

# Ultrafuse® 316L

## Process Instructions

### Product Description

1.75mm and 2.85mm filament for the manufacture of full metal, 316L stainless steel 3D printed parts on most Bowden and direct drive Fused Filament Fabrication (FFF) 3D printers.

### Product Owner

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### Part Design

Parts designed in accordance with the Ultrafuse 316L User Guidelines have been shown to possess improved stability and overall quality. Part features achievable with FFF 3D printers typically require support material for any overhang less than 45° from the horizontal.

Shrinkage resultant from debinding and sintering must be accounted for in print preparation. Standard oversizing factors are provided within in the Ultrafuse 316L User Guidelines. Whenever possible, parts should be debound and sintered in the orientation that they were printed.

### Debinding

Debinding according to the BASF process at 120 °C with  $\text{HNO}_3 > 98 \%$ . Formaldehyde evolving from the parts during debinding can react with oxidizing agents. Explosion limit of formaldehyde with oxygen is 4.5 % by volume. There is some indication that a slow reaction between formaldehyde and nitric acid exists. Therefore, any unintended high dose of nitric acid must be avoided.

Refer to the oven manufacturer's instructions to avoid leakage and therefore hazardous conditions for both personnel and oven parts. We highly recommend keeping the maintenance intervals for the door seals and bearings of the circulation fan. Based on a 50 liter debinding furnace (e.g. Nabertherm NRA 40/02-CDB) a nitric acid feed of typically 30 ml/h and a purging gas (nitrogen) with a throughput of 500 l/h proves to lead to safe processing. At this gas throughput, the acid feed may not be increased to more than 38 l/h. The debinding process is finished when a minimal debinding loss of 10.5% is reached.

### Sintering

Sintering should be done in an atmosphere with 100% clean and dry hydrogen (dewpoint  $< -40 \text{ }^\circ\text{C}$ ) or argon (dewpoint  $< -40 \text{ }^\circ\text{C}$ ).  $\text{Al}_2\text{O}_3$  sintering supports of 99.6% purity are recommended.

A typical sintering cycle consists of a ramp from:

1. room temperature – 5 K/min – 600 °C, hold 1h
2. 600 °C – 5 K/min – 1380 °C, hold 3h
3. Furnace cooling

In the early stage of the sintering process, remaining binder constituents are burnt off and the pyrolysis products should be removed by a suction fan. Removal of condensed pyrolysis products from the wall of the sintering furnace should be done wearing laboratory gloves or, in extreme cases, gloves made of nitrile rubber. Under certain circumstances, deposits can be formed in the sintering furnace containing  $\text{MnO}$ , manganosite. This compound may also exhibit a fiberlike morphology which may pose a health hazard requiring special care during clean-ing of the furnace. It is highly recommended to avoid dust formation and the use of disposable masks with particle filters type FFP3 (DIN EN 149).