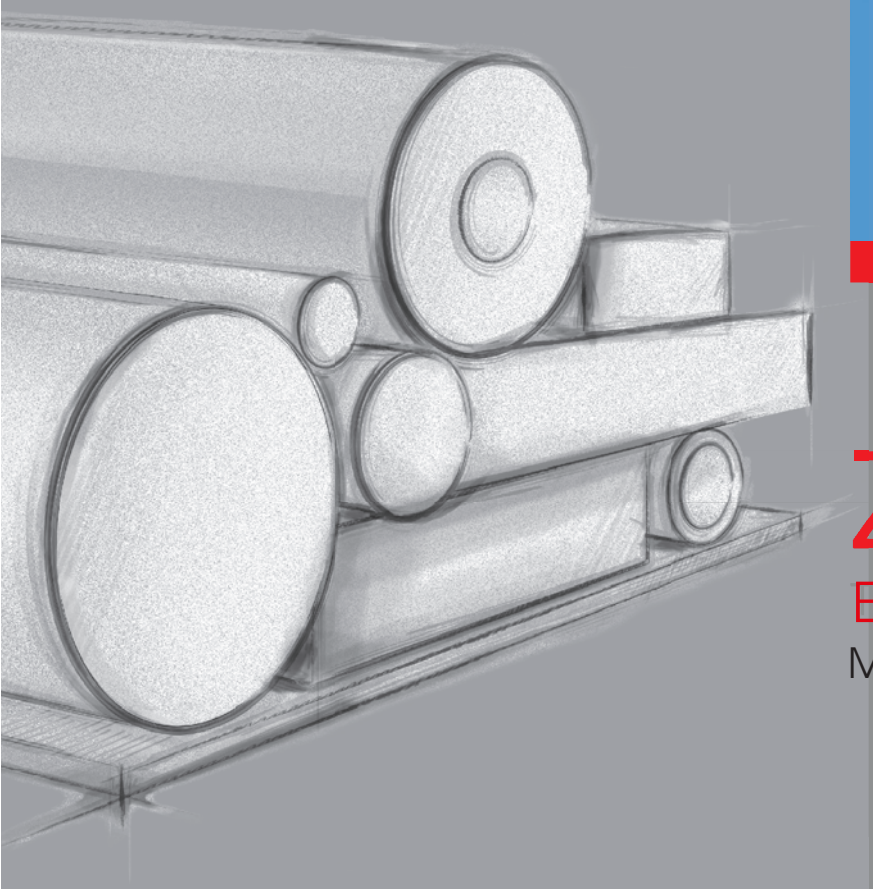
Zell-Metall

Engineering Plastics



ZELLAMID®

Engineering Plastics

Machining Guide

Handling Guideline

Zell-Metall
Engineering Plastics

ZELLAMID® Plastics are produced with high-end technology and stand out for their excellent quality in numerous applications. To safeguard the properties and features of our products, the following guidelines will provide you with information on transportation, storage and machining. Depending on the purpose of use or kind of application, modifications to these can be made by the buyer or customer.

Environmental effects like direct sunlight (UV rays) and moisture can modify the polymeric structure. Prolonged exposure to these can result in moisture expansion, volume changes and discoloration. Stock shapes should be stored at 50% humidity and protected from UV rays (including some interior lighting systems).

Chemical liquids and gases can also damage the polymeric structure and should be avoided.

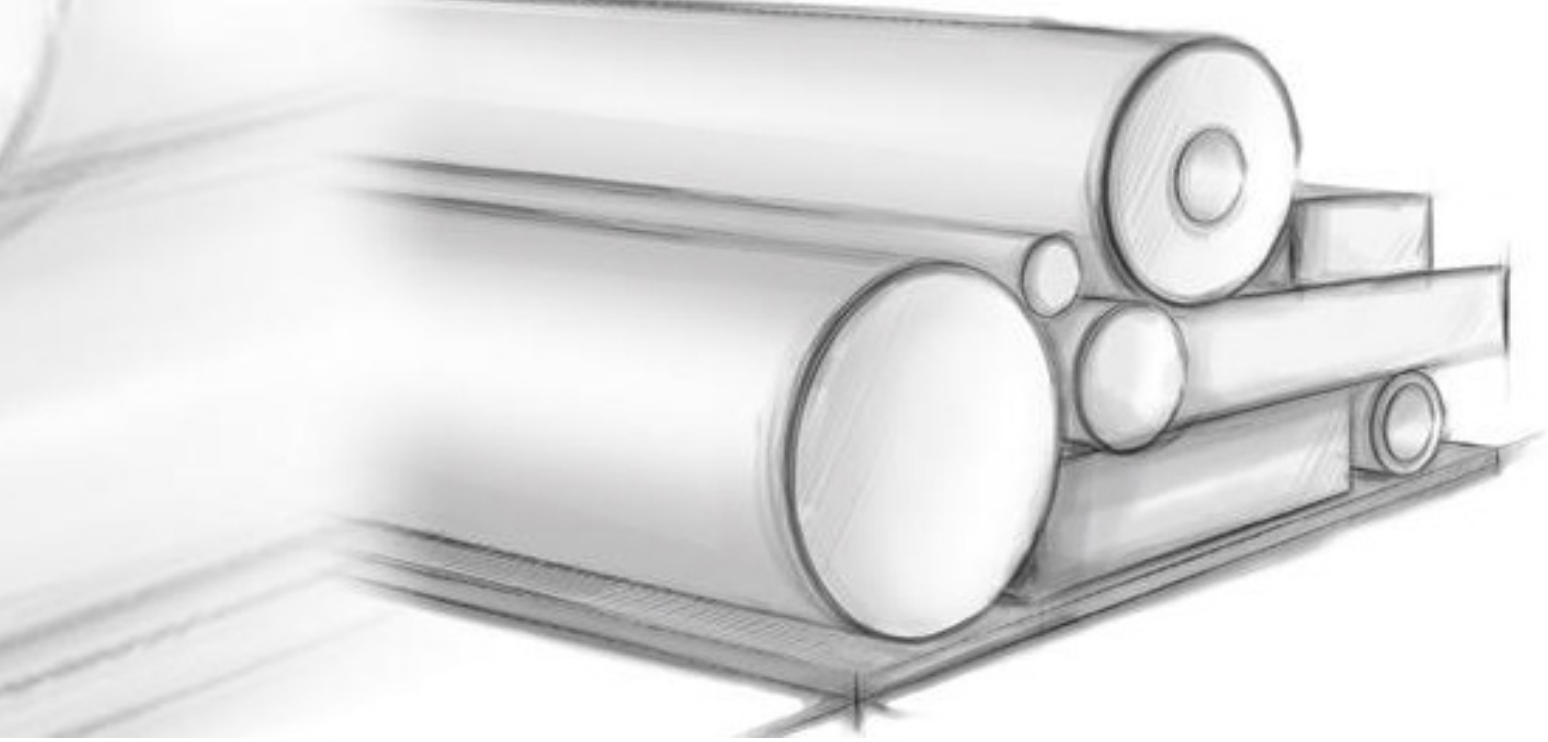
Store the stock material straight without bending in well supported flat racks, as this can deform the stock material permanently and recovering requires extensive effort.

Handle ZELLAMID® materials only with suitable lifting jacks and supports. Please consider the safety rules of public authorities.

Energy radiation like X-rays should be avoided as not every type of plastic is resistant to it.

ZELLAMID® Products alone do not pose a fire risk. However, some types are flammable, so please store them as regulated by law.

For traceability, certificates and further inquires, always keep the invoice and production code number.



Recommendations for storing ZELLAMID® - Products:

Protected from high moisture

Protected from UV light sources

Protected from weather conditions

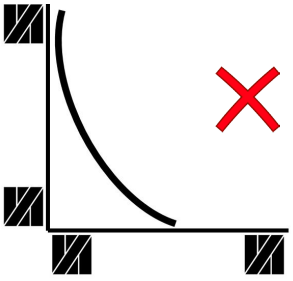
At temperatures between 0°C and + 30°C

Free from chemicals and other liquids

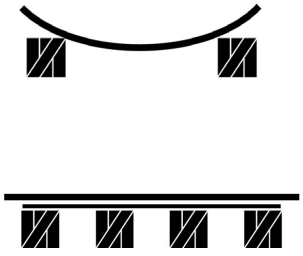
Keep the production code number for traceability

Seperate from flammable materials and heat sources

Protected from radiation



Avoid bending



Flat and straight

ZELLAMID® OFFERS NEW POSSIBILITIES

ZELLAMID® Materials offer new solutions to satisfy your customers. Plastics offer many performance advantages in applications where materials like bronze, stainless steel, cast iron, brass, aluminum or ceramic have previously been used. The advantages are easier handling, lower machining costs and excellent mechanical performance. ZELLAMID® materials have a wide range of applications in several industries ranging from basic industries like construction equipment and food processing, through to high technology industries like medical, semiconductor and alternative energy. The benefits of cost, weight and machining savings keep the market growing rapidly. Our high performance materials like ZELLAMID® 1500 X can be used at temperatures up to 260°C.

Differences between metals and plastics:

The most important point is cooling. Plastics are thermal insulating and have much lower heat transfer ability than metals.

The thermal expansion is up to 20 times higher compared to metals. This difference is substantial when using clamping devices and considering machining forces.

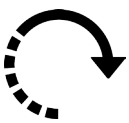
The melting temperature is much lower than the one for metals. Thus, plastics are very sensitive to high temperatures which are generated during machining.

The most important advice for machining:

Tools must be sharp and well ground

The tool's relief angle should be large enough to keep the chips short

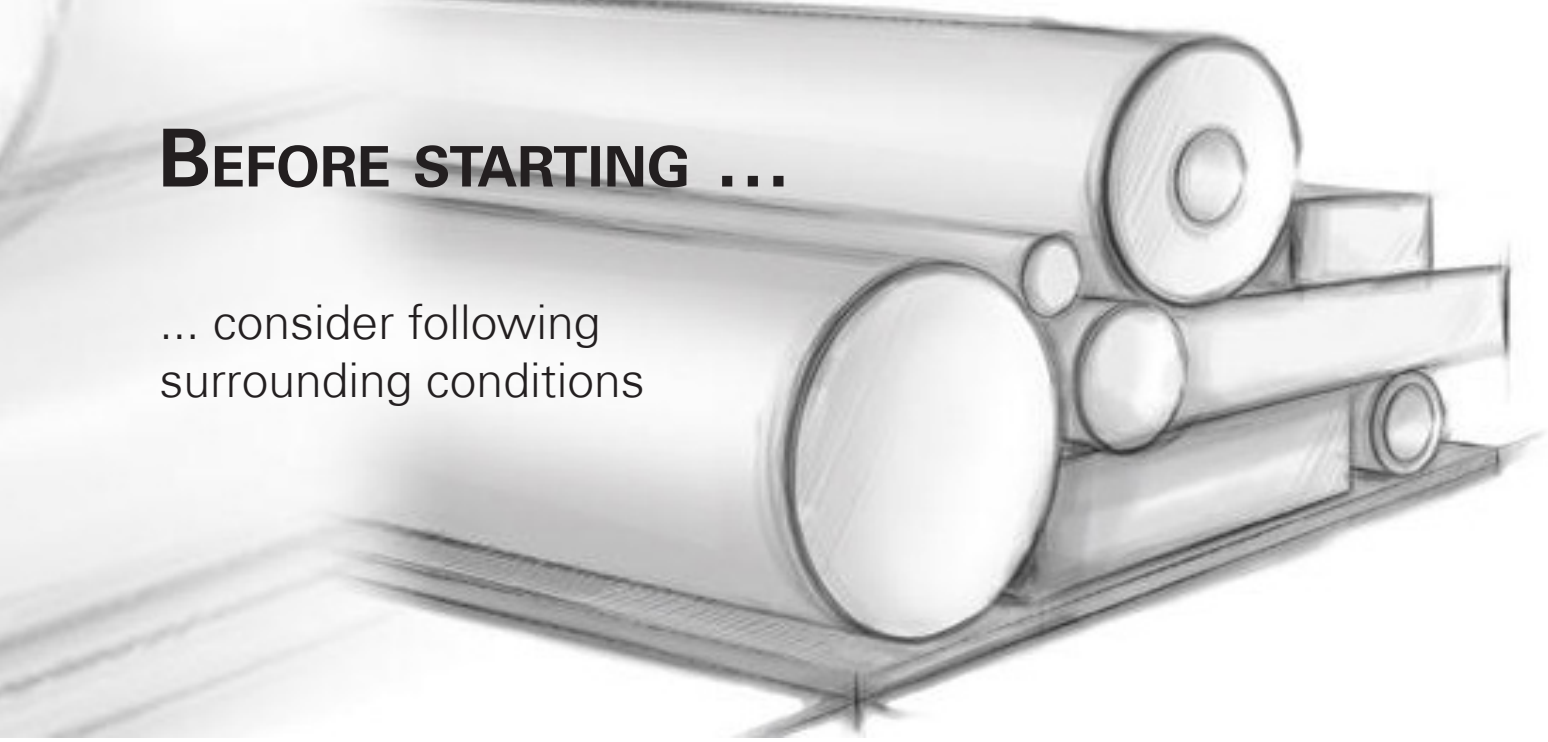
Set form feed as high as possible for low development of heat



Remove the chips to prevent queue or jamming

Use sufficient coolant (or compressed air) in order to avoid heat

Store the stock shape in a machining environment for at least 24 hours before machining



Before starting ...

... consider following surrounding conditions

Coolant

Insufficient cooling can cause softening, melting and material degradation. The best and simplest way for cooling is dissipating the heat with the chips. We consider a water-based emulsion as a liquid coolant. For mixing with water please read the recommendation of the supplier. Another simple and easy possibility is cooling with compressed air.

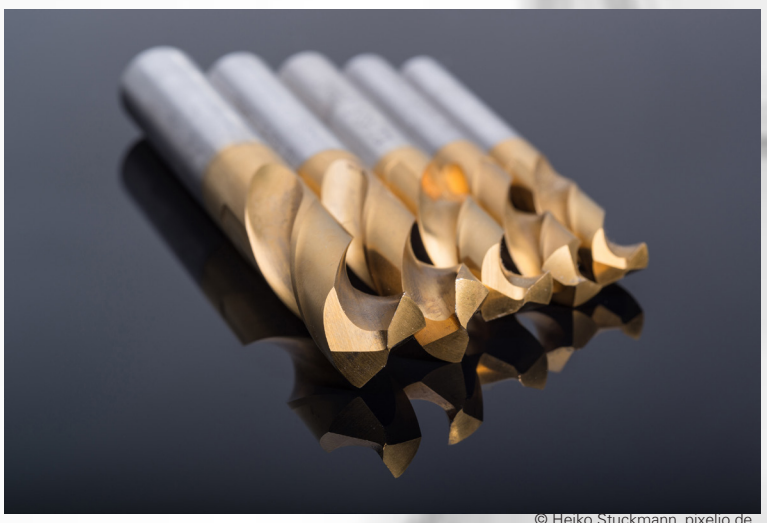
Machines and tools

Engineering plastic stock shapes can be easily machined on metall and woodworking machines. Tools with HSS (high speed steel), hard metal or diamond equipped edges can be used. Circular saws should be equipped with hard metal saw blades. Use only sharp and well ground tools. Reinforced products can be abrasive to tools, therefore they should be machined with diamond equipped tools, which are expensive but perform excellently in the endurance of sharp edges.

Machining and clamping

Compared to metals, plastic materials show a lower thermal conductivity and modulus of elasticity. The clamping force should be as low as possible to reduce surface damage and deformation of the parts. Complex machining requires supervision of the clamping force, as both deflection and bending of the work piece must be avoided. „Pie jaws“ (which can be made of plastics as well) are recommended for lathe clamping to provide the clamping force around the diameter evenly.

Drilling



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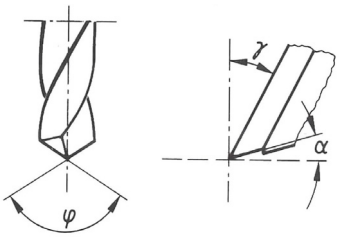
Usual HSS sharpened tools can be used for drilling. Remove chips constantly in order to prevent high temperatures, especially when drilling deep holes.

It is recommended for **large holes** (Ø 30mm) to **drill first with a smaller diameter** (approx. 10-20 mm) and then to finish with a single-point cutting tool. Drilling in solid material should only be done with sharp edges.

Furthermore, the drill has to be removed out of the hole during drilling to ensure an acceptable **chip removal**. Otherwise the plastic can be heat up to the melting point. The low thermal conductivity of the material prevents heat dissipation which leads to extreme material expansion in the center. The outer wall is still cold and a large area of stress is generated. Notch effect of the tool may lead to cracking if above mentioned rules are not followed. This effect may also appear with high impact the resistant materials. For cooling, compressed air can be used.

Bending of the workpiece can be avoided with a support underneath the clamping device.



	side relief angle (°)	rake angle (°)	top angle(°)	cutting speed (m/min)	feed (mm/ rev.)
ZELLAMID®	α	γ	φ	V	S
202 (PA6), 1100 (PA6 G)	5-15	5-20	90	50-150	0.1-0.3
250 (PA6.6)	5-15	10-20	90	50-150	0.1-0.3
900 (POM-C), 900 H (POM-H)	5-10	15-30	90	50-200	0.1-0.3
1400 (PET), 1400 HI (PET HI), 1400 T	5-10	10-20	90	50-100	0.2-0.3
1500 X, 1500 (PEEK)	5-10	10-30	90-120	50-200	0.1-0.3
1000 (PEI)	5-15	10-20	90	20-80	0.1-0.3
1900 (PPS)	5-10	10-30	90	50-200	0.1-0.3
2100 (PPSU)	3-10	10-20	90	20-100	0.1-0.3
ZELLAMID® reinforced	5-10	5-10	120	80-100	0.1-0.3

Sawing

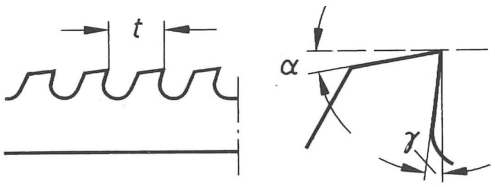
Engineering plastics can be cut either with band saws or circular saws. The choice depends on the shape of the semi-finished material.

Appliance of a band saw is especially recommended for cutting rods and tubes. The generated heat is dissipated by the saw blade.

With **crosswise teeth** blade jamming can be prevented.

Circular saws are generally used for cutting plates to achieve straight cuts. Work with high feed rates to ensure a good chip removal and to prevent clamping of the saw blade or overheating of the plastic at the cutting edge.
The use of saw blades with side cutters or evacuators (chip removal spaces) is suggested.

The use of diamond dipped teeth is highly recommended for reinforced ZELLAMID® products.



		side relief angle (°)	rake angle (°)	cutting speed (m/min)	pitch (mm)
	ZELLAMID®	α	γ	V	t
band saw	202 (PA6), 1100 (PA6 G)	20-30	2-5	500	3-8
	250 (PA6.6)	20-30	2-5	500	3-8
	900 (POM-C), 900 H (POM-H)	20-30	0-5	500-800	2-5
	1400 (PET), 1400 HI (PET HI), 1400 T	15-30	5-8	300	2-8
	1500 X, 1500 (PEEK)	15-30	0-5	250-500	3-5
	1000 (PEI)	15-30	0-4	250-500	2-5
	1900 (PPS)	15-30	0-5	250-500	3-5
	2100 (PPSU)	15-30	0-4	250-500	2-5
	ZELLAMID® reinforced	15-30	10-15	200-300	3-5

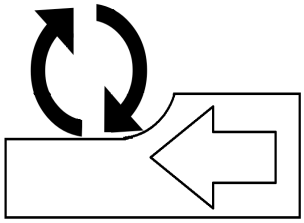
Milling

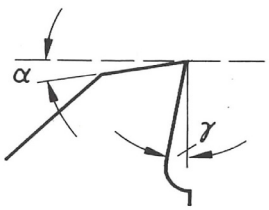
For milling, common milling machines can be used and will allow huge economic advantages. Fast cutting speeds and medium feed rates enable short machining times with high surface quality. A feed rate up to 0.5 mm / tooth is possible.

The number of teeth can vary depending on the equipment and type of cut. The final cut should be milled as smooth as possible. For inside pockets the tool should have **round edges** in order to reduce any sharp inside corners, which can cause stress cracking.

With a larger chip space the heat and chip removal is improved.

For smooth surfaces and low heat generation, we suggest **parallel-feed-milling**, whereby the direction of form feed and the rotating direction are the same.





	side relief angle(°)	rake angle (°)	cutting speed (m/min)
ZELLAMID®	α	γ	V
202 (PA6), 1100 (PA6 G)	5-20	5-15	250-500
250 (PA6.6)	5-20	5-15	250-500
900 (POM-C), 900 H (POM-H)	5-15	5-15	250-500
1400 (PET), 1400 HI (PET HI), 1400 T	5-15	5-15	250-500
1500 X, 1500 (PEEK)	5-15	6-10	180-500
1000 (PEI)	5-20	5-15	250-500
1900 (PPS)	5-15	6-10	250-500
2100 (PPSU)	2-10	1-5	250-500

Turning

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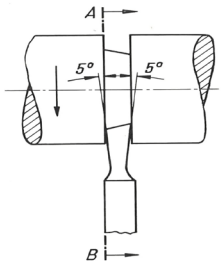
Turning of some thermoplastics produces a continuous chip stream. An ideal chip removal must be assured to prevent rotating or winding of the chip around the tool or work piece.

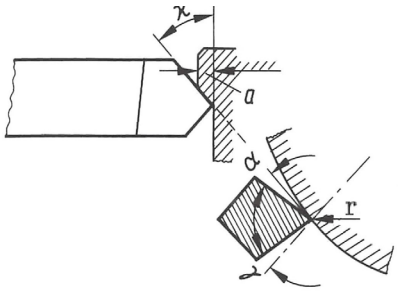
The surface quality is optimized with a broadly based cutting edge and a **minimum of 0.5 mm depth of cut.** The tip radius should be 0.5 mm.

Cooling with compressed air is very sufficient.

Due to the fact that plastics show lower rigidity, long turning pieces can sag and therefore the use of a **steady rest or a sub spindle** is advisable.

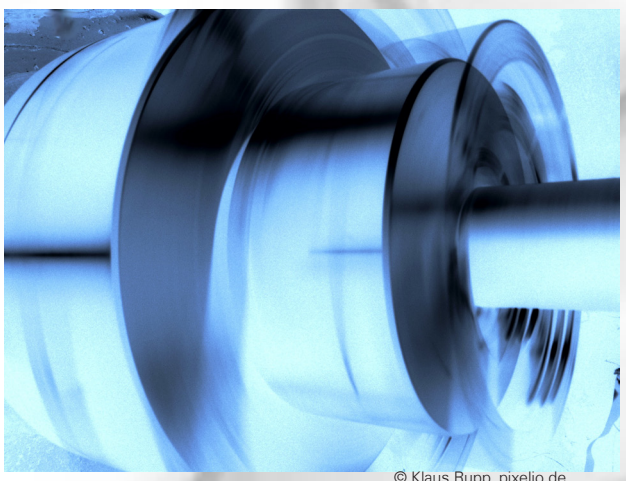
The **offset cutting tool** should usually have an angle directed towards the work piece. This angle reduces the center waste.





ZELLAMID®	side relief angle (°) α	rake angle (°) γ	setting angle (°) χ	cutting speed (m/min) V	feed (mm/rev.) S
202 (PA6), 1100 (PA6 G)	6-15	0-5	45-60	250-500	0.1-0.5
250 (PA6.6)	6-15	0-5	45-60	250-500	0.1-0.5
900 (POM-C), 900 H (POM-H)	6-8	0-5	45-60	300-600	0.1-0.5
1400 (PET), 1400 HI (PET HI), 1400 T	5-15	0-5	45-60	300-400	0.2-0.4
1500 X, 1500 (PEEK)	6-10	0-5	45-60	250-500	0.1-0.4
1000 (PEI)	6-10	0-5	45-60	200-400	0.1-0.3
1900 (PPS)	6-8	0-5	45-60	250-500	0.1-0.5
2100 (PPSU)	6-10	0-10	45-60	350-400	0.1-0.3
ZELLAMID® reinforced	6-8	2-8	45-60	150-200	0.1-0.5

Accuracy
Dimensional stability
Post-Treatment



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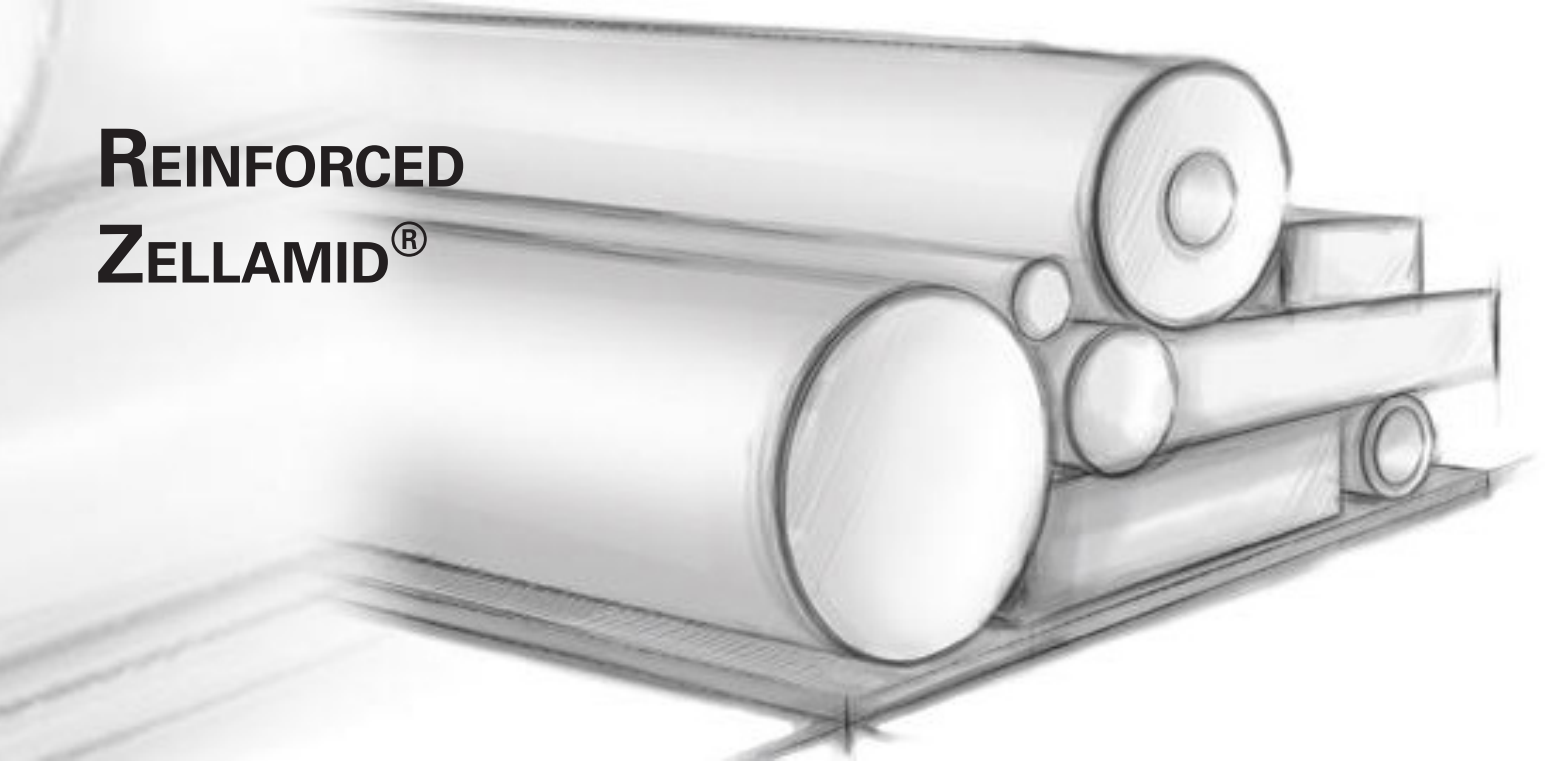
Accuracy:
Even after annealing processes of our ZELLAMID® stock shapes at our production site, internal tension can be created by incorrect machining. Try to use raw material with similar dimensions to the desired finished part. To achieve tighter tolerances increase the number of machining steps and implement intermediate annealing.

Post - Annealing:
Annealing is a temperature treatment of plastic to relieve internal stress. The surrounding temperature should be slowly and continuously increased and decreased. This process should not be accelerated as changing the temperature too fast can thermally shock the material, actually increasing the internal stress and reducing dimensional stability of the finished part.
The warming and cooling rate should be between 10°C and 20°C per hour. The holding temperatures for the different materials are listed below. The holding time should be approx 6 minutes per cm of wall thickness.

ZELLAMID® 202, 900, 1100	150-160°C
ZELLAMID® 250, 1400, 1400 T	170-180°C
ZELLAMID® 1000	180-200°C
ZELLAMID® 1900, 2100	ca. 200°C
ZELLAMID® 1500, 1500 X	220-240°C

Conditioning:
ZELLAMID® 202, 250 and 1100 have a higher moisture absorption rate than other ZELLAMID® materials, they should be conditioned in a warm water bath before machining. The water temperature should be 80°C and the duration is recommended with 1 day per cm of wall thickness. The impact strength can be improved for the application.

Reinforced Zellamid®



Reinforced ZELLAMID® products have glass, carbon fibres or ceramic fillers integrated in the polymer matrix in order to modify mechanical properties. Those materials are especially difficult to be machined. Following materials are reinforced: ZELLAMID® 250 GF30, 1500 XT, 1500 XGF30, 1500 XCA30, 1500 XC20, 1000 GF30, 1900 GF40.

The **most important advice** for machining are the following:

- Deploy intensive cooling (external and internal)
- Avoid heat by increasing the feed rate
- Check the sharpness of the tools regularly
- Use diamond equipped or special coated tools
- Pre heating

PRE HEATING

Reinforced ZELLAMID® products like 250 GF30, 1500 XT, 1500 XGF30, 1500 XCA30, 1500 XC20, 1000 GF30, 1900 GF40 and unreinforced products like 1400, 1400 HI, 1900 should be pre heated before sawing or drilling (rods from 80 mm and plates from 50 mm thickness). The temperature should be between 90 and 120°C with a heating and cooling rate of approximately 10°C per hour. All other materials should have room temperature before machining.

DIAMOND TIPPED TOOLS

Reinforced products should be machined with diamond equipped tools, which are expensive, but perform excellently in the endurance of sharp edges.

07/2015

Zell-Metall
Engineering Plastics

a member of klepsch group

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