FORWARD AM
Innovating Additive Manufacturing

BASF
We create chemistry

Ultrasint® TPU 88A

Rubber like | Strong and flexible | Easy to use

Extended TDS

Complete Technical Documentation and Testing Summary

V1

Content

forward-am.com +49 6221 67417 900 sales@basf-3dps.com

Technical Data Sheet

Rubber like material for SLS parts that require shock-absorption, high flexibility and resistance to fatigue.

General Properties	Norm	Typical Values
Appearance	-	Natural white powder
Density (printed part)	DIN EN ISO 1183-1	1.1
Density (Bulk Density) [g/cm³]	DIN EN ISO 60	0.5
Mean Particle Size d50 [µm]	ISO 13320	70-90
Glass Transition Temperature [°C]	ISO 11357 (20 K/min)	-48
Melting Temperature [°C]	ISO 11357 (20 K/min)	120 – 150

Tensile Properties	Norm	Typical Values	
		X-Direction	Z-Direction
Tensile Modulus [MPa]	ISO 527-2, 1A, 1mm/min	75	75
Ultimate Tensile Strength [MPa]	DIN 53504, S2, 200mm/min	8	7
Elongation at Break [%]	DIN 53504, S2, 200mm/min	280	130

Flexural Properties	Norm	Typical Values	
		X-Direction	Z-Direction
Flexural Modulus [MPa]	DIN EN ISO 178	70	70
Tear Resistance (propagation, Trouser) [kN/m]	DIN ISO 34-1, A	26	26
Tear Resistance (initiation, Graves) [kN/m]	DIN ISO 34-1, B	43	37
Compression Set B (23°C, 72h) [%]	DIN ISO 815-1	24	24
Rebound Resilience [%]	DIN 53512	63	63

Impact Properties	Norm	Typical Values	
		X-Direction	Z-Direction
Charpy Notched, 23°C [kJ/m²]	DIN EN ISO 179-1	No break	No break
Charpy Notched, -10°C [kJ/m²]	DIN EN ISO 179-1	60	58

Thermal Properties	Norm	Typical Values	
		X-Direction	Z-Direction
Vicat/A (10 N) [°C]	DIN EN ISO 306	98	98

Hardness and Abrasion	Norm	Typical Values	
		X-Direction	Z-Direction
Shore Hardness A	DIN ISO 7619-1	88-90	88-90
Abrasion Resistance [mm³]	DIN ISO 4649	86	95

Other	Norm	Typical Values
Cytotoxicity - Neutral Red	ISO 10993-5 (2009)	PASS
In Vivo Sensitization - Local Lymph Node Assay	ISO 10993-10 (2013); OECD Guideline No. 429	PASS
In Vitro Skin Irritation	OECD Guideline No. 439	PASS

Mechanical properties overview

International Material Data System (IMDS)

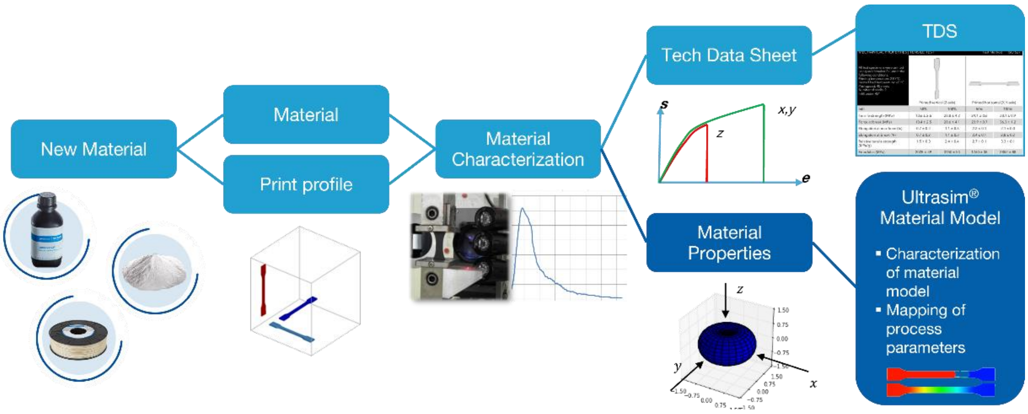
This material is listed in the IMDS (International Material Data System), which contains information on materials used in the automotive industry. Access to the database can be granted on request by sharing the IMDS ID with us (sales@basf-3dps.com).

Printing Performance

The combination of 3D printer and material has a huge impact on the quality of the parts produced.

Material Model & FEA Simulation

3D simulation helps to speed up the engineering process using a digital twin. Backed up by decades of simulation experience in injection molding, we provide material models optimized for 3D printing considering its characteristics (e.g. anisotropy, temperature, strain-rates, etc.) and run FEA simulations to understand part performance.

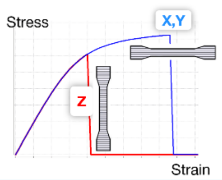


Material modeling workflow

We offer 3 easy methods to get started:

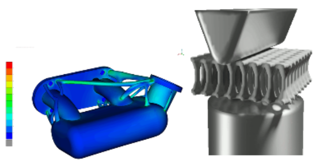
Raw Material Data

Starter:
Get the curves behind our TDS data to start basic simulation work.



3D Simulation

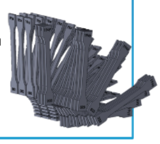
Premium:
We run the simulation for you. We help you to speed up your engineering process and increases confidence in part performance using a digital twin of your part.



Material Model as a Service

Enterprise:
Use our in-house developed material models for 3D-Printing incl. anisotropy of the process and FEA support of our experienced virtual engineers.

- Anisotropic
- Nonlinear
- Strain-rate sensitive
- Tensile-compression asymmetry
- Failure modelling
- Temperature dependent



Ultrasim® 3D Simulation (FEA)

	Available temperatures			Strain rate / loads		Print Orientation / Aniso-tropy
	Low	23°C	High	Quasi static	High speed	
Ultrasint® TPU 88A		■		■	■	■

■ Validated, available via Ultrasim® Material Model

Simulation material availability

Support is available on request: ultrasim3d-support@basf-3dps.com

Cyclic Mechanical Testing

When a component operates under conditions where it is repeatedly loaded, it can experience cracking or fracturing which can lead to failure. The goal of any fatigue test is to determine how well a product or material can withstand cyclic fatigue loading forces without failure. This is a critical measure for many engineering applications such as automotive suspension system parts or industrial machinery parts among others.

Test method and specimens

The tests have been performed according to ASTM Method D1052, also known as ROSS flex test. All samples were printed in XZ direction for this test.

Initial state | After 100k cycles at 23°C | After 100k cycles at -10°C

Test set-up of Ross flex measurement of Ultrasint® TPU 88A

Results

The result of this test is measured by the possible growth of the incision that was made before the continuous bending was performed. If the cut grows or a beam in the lattice breaks, that could indicate a limitation for certain applications in the market.

ROSS Flex tests	Results
Plate, 23°C, 90°, 2mm thickness	Passed 100.000 cycles
Plate, -10°C, 90°, 2mm thickness	Passed 100.000 cycles

Results of fatigue resistance test of Ultrasint® TPU 88A

Industrial Chemical Resistance

The resistance of plastic materials against chemicals, solvents and other contact substances is an important criterion of selection for many applications. When contacting such substances, the mechanical properties of plastic materials can be affected. This summary table provides a survey in tabular form of the behavior of Ultrasint® TPU 88A towards common contact substances.

General chemical resistance depends on the period of exposure, the temperature, the quantity, the concentration and the type of the chemical substance.

Test method and specimens

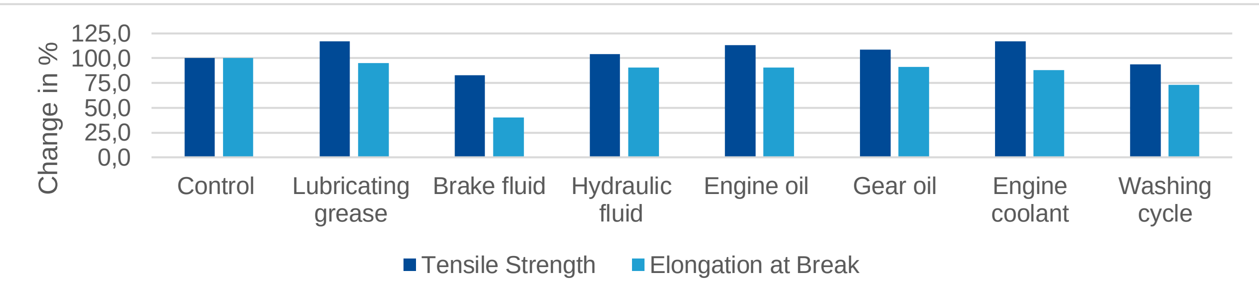
- Test Specimens Standard S2 dumbbells according to DIN 53504

Used hydrocarbons and cleaning chemicals

Fluid	Conditions
Lubricating grease Nigrin Mehrzweckfett	23°C for 42 days
Brake fluid Bosch DOT 4	23°C for 42 days
Hydraulic fluid (green) febi 46161	23°C for 42 days
Engine oil - Castrol Edge	23°C for 42 days
Gear oil - Valvoline ATF Gear oil	23°C for 42 days
Engine coolant - BASF Glysantin G48	23°C for 42 days
Washing Cycle 15 – With regular soap and softener	1.5h each, 40°C

Mechanical testing

Ultrasint® TPU 88A as ester based TPU shows a good chemical resistance. Tensile strength and elongation at break remain quite stable for most of the tested chemicals with an exception of brake fluid and long washing cycles at 40°C.



Change of mechanical performance of Ultrasint® TPU 88A due to exposure of chemicals

Long-term UV

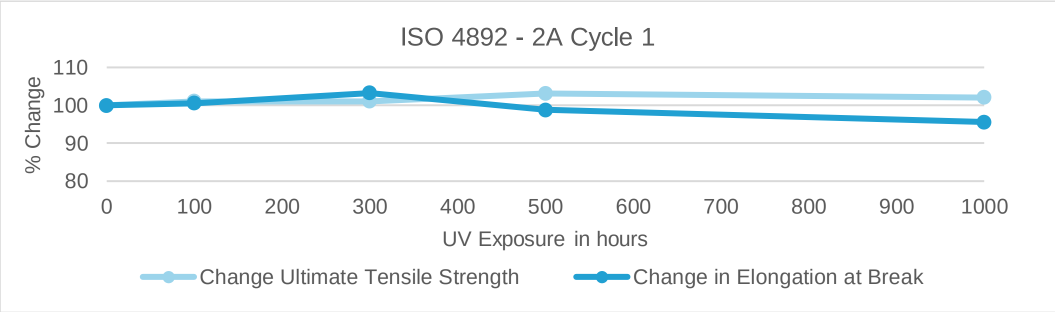
Durability is a key feature for components across many industries. The materials used in automotive or consumer applications for instance, must be put through a variety of severe tests to ensure that they can withstand years of exposure to the elements. Plastics are chemically degraded by the effect of UV radiation. The degree of ageing depends on duration and intensity. In the case of polyurethanes, the effect is seen initially as surface embrittlement. This is accompanied by a yellowing in color and a reduction in mechanical properties. The chemistry behind Ultrasint® TPU 88A (aliphatic) has an intrinsically high UV stability in comparison to aromatic materials where degradation is more prominent.

Test method and specimens

The UV resistance was examined both for outdoor weathering condition use and indoor use using conventional accelerated weathering tests at BASF lab as per the Norm ISO 4892-2:2013 Method A and ISO Norm ISO 4892-2:2013 Method B.

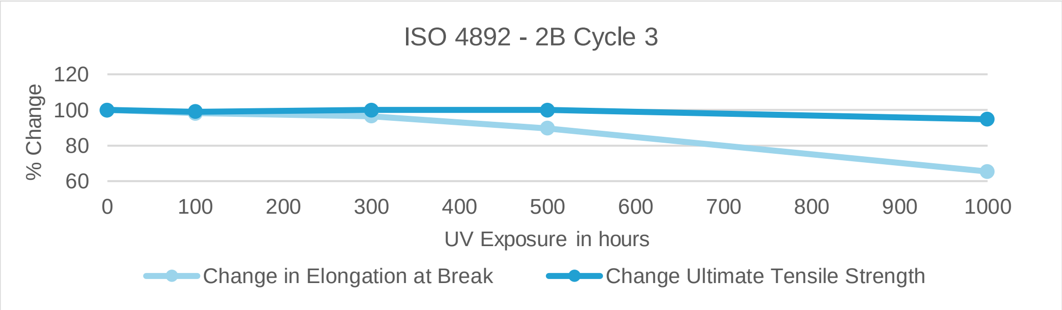
Mechanical Testing

When looking at the mechanical properties of the material after performing the test conditions A, the tensile strength stays quite constant over time.



ISO 4892 – 2A Cycle 1 Change of mechanical properties over of 1000 hours of UV exposure

When looking at the mechanical properties of the material after performing the test conditions method B, the tensile strength stays constant over time while the elongation at break drops after 300g of exposure.



ISO 4892 – 2B Cycle 3 Change of mechanical properties over of 1000 hours of UV exposure

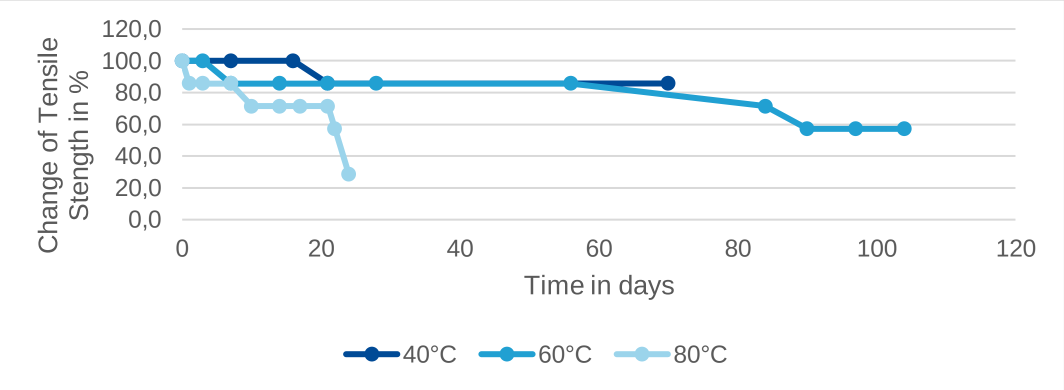
Hydrolysis Resistance

Overall, hydrolysis resistance is important because it helps to ensure the stability, safety, and effectiveness of many different products and materials that are exposed to water.
If polyester-based polyurethanes are exposed for lengthy periods to hot water, moisture vapor or tropical climates, an irreversible break-down of the polyester chains occurs through hydrolysis. This results in a reduction in mechanical properties. This effect is more marked in flexible grades, where the polyester content is correspondingly higher than in the harder formulations.

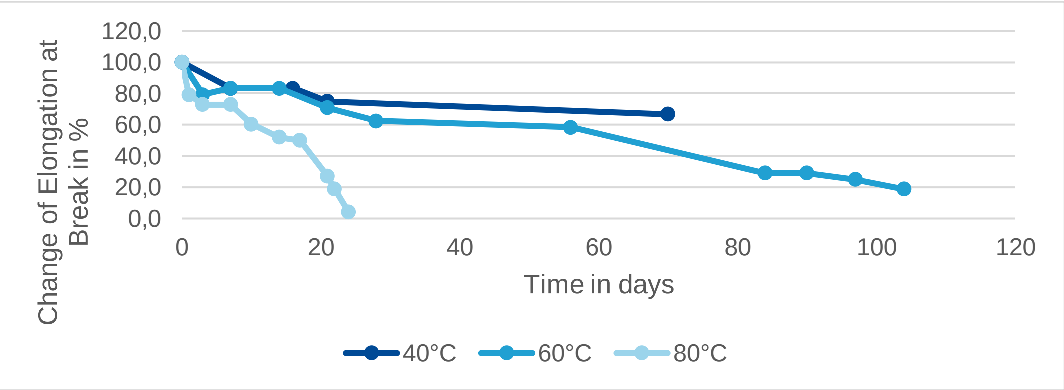
Test method and specimens

Storage of S2 tensile bars (X-direction), immersed in water, at various temperatures (40°C, 60°C, 80°C)

Results



Change of tensile strength of Ultrasint® TPU 88A over time of water exposure



Change of elongation of break of Ultrasint® TPU 88A over time of water exposure

Due to a good stabilization, a degradation of polyester-based Ultrasint® TPU 88A is rarely experienced at room temperature, at 40°C the printed parts properties stay quite constant for over >70 days.

Like for all polyester-based TPUs, water at high temperature can be a problem, therefore with Ultrasint® TPU 88A parts in contact with water at high temperature (>60°C) should be avoided to prevent a decrease in mechanical performance.

Air and Fluid Tightness

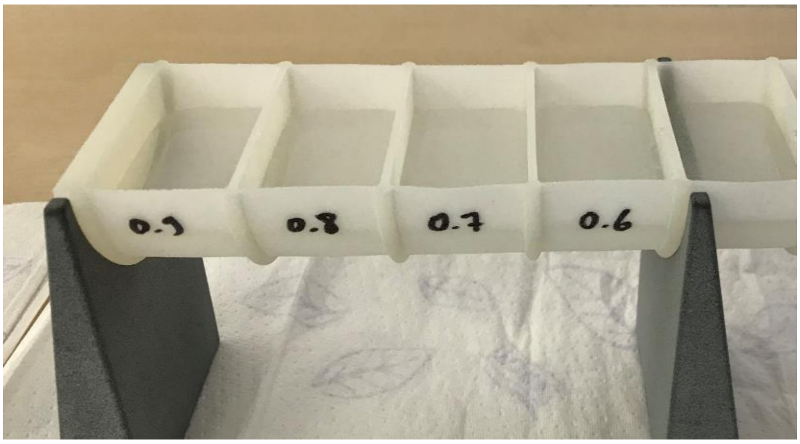
Air and fluid tightness are important for many industries and applications because they help to prevent leaks, contamination and loss of efficiency. The goal of this test is to determine how well -Ultrasint® TPU 88A parts can achieve watertight properties without any additional post processing.

Fluid tightness is key for applications such as ducts, deposits, waterproof covers or hydraulic/ pneumatic systems that work with water, oil, air or other substances, even under pressure. These are the main variables of design, which define the maximum pressure any given part can withstand:

- Wall thickness
- Shape
- Temperature
- Pressure
- Type of fluid

Water Tightness

Certain applications, such as fluid reservoirs or deposits, require a leakage test. The watertightness characterization test has been performed using two different shapes, hollow spheres and vertical cylinders, and seven different wall thicknesses and with water fluid to room temperature.



Testing conditions for water tightness with vertical cylinder

The results after 1 week were the following:

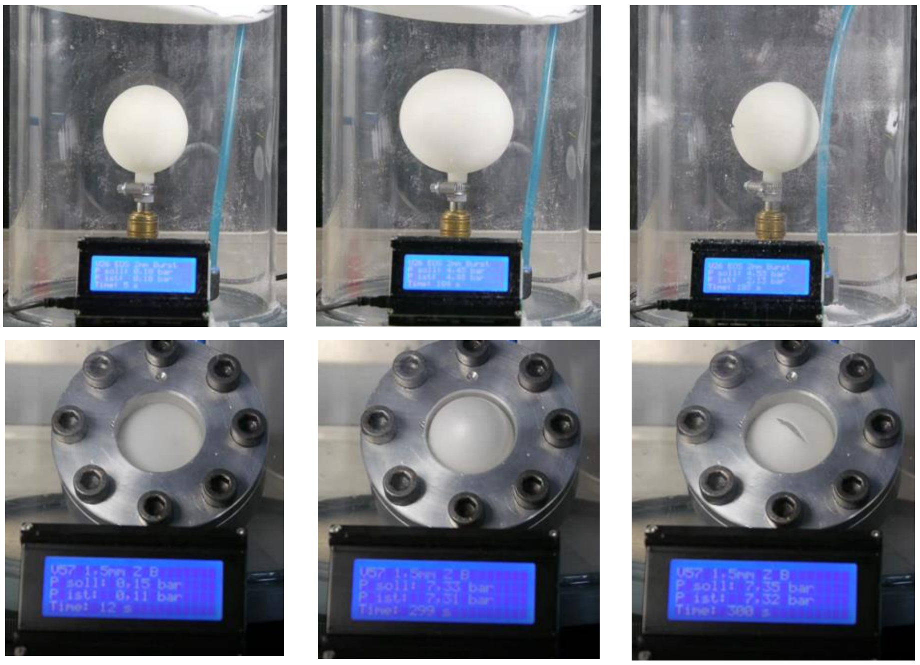
Wall thickness	Vertical cylinder
0.6 mm	watertight
0.7 mm	watertight
0.8 mm	watertight
0.9 mm	watertight

Testing results after 1 week

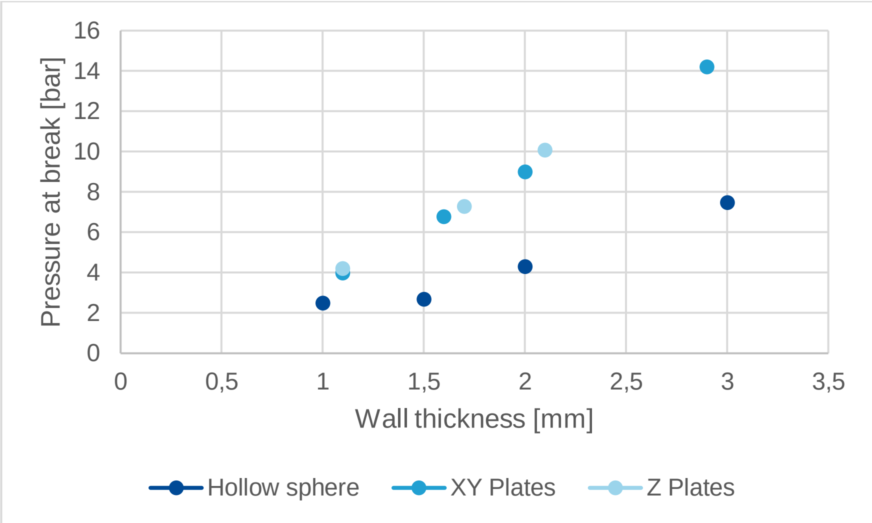
Burst Pressure

The pressure resistance of components is important in many areas such as security, cost or overall part performance. The results on such tests are key to meet the requirements of hydraulic components, automotive components or hoses, pipes and pipe connections for example.

After choosing different geometries to be tested, the pressure is incrementally increased from 25mbar/s = 1.5 bar/min until part breaks. The tested geometries were hollow spheres, plates printed horizontally in XY and vertically in Z, each in two wall thicknesses to obtain good reproducibility.



Test set-up for measuring burst pressure

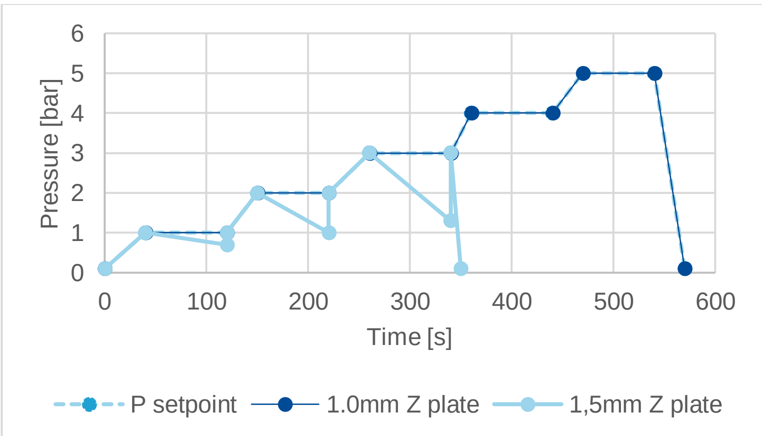


Burst pressure of various geometries in Ultrasint® TPU 88A

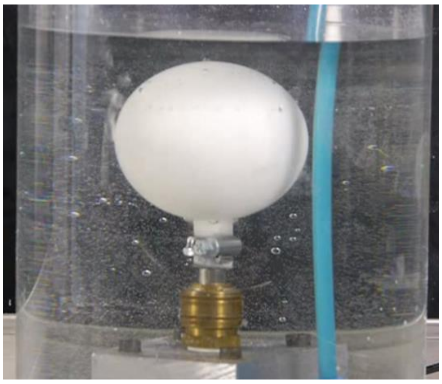
As can be seen in the graph, good homogeneity between XY and Z directions is accomplished in the plates which can withstand higher burst pressures than plates. This could be due to small inhomogeneities in wall thicknesses and varying overlap of printed layers in the sphere, which leads more easily to weak spots.

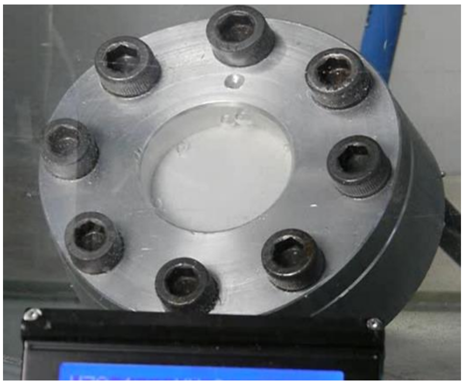
Air Tightness

After choosing different geometries to be tested, the pressure is incrementally increased in steps from 25mbar/s = 1.5bar/min until part breaks or up to a maximum of 5 bar. The tested geometries were hollow spheres, plates printed horizontally in XY and vertically in Z in different thicknesses. The main difference between the air tightness test and the burst pressure test is that the first is performed under water and leakage is detected through bubble formation and recorded pressure drop.



Air tightness of various geometries in Ultrasint® TPU 88A





Test set-up for measuring air tightness

Wall thickness	Hollow spheres	XY plates	Z plates
1 mm	not airtight	airtight up to 2 bar	not airtight
1.5 mm	not airtight	airtight up to 5 bar	airtight up to 5 bar
2 mm	airtight up to 3 bar		
3 mm	airtight up to 5 bar		

Results of air tightness measurement

Flame Resistance

This material does not contain any flame retardants, so the flammability behavior is in principle comparable to regular plastics.

FMVSS 302 (car interior applications)

Heat stability tests are of central importance for materials in car interiors and aim to determine the burn resistance capabilities of materials under standardized conditions.

- Tests are subject to geometry
- Thin plates or thin/fine lattices are to have the worst results
- Test plates 356x102mm:

Result of 5 samples:

Orientation	Thickness	Max. burning rate (limit ≤ 102mm/min)
XY	1.08 mm	84 mm/min
Z	1.2 mm	84 mm/min

Results of flamability resistance test of Ulrasint® TPU 88A

Vehicle Interior Air Quality

When a component needs to go inside a vehicle interior, they need to pass stringent odor, fogging, and emissions standards for interior automotive applications. Automotive requirements might differ from company to company.

Standards and General Targets

	Test Method	Description	General Target*
Odor	VDA 270	Determination of the olfactory characteristics of car materials	< 3
Formaldehyde	VDA 275	Control of formaldehyde emissions	< 5 mg/kg
Volatile Organics (VOC)	VDA 276	Determination of organic substances as emitted from automotive interior products using a 1 m³ test cabinet	
Volatile Organics (VOC)	VDA 278	Thermal desorption. Emissions of volatile compounds from materials	< 220 ppm
Fogging	DIN 75201 Method B	Fogging behavior. Condensation of semi-volatile compounds that generate lack of visibility	< 1 mg
Semi-Volatile Organics (FOG)	VDA 278	Emissions of semi-volatile compounds from materials	< 220 ppm

Testing standards and general targets for vehicle interior air quality

*Limits are manufacturer dependent, given are just typical limit values as an indication.

Results

The table below displays the results of analysis conducted on interior parts produced from Ultrasint® TPU 88A. The test specimens have been sandblasted and further processed after printing. Details and further data are available upon request.

SB = Sandblasted

PR = Processing

Name	Odor	Formaldehyde	Volatile Organics (VOC)	Fogging	Semi-Volatile Organics (FOG)
Method	VDA 270	VDA 275	VDA 278	DIN 75201 Method B	VDA 278
SB	< 3	< 0.3 mg/kg	319-587ppm	0,1mg	422–457 ppm
SB + PR	Not tested	Not tested	250-250ppm	0,23mg	191-199ppm
General Target	**< 3**	**< 5 mg/kg**	**< 220 ppm**		**< 220 ppm**

Results of VDA tests

Regulatory documents

In terms of certification, Ultrasint® TPU powders contain regulatory documents for:

- Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)
- Restriction of Hazardous Substances (RoHS)
- Substance of Very High Concern (SVHC)
- End-of-Life Vehicle (ELV)
- Global Automotive Declarable Substance List (GADSL)

Ultrasint® TPU powders are listed in the International Material Data System (IMDS) for automotive industry. These and further certifications are available upon request.

Bio Compatibility: Ultrasint® TPU 88A

BASF
We create chemistry

Product Information

Page 1 / 1

Product: Ultrasint TPU 88A
Revision: 09.02.2022 Version: 5.0

Contact:
BASF 3D Printing Solutions GmbH
Speyer Straße 4
69115 Heidelberg, Germany
sales@basf-3dps.com

3D printed test items of the above stated product have fulfilled the requirements of tests as stated below:

Cytotoxicity Testing- Neutral red: Pass
(ISO 10993-5 (2009))
In vitro Skin Irritation Testing- Human Skin Model: Pass
(OECD Guideline No. 439)
In vivo Sensitisation Testing- Local Lymph Node Assay: Pass
(ISO 10993-10 (2013); OECD Guideline No. 429)

Sampling preparation: The test specimens were dry ice blasted and handled only with disposable medical gloves. The test specimens were wrapped in aluminum foil for shipment to the testing laboratory.

However, the biocompatibility tests were recorded on test specimen of the above referenced product to show compatibility of the material in general. The biocompatibility tests listed are not part of any continuous production protocol. The test assessments reflect only the test specimen and have to be retested on the final product. It remains the responsibility of the device manufacturers and/or end-users to determine the suitability of all printed parts for their respective application.

For notice:
We give no warranties, expressed or implied, concerning the suitability of above-mentioned product for use in any medical device and pharmaceutical applications.

All information contained in this document is given in good faith and is based on sources believed to be reliable and accurate at the date of publication of this document.

It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislation are observed. The certificate is exclusively for our customers and respective competent authorities. It is not intended for publication either in printed or electronic form (e.g. via Internet) by others. Thus, neither partial nor full publication is allowed without written permission.

This product information was generated electronically and is valid without signature.

Please request the official biocompatibility statement to your sales representative.

Food Contact

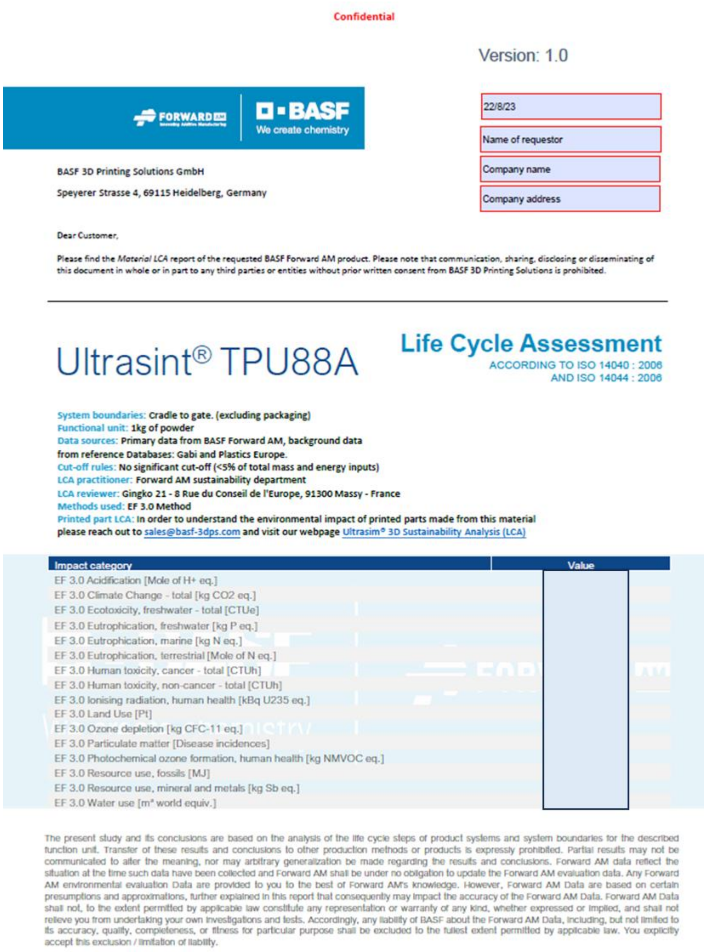
Ultrasint® TPU 88A is not produced according to any food contact guidelines and **does not have food contact approval**.

forward-am.com +49 6221 67417 900 sales@basf-3dps.com

Sustainability (LCA, Recycling, Carbon Compensation)

The sustainability concept of Ultrasint® TPU 88A is set up on three main approaches.

1. A **life-cycle assessment (LCA)** of the material production from granulate to powder according to ISO 14040:2006 and ISO 14044:2006 has been executed and reviewed by external third party to analyze the emission of carbon per kg of TPU. The study serves as a baseline for better understanding the main contributor to the carbon footprint and how to reduce the emission. The analysis is available on request for free.



Confidential

Version: 1.0

22/8/23

Name of requestor

Company name

Company address

BASF 3D Printing Solutions GmbH

Speyerer Strasse 4, 69115 Heidelberg, Germany

Dear Customer,

Please find the *Material LCA* report of the requested BASF Forward AM product. Please note that communication, sharing, disclosing or disseminating of this document in whole or in part to any third parties or entities without prior written consent from BASF 3D Printing Solutions is prohibited.

Ultrasint® TPU88A

Life Cycle Assessment
ACCORDING TO ISO 14040 : 2006
AND ISO 14044 : 2006

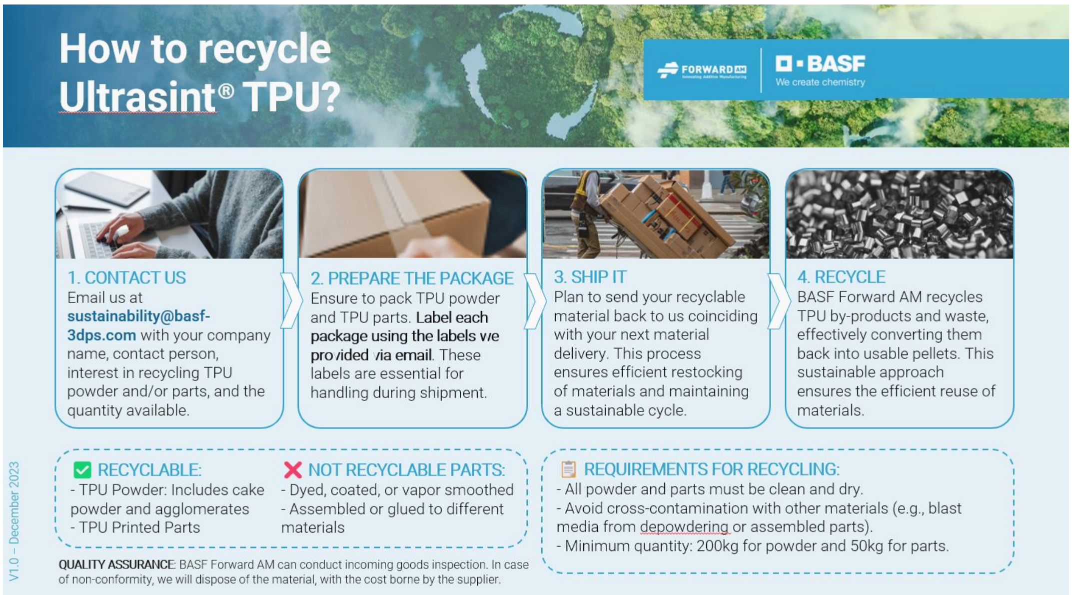
System boundaries: Cradle to gate. (excluding packaging)
Functional unit: 1kg of powder
Data sources: Primary data from BASF Forward AM, background data from reference Databases: Gabi and Plastics Europe.
Cut-off rules: No significant cut-off (<5% of total mass and energy inputs)
LCA practitioner: Forward AM sustainability department
LCA reviewer: Gingko 21 - 8 Rue du Conseil de l'Europe, 91300 Massy - France
Methods used: EF 3.0 Method
Printed part LCA: In order to understand the environmental impact of printed parts made from this material please reach out to sales@basf-3dps.com and visit our webpage Ultrasim® 3D Sustainability Analysis (LCA)

Impact category	Value
EF 3.0 Acidification [Mole of H+ eq.]	
EF 3.0 Climate Change - total [kg CO2 eq.]	
EF 3.0 Ecotoxicity, freshwater - total [CTUe]	
EF 3.0 Eutrophication, freshwater [kg P eq.]	
EF 3.0 Eutrophication, marine [kg N eq.]	
EF 3.0 Eutrophication, terrestrial [Mole of N eq.]	
EF 3.0 Human toxicity, cancer - total [CTUh]	
EF 3.0 Human toxicity, non-cancer - total [CTUh]	
EF 3.0 Ionising radiation, human health [kBq U235 eq.]	
EF 3.0 Land Use [Pt]	
EF 3.0 Ozone depletion [kg CFC-11 eq.]	
EF 3.0 Particulate matter [Disease incidences]	
EF 3.0 Photochemical ozone formation, human health [kg NMVOC eq.]	
EF 3.0 Resource use, fossils [MJ]	
EF 3.0 Resource use, mineral and metals [kg Sb eq.]	
EF 3.0 Water use [m³ world equiv.]	

The present study and its conclusions are based on the analysis of the life cycle steps of product systems and system boundaries for the described function unit. Transfer of these results and conclusions to other production methods or products is expressly prohibited. Partial results may not be communicated to alter the meaning, nor may arbitrary generalization be made regarding the results and conclusions. Forward AM data reflect the situation at the time such data have been collected and Forward AM shall be under no obligation to update the Forward AM evaluation data. Any Forward AM environmental evaluation Data are provided to you to the best of Forward AM's knowledge. However, Forward AM Data are based on certain presumptions and approximations, further explained in this report that consequently may impact the accuracy of the Forward AM Data. Forward AM Data shall not, to the extent permitted by applicable law constitute any representation or warranty of any kind, whether expressed or implied, and shall not relieve you from undertaking your own investigations and tests. Accordingly, any liability of BASF about the Forward AM Data, including, but not limited to its accuracy, quality, completeness, or fitness for particular purpose shall be excluded to the fullest extent permitted by applicable law. You explicitly accept this exclusion / limitation of liability.

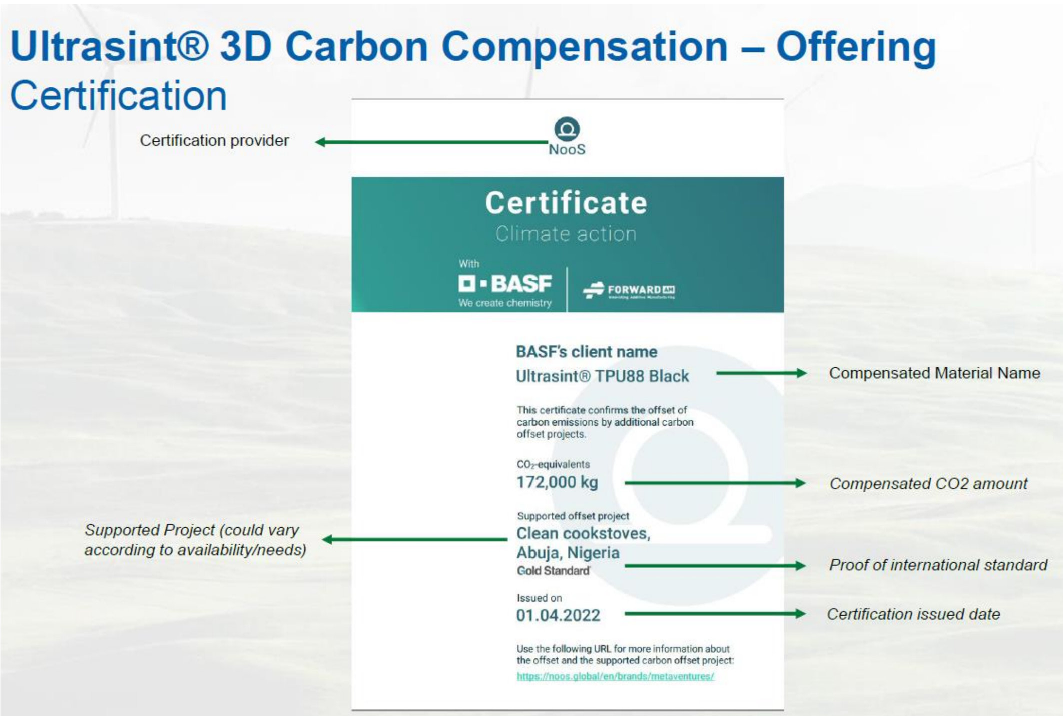
Example of Life-Cycle Assessment Document for Ultrasint® TPU

2. Even though Ultrasint® TPU 88A has already a high printing refresh rate of 80/20, there might be some cake powder or agglomerates which won't be used any further. BASF Forward AM offers to take back these leftovers as well as printed parts from worn out application to give them a second life after **recycling into granulate.**



Recycling Take-Back Program of Ultrasint® TPU

3. Additional to the carbon reduction measurements, BASF Forward AM offers to compensate a Ultrasint® TPU 88A **carbon compensated** material to drive down the full carbon footprint by company.



Example Certificate for Compensating Carbon Emission