strength of the Technicoll 9411 glue compared to samples without primer.

Some tips:

- Work fast with the dual component glues. The final strength clearly reduces towards the end of the open time.
- If more time is needed for a complex gluing situation, UHU Plus Endfest 300 with its 90 minute open time could be a good choice.
- Work two-sided with the cyanoacrylate glue and one-sided with the 2K systems.
- Do not use the first few centimetres of glue from a cartridge, as the mixing ratio is not yet optimal.
- Setting time begins as soon as two components meet in the mixer nozzle. With small quantities per sample, the glue exiting the nozzle might have 'used' much of its open time.
- If using a spatula, use more glue than you need to get a better mixing ratio.
- If you need a transparent color, use Ruplo 1505 VN or Araldite 2028-1.
- If a black color is required, +PLUSeries Composite 1 minute seems the best option.
- +PLUSeries Composite 1 minute is also a good choice if you need to fill bigger gaps.

Every situation is different, so do not rely on the results of this limited test (static test >24h after gluing). For dynamic loading, a flexible glue might be more suitable than a brittle cyanoacrylate glue. Moisture and temperature can influence the strength of a glue connection. Test your glue connection within the circumstances it should perform and get expert advice if needed.

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