LICHARZ

Semi-finished products
Product range

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First-class semi-finished products made from engineering plastics

We specialise in the manufacture and distribution of semi-finished products made from engineering plastics, with an annual volume of over 7,000 tonnes – making us one of the world's leading manufacturers. Our focus is on PA 6 G, an extremely hard, lightweight and durable cast polyamide developed in-house, which is available under the LiNNOTAM brand as plates, bars, and tubes. Our portfolio is complemented by an extensive range of PA 6 E, PA 66, POM-C, PET, and PET-GL.

As an experienced manufacturer, Licharz has been a competent partner to a wide range of sectors and industries for over 60 years. We provide comprehensive advice on the use of semi-finished plastic products and work with you to develop customised solutions for your requirements. Our semi-finished products are particularly dimensionally stable, have low residual stresses, and are excellent for machining. The number of products manufactured from Licharz semi-finished products worldwide is impressive. International processors have relied on our semifinished products made of engineering plastics for years.

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The all-rounders

Discover LiNNOTAM, Licharz's outstanding product line, which we have specially developed to meet the highest demands. Our cast polyamides are the ideal materials for precise and complex components. With LiNNOTAM, you benefit from simple and efficient processing, as well as from comprehensive diversity. We offer a wide range of shapes, casting weights, and dimensions, so that you can get your hands on the exact material that meets your specific requirements.

Overview

LiNNOTAM

LiNNOTAM is our brand for high-quality cast polyamide 6 (PA 6 C). LiNNOTAM is a semi-crystalline thermoplastic material produced by polymerising the raw material caprolactam. LiNNOTAM impresses with its high strength, excellent wear resistance and very good dimensional stability – ideal for use in components subject to high mechanical stress.

Available shapes

- Plate
- Round bar
- Hollow bar
- Ring
- Disc

Available colours

- natural
- black
- MoS black
- blue

LiNNOTAM GLiDE

LiNNOTAM GLiDE is a highly crystalline modification of LiNNOTAM that has been specially designed for use in sliding applications by adding lubricating additives and oil. Its excellent properties make LiNNOTAM GLiDE the ideal material for highly stressed components in mechanical and plant engineering. Compared to standard quality, a 50 per cent reduction in the coefficient of sliding friction can be achieved, resulting in less frictional heat and therefore considerably higher load capacity.

Available shapes

- Plate
- Round bar
- Hollow bar

Available colours

- black
- yellow
- green
- natural
- blue
- red

LiNNOTAM GLiDE Pro T

LiNNOTAM GLiDE Pro T is a further development of our tried-and-tested LiNNOTAM GLiDE, and the addition of solid lubricants and special additives makes it particularly suitable for sliding applications. It stands for maximum wear resistance and a long service life. This results in a coefficient of sliding friction that is exceptionally low at 0.15 µ. The tendency to stick-slip is also reliably reduced.

Available shapes

- Plate
- Round bar
- Hollow bar

Available colours

- grey
- green
- natural
- red

LiNNOTAM HiPERFORMANCE

LiNNOTAM HiPERFORMANCE is a group of high-performance polyamides made from the raw materials caprolactam and laurinlactam. Compared to pure LiNNOTAM, LiNNOTAM HiPERFORMANCE 612 and 1200 materials have a higher impact and shock resistance and a lower tendency to absorb moisture – depending on the type – while retaining the same sliding and wear properties. The materials are also characterised by improved creep behaviour, greater elasticity, and better recovery behaviour.

Available shapes

- Plate
- Round bar
- Hollow bar

Available colours

- natural

LiNNOTAM DRiVE

LiNNOTAM DRiVE was developed specifically for drive technology and uses a knurled metal core coated with LiNNOTAM HiPERFORMANCE 612 or 1200. The cooling polymer shrinks onto the core after casting. This form- and force-fitting composite applies high forces to the metal axle and uses the advantages of plastic to ensure optimum power transmission: low noise, higher wear resistance, and higher impact strength on the outer casing.

Available shapes

- Round bar with metallic core

Available colours

- natural

LiNNOTAM
The all-rounder

$\rho = 1.15\ g/cm^3$

LiNNOTAM Plates

Thickness	Tolerance	3,050 × 1,220			2,000 × 1,220			2,000 × 1,000					1,000 × 1,000		
											+ MoS				
in mm	in mm	kg/m			kg/m			kg/m					kg/m		
8	+0.2/+1.5							11.5	+	+	O				
10		17.0	+	+	16.5	+	+	13.5	+	+	+	+			
12	+0.3/+2.5	20.1	+	+	19.4	+	+	16.0	+	+	O	+			
15		24.3	+	+	24.3	+	+	20.0	+	+	O	+			
16					25.0	+	+	21.5	+	+	O	O			
18								24.5	+	+	O	O			
20		31.0	+	+	31.0	+	+	26.0	+	+	+	+			
22								29.0	+	O	O	O			
25		39.0	+	+	39.0	+	+	32.0	+	+	O	+			
30	+0.5/+3.5	47.0	+	+	47.0	+	+	38.5	+	+	+	+			
35		55.8	+	+	55.8	O	+	45.3	+	+	O	O			
40		62.0	+	+	62.0	+	+	51.0	+	+	+	+			
45		68.0	+	O	68.0	O	O	57.0	+	+	O	O			
50		78.0	+	+	78.0	+	+	63.5	+	+	+	+			
55	+0.5/+5.0	84.0	O	O				70.0	+	+	O	O			
60		93.0	+	+	93.0	+	+	76.0	+	+	O	+			
65		100.0	O	O				82.5	+	+	O	O			
70		108.0	+	+	108.0	O	O	88.5	+	+	O	+			
75	+0.5/+7.0							94.5	O	O	O	O			
80		122.0	+	+	122.0	O	O	101.0	+	+	O	+			
85								108.0	+	O	O	O			
90		135.0	O	O	135.0	O	O	113.0	+	+	O	O			
95								120.5	O	O	O	O			
100		148.0	+	+	148.0	O	O	126.0	+	+	O	+			
110	+0.5/+9.0	161.0	+	+				139.0	+	+	O	O	139.0	+	+
120		180.0	+	O				147.0	+	O	O	O	147.0	+	+
130								159.0	+	O	O	O	159.0	+	+
140								171.0	+	O	O	O	171.0	+	+
150								189.0	+	O	O	O	189.0	+	+
160								195.0	+	O	O	O	195.0	+	+
165													222.0	O	O

\+ = Stock item
O = On request

Length tolerance: +0 %/+3 %
Width tolerance: +0.5 %/+4 %

Customised cuts, alternative colours, and food-grade versions are available on request.

ρ = 1.15 g/cm³

LiNNOTAM
Round bars

Nominal size	Tolerance	2,000			1,000				
								+ MoS	
Ø in mm	in mm	kg/m			kg/m				
30	+0.2/+1.4	0.85	+	+	0.85	+	+	O	O
35					1.2	+	+	O	O
40		1.5	+	+	1.5	+	+	O	O
45	+0.3/+1.9				1.9	+	+	O	O
50		2.4	+	+	2.4	+	+	O	O
55		2.8	+	+	2.8	+	+	O	O
60	+0.3/+2.5	3.4	+	+	3.4	+	+	O	O
65		4.0	+	+	4.0	+	+	O	O
70		4.8	+	+	4.8	+	+	O	
75	+0.4/+2.8	5.6	+	+	5.6	+	+	O	
80		6.2	+	+	6.2	+	+	O	+
85	+0.5/+3.2	7.0	+	+	7.0	+	+	O	O
90		7.8	+	+	7.8	+	+	O	+
95	+0.6/+3.5	8.7	+	O	8.7	+	O	O	O
100		9.6	+	+	9.6	+	+	+	+
110	+0.7/+3.9	11.6	+	+	11.6	+	+	+	+
115	+0.8/+4.3	12.9	+	+	12.9	+	+	O	O
120		13.6	+	+	13.6	+	+	+	+
125		15.3	+	+	15.3	+	+	O	+
130	+0.8/+0.5	16.4	+	+	16.4	+	+	+	+
135		17.7	+	O	17.7	+	O	O	O
140		18.9	+	+	18.9	+	+	+	+
145	+0.8/+5.3				20.4	O	O	O	O
150		21.6	+	+	21.6	+	+	+	+
155	+0.8/+6.0				23.9	+	O	O	O
160		24.6	+	+	24.6	+	+	O	O
165	+1.07/+6.5				26.0	+	+	O	O
170		27.4	+	+	27.4	+	+	O	O
175					29.7	+	O	O	O
180		30.6	+	+					
190	+1.0/+7.5	34.5	+	+	34.5	+	+	O	O
200	+1.0/+8.5	38.2	+	+	38.2	+	+	O	+
210					42.2	+	+	+	O
220					46.9	+	+	O	O
230	+1.0/+9.5				50.0	+	+	O	O
240					55.0	+	+	O	O
250					60.4	+	+	O	+
260	+1.0/+11.0				65.2	+	+		O
270					70.0	+	+		O
280					75.0	+	+		O
290	+1.5/+12.0				80.7	+	+		O
300					86.3	+	+		+
310					92.0	+	+		O
320					98.0	+	+		O

\+ = Stock item
O = On request

Length tolerance: +0 %/+3 %

Nominal size	Tolerance	1,000			
Ø in mm	in mm	kg/m			
330	+1.5/+13.5	104.0	+	+	O
340		113.0	+	+	
350		117.5	+	+	O
360		124.0	+	+	O
370	+1.5/+15.0	131.0	+	+	
380		140.0	+	+	
390		144.0	+	+	
400		153.0	+	+	O
410	+1.5/+16.5	165.0	+	+	
420		173.8	+	+	
430		183.0	+	+	O
440		187.0	+	+	O
450		195.0	+	+	O
460	+1.5/+18.0	205.0	+	+	
470		216.6	+	+	
480		221.0	+	+	
490		233.0	+	O	
500		242.0	+	+	O
510	+3.00/+21.0	251.0	+	+	
520		262.4	+	+	
530		268.0	+	+	
540		276.5	O	O	
550		294.0	+	O	O
560		309.0	+	+	
570		311.0	+	O	O
580		316.0	+	O	
590		331.0	+	O	
600		346.0	+	+	
610	+3.0/+25.0	348.0	+	O	
620		365.0	+	+	
625		367.0	O	O	
630		376.0	O	O	
640		385.0	O	O	
650		400.0	+	+	
660		408.0	+	+	
670		425.0	+	O	
690		449.0	O	O	
700		470.0	+	+	
710		483.0	+	O	
720		492.0	O	O	
730		506.0	O	O	
750		535.0	+	O	
790		591.0	O	O	
800		601.0	+	O	

Customised cuts, alternative colours, and food-grade versions are available on request.

ρ = 1.15 g/cm³

LiNNOTAM
Hollow bars

Weight in kg/m

ID \ OD	50	55	60	65	70	75	80	85	90	95	100	110	120	130	140	150	160	170	180
30	1.8	2.4	3.1	3.5	4.2	5.0	5.89												
40	1.3		2.5	3.1	3.6	4.4	5.0	6.0	6.9		8.7	10.6	12.7	15.0	17.8	20.5	23.7	26.5	29.8
50				2.3	3.3	3.6	4.4		6.2		8	9.8	12.7	14.2	17.1	20.6	22.7	25.8	29.1
60						2.7	3.5		5.2		7.1	9.3	11.3	13.4	17.0	18.2	21.9	25.2	27.0
70								3.2	4.1	5.1	6.0	7.9	10.5	12.7	15.5	18.2	20.8	23.8	27.0
80											4.6	7.0	8.9	11.5	14.8	17.2	20.1	23.2	26.6
90												5.5	7.9	10.0	12.9	15.8	18.7	21.8	24.8
100													5.8	8.4	11.2	14.2	17.1	20.2	23.6
110															9.4	12.4	15.3	18.4	21.4
120															7.4	10.4	13.3	16.4	19.4
130																9.1	11.2	14.3	17.3
140																		11.9	15.2
150																			12.4

- Length: 3,000 mm
- Length: 2,000 mm
- Length: 1,000 mm

Length tolerance: +0 %/+3 %

ID \ OD	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370
30																			
40	32.7	36.7	40.0	44.5	48.8	52.6													
50	32.0	36.0	39.9	43.9	48.4	52.0	58.0	63.2	67.7	72.3	78.6	83.0							
60	32.1	35.2	39.2	43.3	47.4	51.3	57.2	62.5	66.9	71.5	77.9	82.2							
70	30.4	35.3	37.4	42.2	46.4	50.3	56.3	61.5	65.9	70.5	76.9	80.7							
80	29.0	33.3	37.3	41.0	45.2	49.2	55.1	60.4	64.8	69.4	75.7	80.2	85.7	92.8	97.5	104.4	110.1	116.7	124.0
90	27.7	32.1	35.8	39.8	43.9	47.9	53.8	61.2	63.5	68.0	74.4	78.7	84.4	91.4	96.2	103.0	108.8	115.3	122.8
100	26.7	30.7	34.3	38.3	42.3	46.4	52.3	57.5	62.0	66.5	72.9	77.4	83.1	89.9	94.9	101.5	107.3	113.0	121.2
110	24.9	28.9	32.4	36.5	40.8	44.7	50.5	55.8	60.3	64.8	71.4	75.7	71.4	88.4	93.2	99.8	105.8	112.3	119.7
120	22.9	27.0	30.4	34.8	38.9	42.9	49.6	54.0	58.4	62.9	69.5	73.9	79.5	86.5	91.3	98.1	103.9	110.6	117.8
130	20.7	24.8	28.2	32.5	36.8	40.8	46.8	51.9	56.3	60.9	67.4	71.8	77.5	84.5	89.3	96.3	102.0	108.4	116.0
140	18.4	22.4	25.9	30.3	35.0	38.6	44.4	49.7	54.0	58.6	65.5	73.2	75.5	82.0	87.3	94.1	99.9	106.6	114.3
150	15.9	19.9	23.3	27.8	32.5	36.5	45.0	50.2	51.7	56.7	63.0	67.8	73.1	80.0	84.9	91.7	97.7	104.3	111.7
160	13.1	17.2	20.7	25.1	29.9	33.9	42.2	47.3	52.6	58.1	63.8	65.1	70.5	77.8	82.5	89.4	95.5	101.7	109.1
170		15.0	17.7	22.25	27.0	31.0	39.1	44.3	49.5	55.1	60.7	66.7	67.8	75.0	79.9	86.5	92.4	99.0	106.4
180			15.0	19.0	23.9	28.0	35.9	41.1	46.3	51.6	57.5	63.4	69.4	75.8	76.9	83.8	89.5	96.4	103.4
190				15.8	20.7	24.7	32.4	37.5	42.9	48.0	54.1	60.0	66.1	72.4	78.9	80.7	87.6	94.8	102.2
200					17.3	21.3	28.9	34.0	39.3	44.8	50.5	56.4	62.5	68.8	75.3	82.0	88.8	92.0	99.1
210							25.0	30.2	35.4	40.9	46.7	52.6	58.6	46.9	71.4	78.1	85.0	92.0	96.1
220								26.1	31.4	36.9	42.7	48.5	54.6	60.9	67.4	74.1	81.0	88.0	95.3
230								22.0	27.2	32.8	38.4	44.3	50.4	56.7	63.2	69.9	76.8	83.8	91.1
240									22.9	28.4	34.1	40.0	46.1	52.3	58.8	65.5	72.4	79.4	86.7
250										23.7	29.6	35.3	41.5	47.7	54.2	60.8	67.8	74.8	82.0
260											24.6	30.5	36.6	42.9	49.4	56.1	63.0	70.0	77.3
270												25.5	31.6	37.9	44.4	51.0	58.0	65.0	72.3
280													26.5	32.7	39.2	45.9	52.8	59.8	67.1
290														27.4	33.8	40.5	47.4	54.5	61.7
300															28.2	34.9	41.8	48.8	56.1
310																29.2	36.0	43.1	50.4
320																	30.1	37.1	44.4
330																		31.0	38.2
340																			31.9

Customised cuts, alternative colours, and food-grade versions are available on request.

$\rho = 1.15\ g/cm^3$

LiNNOTAM
Hollow bars

Weight in kg/m

ID \ OD	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560
80	130.3	138.8	146.8	155.9	161.3	170.0	178.0	186.3	193.8	203.3									
90	129.1	137.5	145.7	154.6										O					
100	127.5	136.0	143.3	152.3	158.5	167.2	175.2	183.5	191.0	200.5	209.3		228.4	O	O				
110	125.8	134.5	141.6	150.8	157.0	165.6	173.7	181.9	189.5	198.8		217.6	226.8	O	O	O	O		
120	124.1	132.6	139.9	149.0	155.1	163.8	171.8	180.2	187.9	197.1	205.9	215.8	225.0	O	O	O	O	O	O
130	122.1	130.8	137.9	147.1	153.3	161.9	170.0	178.2	185.8	195.3	204.0	214.0	223.0	O	O	O	O	O	O
140	120.0	128.6	135.9	144.9	151.0	159.7	167.8	176.0	183.6	193.0	201.9	211.8	221.0	O	O	O	O	O	O
150	117.9	126.4	133.8	142.8	148.9	157.6	165.6	173.9	181.5	190.9	199.7	209.6	218.5	O	O	O	O	O	O
160	115.3	123.9	131.2	140.2	146.4	162.9	163.1	171.3	178.9	188.4	197.2	207.1	216.3	O	O	O	O	O	O
170	112.6	121.1	128.5	137.5	143.6	152.3	160.4	168.8	176.2	185.6	194.5	204.3	213.5	O	O	O	O	O	O
180	111.8	120.3	127.6	134.6	140.7	149.4	157.4	165.7	173.6	182.7	191.8	201.7	210.9	O	O	O	O	O	O
190	109.4	117.0	124.3	131.5	137.6	146.3	154.7	162.9	170.5	179.6	188.7	198.6	207.8	O	O	O	O	O	O
200	106.1	114.0	119.9	128.5	134.3	143.3	151.4	160.3	167.2	176.7	185.5	195.4	204.5	O	O	O	O	O	O
210	102.7	110.6	116.4	125.1	130.9	140.6	149.3	157.6	164.5	174.6	183.4	193.3	201.4	O	O	O	O	O	O
220	99.0	106.9	112.8	121.4	127.6	136.3	145.0	153.3	160.1	169.6	178.8	189.0	198.2	O	O	O	O	O	O
230	98.6	103.1	109.0	117.6	123.8	133.2	141.3	149.5	157.0	166.6	175.3	185.2	194.4	O	O	O	O	O	O
240	94.2	101.8	105.0	113.6	119.8	129.3	137.3	145.6	153.1	162.6	171.4	181.3	190.5	O	O	O	O	O	O
250	89.6	79.2	105.0	109.4	115.6	125.5	133.6	141.9	149.4	158.6	167.4	177.6	186.7	O	O	O	O	O	O
260	84.8	92.4	100.3																
270	79.8	87.4	95.3	103.3	106.7	116.7	124.8	133.0	140.6	150.0	158.9	168.8	177.9	O	O	O	O	O	O
280	74.6	82.3	90.0	98.2	106.7	112.2	120.3	128.5	136.1	145.5	154.4	164.2	173.4	O	O	O	O	O	O
290	69.2	76.9	84.7	92.8	97.0	107.7	115.8	124.0	131.6	141.0	149.9	159.7	168.9	O	O	O	O	O	O
300	63.6	66.3	79.1	87.1	95.4	103.05													
310	57.8	65.5	73.3	81.4	89.6	98.4	105.5	113.8	121.4	130.8	139.6	149.5	158.7	O	O	O	O	O	O
320	51.0	59.5	67.4	75.4	83.7	92.2	100.7												
330	45.7	53.3	61.2	69.2	77.5	86.0	94.6												
340	39.3	47.0	54.8	62.9	71.1	79.96	88.2	97.0	107.6	117.0	125.8	135.7	144.9	O	O	O	O	O	O
350	35.4	40.0	48.3	56.3	64.6	73.0	81.6	91.5	99.5	111.2	120.01	129.8	139.2	O	O	O	O	O	O
360		36.4	41.5	49.5	57.8	66.3	74.9	83.7	92.8	102.0	114.0	123.8	133.1	O	O	O	O	O	O
370				42.6	50.8	59.3	67.9	76.8	85.8	95.0	97.3	117.7	126.8	O	O	O	O	O	O
390						44.8	53.5	69.6	71.3	80.5	90.0	99.6		O	O	O	O	O	O
400							45.9	62.3	66.1	73.0	83.4	92.0	101.8	O	O	O	O	O	O
410								47.0	56.0	65.2	76.7	84.3	94.1	O	O	O	O	O	O
420								42.2	48.1	57.3	66.7	76.4	86.2	O	O	O	O	O	O
430										49.2	58.6	68.2	78.0	O	O	O	O	O	O
440											50.3	59.9	69.7	O	O	O	O	O	O
450												51.4	61.2	O	O	O	O	O	O
460													52.5			O	O	O	O
470																	O	O	O
480																		O	O
490																			O

- Length: 3,000 mm
- Length: 2,000 mm
- Length: 1,000 mm

Length tolerance: +0 %/+3 %

O = On request

ID \ OD	570	580	590	600	610	620	630	640	650	660	670	690	700	710	720	730	750	770	790	800
130	o	o																		
140	o	o	o	o																
150	o	o	o	o	o															
160	o	o	o	o	o	o	o													
170	o	o	o	o	o	o	o	o	o	o										
180	o	o	o	o	o	o	o	o	o	o	o	o	o							
190	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o				
200	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o			
210	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		
220	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
230	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
240	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
250	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
260																				
270	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
280	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
290	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
300																				
310	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
320																				
330																				
340	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
350	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
360	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
370	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
390	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
400	o	o	o	o	o															
410	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
420	o	o	o	o	o															
430	o	o	o	o	o															
440	o	o	o	o	o															
450	o	o	o	o	o															
460	o	o	o	o	o															
470	o	o	o	o	o															
480	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
490	o	o	o	o	o															
500	o	o	o	o	o															
510		o	o	o	o															
520			o	o	o															
530				o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
560										o	o	o	o	o	o	o	o	o	o	o
600													o	o	o	o	o	o	o	o

Customised cuts, alternative colours, and food-grade versions are available on request.

ρ = 1.15 g/cm³

LiNNOTAM
Rings

ID \ OD	600	625	625	640	650	675	675	687	700	725	750	750	750	770	775	800	820	820	830	840	850	860	875	900	925	950	975	1,000
370	O																											
380	O																											
390	O																											
400	O	O																										
410	O	O																										
420	O	O																										
430	O	O																										
440	O	O																										
450	O	O																										
460	O	O																										
470	O	O	O	O	O																							
480	O	O	O	O	O	O																						
490	O	O	O	O	O	O																						
500	O	O	O	O	O	O																						
510	O	O	O	O	O	O			O																			
520	O	O	O	O	O	O			O					O														
530	O	O	O	O	O	O			O					O	O													
540	O	O	O	O	O	O			O	O				O	O													
550	O	O	O	O	O	O			O	O				O	O													
560		O	O	O	O	O	O	O	O	O				O	O													
570		O	O	O	O	O	O	O	O	O				O	O													
580		O	O	O	O	O	O	O	O	O	O			O	O													
590		O	O	O	O	O	O	O	O	O	O			O	O													
600				O	O	O	O	O	O	O	O			O	O						O							
610					O	O	O	O	O	O	O			O	O						O							
620						O	O	O	O	O	O	O		O	O						O							
630						O	O	O	O	O	O	O		O	O						O							
640						O	O	O	O	O	O	O		O	O	O	O				O							
650								O	O	O	O	O	O	O	O	O	O				O							
660									O	O	O	O	O	O	O	O	O				O							
670										O	O	O	O	O	O	O	O				O	O						
680										O	O	O	O	O	O	O	O				O	O						
690											O	O	O	O	O	O	O	O			O	O						
700											O	O	O	O	O	O	O	O	O		O	O						
710														O	O	O	O	O	O		O	O						
720															O	O	O	O	O		O	O	O					
730																O	O	O	O		O	O	O					
740																	O	O	O		O	O	O					
750																	O	O	O		O	O	O	O				
760																	O	O	O		O	O	O	O				
770																	O		O		O	O	O	O				
780																	O					O	O	O	O			
790																	O						O	O	O			
800																							O	O				
810																							O	O	O			
820																								O	O			
830																								O	O			
840																								O	O	O		
850																									O	O		
860																									O	O		
870																										O	O	
880																										O	O	
890																										O	O	
900																											O	O
910																												O
920																												O
930																												O

- Length: 370 mm
- Length: 440 mm
- Length: 500 mm
- Length: 540 mm
- Length: 580 mm
- Length: 640 mm
- Length: 730 mm
- Length: 750 mm

O = On request

ρ = 1.15 g/cm³

LiNNOTAM
Discs

Outer Ø			+ MoS
750	O	O	O
800	O	O	O
850	O	O	O
900	O	O	O
950	O	O	O
1,000	O	O	O
1,050	O	O	O
1,100	O	O	O
1,150	O	O	O
1,200	O	O	O
1,250	O	O	O
1,300	O	O	O
1,350	O	O	O
1,400	O	O	O
1,450	O	O	O
1,500	O	O	O
1,650	O	O	O

Height: 50 – 200 mm (+ sprue, unmachined)

O = On request

LiNNOTAM GLiDE

The robust glider

$\rho = 1.14\ g/cm^3$

LiNNOTAM GLiDE
Plates

Thickness	Tolerance	3,050 × 1,220			2,000 × 1,220			2,000 × 1,000							1,000 × 1,000		
in mm	in mm	kg/m			kg/m			kg/m							kg/m		
8	+0.2/+1.5							11.5	+	+		O					
10		17.0	+	+	16.5	O	O	13.5	+	+	+	+	+	O			
12	+0.3/+2.5	20.1	+	+	19.4	O	O	16.0	+	+	+	+	O	O			
15		24.3	+	O	24.3	O	O	20.0	+	+	O	O	+	O			
16		25.0	O	O	25.0	O	O	21.5	O	+	O	+	O	O			
18								24.5	+	O	O	O	O	O			
20		31.0	+	O	31.0	O	O	26.0	+	+	+	+	+	O			
22								29.0	+	O	O	O	O	O			
25		39.0	+	O	39.0	O	O	32.0	+	+	+	+	O	O			
30	+0.5/+3.5	47.0	+	O	47.0	O	O	38.5	+	+	+	O	+	O			
35		55.8	+	O	55.8	O	O	45.3	+	O	O	O	O	O			
40		62.0	+	O	62.0	O	O	51.0	+	+	+	+	+	O			
45		68.0	+	O	68.0	O	O	57.0	+	O	O	O	O	O			
50		78.0	+	O	78.0	O	O	63.5	+	+	+	+	+	O			
55	+0.5/+5.0	84.0	+	O	84.0	O	O	70.0	+	O	O	O	O	O			
60		93.0	+	O	93.0	O	O	76.0	+	O	O	O	O	O			
65		100.0	O	O	100.0	O	O	82.5	O	O	O	O	O	O			
70		108.0	+	O	108.0	O	O	88.5	+	O	O	O	O	O			
75	+0.5 /+7.0				115.8	O	O	94.5	O	O	O	O	O	O			
80		122.0	+	O	122.0	O	O	101.0	+	O	O	O	O	O			
85					131.0	O	O	108.0	O	O	O	O	O	O			
90		135.0	+	O	135.0	O	O	113.0	+	O	O	O	O	O			
95					146.4	O	O	120.5	O	O	O	O	O	O			
100		148.0	O	O	148.0	O	O	126.0	+	O	O	O	O	O			
110	+0.5/ +9.0	161.0	O	O				139.0	O	O	O	O	O	O	139.0	O	O
120		180.0	O	O				147.0	O	O	O	O	O	O	147.0	O	O
130								159.0	O	O	O	O	O	O	159.0	O	O
140								171.0	O	O	O	O	O	O	171.0	O	O
150								189.0	O	O	O	O	O	O	189.0	O	O
160								195.0	O	O	O	O	O	O	195.0	O	O
165															222.0	O	O

\+ = Stock item
O = On request

Length tolerance: +0 %/+3 %
Width tolerance: +0.5 %/+4 %

Customised cuts, alternative colours, and food-grade versions are available on request.

$\rho = 1.14\ g/cm^3$

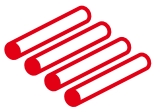
LiNNOTAM GLiDE

Round bars

Nominal size	Tolerance	2,000			1,000						
Ø in mm	in mm	kg/m			kg/m						
30	+0.2/+1.4	0.85	+	+	0.85	+	+	+	O	O	
35					1.2	+	+	O	O	O	
40		1.5	+	+	1.5	+	+	+	O	O	
45	+0.3/+1.9				1.9	+	+	O	O	O	
50		2.4	+	+	2.4	+	+	+	O	O	
55					2.8	+	+	O	O	O	
60	+0.3/+2.5	3.4	+	+	3.4	+	+	+	O	O	
65					4.0	+	+	O	O	O	
70		4.8	+	+	4.8	+	+	+	O		
75	+0.4/+2.8				5.6	+	O	O	O		
80		6.2	+	+	6.2	+	+	+	O		
85	+0.5/+3.2				6.9	+	O	O	O		
90		7.8	+	+	7.8	+	+	+	O		
95	+0.6/+3.5										
100					9.6	+	+	+	O	O	O
110	+0.7/+3.9	11.6	O	O	11.6	+	+	+	O	O	O
115	+0.8/+4.3	12.9	O	O	12.9	O	O	O	O	O	O
120		13.6	O	O	13.6	+	+	+	O	O	O
125		15.3	O	O	15.3	O	O	O	O	O	O
130	+0.8/+0.5	16.4	O	O	16.4	+	+	+	O	O	O
135		17.7	O	O	17.7	O	O	O	O	O	O
140					18.9	+	+	+	O	O	O
145	+0.8/+5.3				20.4	O	O	O	O	O	O
150		21.6	+	O	21.6	+	+	+	O	O	O
155	+0.8/+6.0				23.9	O	O	O	O	O	O
160		24.6	+	O	24.6	+	O	O	O	O	O
165	+1.07/+6.5				26.0	O	O	O	O	O	O
170		27.4	O	O	27.4	+	O	O	O	O	O
175					29.7	O	O	O	O	O	O
180		30.6	O	O	30.6	+	+	O	O	O	O
190	+1.0/+7.5	34.5	O	O	34.5	O	O	O	O	O	O
200	+1.0/+8.5	38.2	O	O	38.2	+	+	O	O	O	O
210					42.2	+	O	O	O	O	O
220					46.9	+	O	O	O	O	O
230	+1.0/+9.5				50.0	O	+	O	O	O	O
240					55.0	O	O	O	O	O	O
250					60.4	+	+	O	O	O	O
260	+1.0/+11.0				65.2	O	O	O	O	O	O
270					70.0	O	O	O	O	O	O
280					75.0	O	O	O	O	O	O
290	+1.5/+12.0				80.7	O	O	O	O		O
300					86.3	O	O	O	O		O
310					92.0	O	O	O	O		O
320					98.0	O	O	O	O		O

\+ = Stock item
O = On request

Length tolerance: +0 %/+3 %



Nominal size	Tolerance	1,000						
Ø in mm	in mm	kg/m						
330	+1.5/+13.5	104.0	O	O	O	O	O	O
340		113.0	O	O	O	O	O	O
350		117.5	O	O	O	O	O	O
360		124.0	O	O	O	O	O	O
370	+1.5/+15.0	131.0	O	O	O	O	O	O
380		140.0	O	O	O	O	O	O
390		144.0	O	O	O	O	O	O
400		153.0	O	O	O	O	O	O
410	+1.5/+16.5	165.0	O	O	O	O	O	O
420		173.8	O	O	O	O	O	O
430		183.0	O	O	O	O	O	O
440		187.0	O	O	O	O	O	O
450		195.0	O	O	O	O	O	O
460	+1.5/+18.0	205.0	O	O	O	O	O	O
470		216.6	O	O	O	O	O	O
480		221.0	O	O	O	O	O	O
490		233.0	O	O	O	O	O	O
500		242.0	O	O	O	O	O	O
510	+3.00/+21.0	251.0	O	O	O	O	O	O
520		262.4	O	O	O	O	O	O
530		268.0	O	O	O	O	O	O
540		276.5	O	O	O	O	O	O
550		294.0	O	O	O	O	O	O
560		309.0	O	O	O	O	O	O
570		311.0	O	O	O	O	O	O
580		316.0	O	O	O	O	O	O
590		331.0	O	O		O		
600		346.0	O	O		O		
610	+3.0/+25.0	348.0	O	O		O		
620		365.0	O	O		O		
625		367.0	O	O		O		
630		376.0	O	O		O		
640		385.0	O	O		O		
650		400.0	O	O		O		
660		408.0	O	O		O		
670		425.0	O	O		O		
690		449.0	O	O		O		
700		470.0	O	O		O		
710		483.0	O	O		O		
720		492.0	O	O		O		
730		506.0	O	O		O		
750		535.0	O	O		O		
790		591.0	O	O		O		
800		601.0	O	O		O		

Customised cuts, alternative colours, and food-grade versions are available on request.

LiNNOTAM GLiDE Pro T

Smooth endurance runner

ρ = 1.14 g/cm³

LiNNOTAM GLiDE Pro T
Plates

Thickness	Tolerance	3,050 × 1,220					2,000 × 1,220					2,000 × 1,000				
in mm	in mm	kg/m					kg/m					kg/m				
8	+0.2/+1.5															
10							16.5	O	O	O	O	13.5	+	O	O	O
12	+0.3/+2.5						19.4	O	O	O	O	16.0	+	O	O	O
15		24.3	O	O	O	O	24.3	O	O	O	O	20.0	+	O	O	O
16		25.0	O	O	O	O	25.0	O	O	O	O	21.5	O	O	O	O
18												24.5	O	O		O
20		31.0	O	O	O	O	31.0	O	O	O	O	26.0	+	O	O	O
22												29.0	O	O		O
25							39.0	O	O	O	O	32.0	+	O	O	O
30	+0.5/+3.5	47.0	O	O	O	O	47.0	O			O	38.5	+	O	O	O
35		55.8	O	O	O	O	55.8	O	O	O	O	45.3	O	O	O	O
40		62.0	O	O	O	O	62.0	O	O	O	O	51.0	+	O	O	O
45		68.0	O	O	O	O	68.0	O	O	O	O	57.0	O	O	O	O
50		78.0	O	O	O	O	78.0	O	O	O	O	63.5	+	O	O	O
55	+0.5/+5.0	84.0	O	O	O	O						70.0	O	O	O	O
60		93.0	O	O	O	O	93.0	O	O	O	O	76.0			O	
65		100.0	O	O	O	O						82.5			O	
70		108.0	O	O	O	O	108.0	O	O	O	O	88.5			O	
75	+0.5/+7.0											94.5			O	
80		122.0	O	O	O	O	122.0	O	O	O	O	101.0	+	O	O	O
85												108.0	O	O	O	O
90		135.0	O	O	O	O	135.0	O	O	O	O	113.0	O	O	O	O
95												120.5	O	O	O	O
100		148.0	O	O	O	O	148.0	O	O	O	O	126.0	O	O	O	O
110	+0.5/+9.0	161.0	O	O	O	O						139.0	O	O	O	O
120		180.0	O	O	O	O						147.0	O	O	O	O
130												159.0	O	O	O	O
140												171.0	O	O	O	O
150												189.0	O	O	O	O
160												195.0	O	O	O	O
165																

\+ = Stock item
O = On request

Length tolerance: +0 %/+3 %
Width tolerance: +0.5 %/+4 %

Customised cuts and alternative colours are available on request.

ρ = 1.14 g/cm³

LiNNOTAM GLiDE Pro T
Round bars

Nominal size	Tolerance	2,000				1,000				
Ø in mm	in mm	kg/m				kg/m				
30	+0.2/+1.4	0.85	O	O	O	0.85	O	O	O	O
35		1.2	O	O	O	1.2	O	O	O	O
40		1.5	O	O	O	1.5	O	O	O	O
45	+0.3/+1.9	1.9	O	O	O	1.9	O	O	O	O
50		2.4	O	O	O	2.4	O	O	O	O
55		2.8	O	O	O	2.8	O	O	O	O
60	+0.3/+2.5	3.4	O	O	O	3.4	O	O	O	O
65		4.0	O	O	O	4.0	O	O	O	O
70						4.8	O		O	
75	+0.4/+2.8					5.6			O	
80						6.2	O	O	O	O
85	+0.5/+3.2					7.0			O	
90						7.8	O	O	O	O
95	+0.6/+3.5					8.7	O	O	O	O
100		9.6	O		O	9.6	O	O	O	O
110	+0.7/+3.9	11.6	O		O	11.6	O	O	O	O
115	+0.8/+4.3	12.9	O		O	12.9	O	O	O	O
120		13.6	O		O	13.6	O	O	O	O
125		15.3	O		O	15.3	O	O	O	O
130	+0.8/+0.5	16.4	O		O	16.4	O	O	O	O
135		17.7	O		O	17.7	O	O	O	O
140		18.9	O		O	18.9	O	O	O	O
145	+0.8/+5.3					20.4	O	O	O	O
150		21.6	O		O	21.6	O	O	O	O
155	+0.8/+6.0					23.9	O	O	O	O
160		24.6	O		O	24.6	O	O	O	O
165	+1.07/+6.5					26.0	O	O	O	O
170		27.4	O		O	27.4	O	O	O	O
175						29.7	O	O	O	O
180		30.6	O		O	30.6	O	O	O	O
190	+1.0/+7.5	34.5	O		O	34.5	O	O	O	O
200	+1.0/+8.5	38.2	O		O	38.2	O	O	O	O
210						42.2	O	O	O	O
220						46.9	O	O	O	O
230	+1.0/+9.5					50.0	O	O	O	O
240						55.0	O	O	O	O
250						60.4	O	O	O	O
260	+1.0/+11.0					65.2	O	O	O	O
270						70.0	O	O	O	O
280						75.0	O	O	O	O
290	+1.5/+12.0					80.7			O	
300						86.3			O	
310						92.0			O	
320						98.0			O	

O = On request

Length tolerance: +0 %/+3 %

Nominal size	Tolerance	1,000	
Ø in mm	in mm	kg/m	
330	+1.5/+13.5	104.0	O
340		113.0	O
350		117.5	O
360		124.0	O
370	+1.5/+15.0	131.0	O
380		140.0	O
390		144.0	O
400		153.0	O
410	+1.5/ +16.5	165.0	O
420		173.8	O
430		183.0	O
440		187.0	O
450		195.0	O
460	+1.5/+18.0	205.0	O
470		216.6	O
480		221.0	O
490		233.0	O
500		242.0	O
510	+3.00/+21.0	251.0	O
520		262.4	O
530		268.0	O
540		276.5	O
550		294.0	O
560		309.0	O
570		311.0	O
580		316.0	O

Customised cuts and alternative colours are available on request.

LiNNOTAM HiPERFORMANCE
The heavy-duty professional

$\rho = 1.12\ g/cm^3$

LiNNOTAM HiPERFORMANCE 612
Plates

Thickness	Tolerance	2,000 × 1,000	
in mm	in mm	kg/m	
8	+0.2/+1.5	11.5	O
10		13.5	O
12	+0.3/+2.5	16.0	O
15		20.0	O
16		21.5	O
20		26.0	O
25		32.0	O
30	+0.5/+3.5	38.5	O
35		45.3	O
40		51.0	O
45		57.0	O
50		63.5	O
55	+0.5/+5.0	70.0	O
60		76.0	O
65		82.5	O
70		88.5	O
75	+0.5/+7.0	94.5	O
80		101.0	O
85		108.0	O
90		113.0	O
95		120.5	O
100		126.0	O

O = On request

Length tolerance: +0 %/+3 %
Width tolerance: +0.5 %/+4 %

Alternative colours and versions in 600 FR and 1200 FR in accordance with DIN 45545 are available on request.

$\rho = 1.03\ g/cm^3$

LiNNOTAM HiPERFORMANCE 1200

Plates

Thickness	Tolerance	2,000 × 1,000	
in mm	in mm	kg/m	
8	+0.5/+1.5	10.1	O
10		12.1	O
12		14.2	O
15	+0.5/+2.0	18.2	O
16		20.3	O
18		21.1	O
20		23.1	O
25	+0.5/+2.5	29.0	O
30		34.2	O
35		39.5	O
40	+0.5/+3.0	45.3	O
45		50.4	O
50		55.7	O
55	+0.5/+3.5	64.6	O
60		66.8	O

O = On request

Length tolerance: +0/+20 mm
Width tolerance: +0/+20 mm

Alternative colours and versions in 600 FR and 1200 FR in accordance with DIN 45545 are available on request.

$\rho = 1.12\ g/cm^3$

LiNNOTAM HiPERFORMANCE 612
Round bars

Nominal size	Tolerance	1,000	
Ø in mm	in mm	kg/m	
30	+0.2/+1.4	0.9	O
35		1.2	O
40		1.5	O
45	+0.3/+1.9	1.9	O
50		2.4	O
55		3.1	O
60	+0.3/+2.5	3.4	O
65		4.2	O
70		4.8	O
75	+0.4/+2.8	5.6	O
80		6.2	O
85	+0.5/+3.2	6.9	O
90		7.8	O
95	+0.6/+3.5	8.7	O
100		9.6	O
110	+0.7+3.9	11.6	O
115	+0.8/+4.3	12.9	O
120		13.6	O
125		15.3	O
130	+0.8/+5.0	16.4	O
135		17.7	O
140		18.9	O
145	+0.8/+5.3	20.4	O
150		21.6	O
155	+0.8/+6.0	23.9	O
160		24.6	O
165	+1.0/+6.5	26.0	O
170		27.4	O
175		29.7	O
180		30.6	O
190	+1.0/+7.5	34.5	O
200		38.2	O
210	+1.0/+8.5	42.2	O
220		46.9	O
230	+1.0/+9.5	50.0	O
240		55.0	O
250		60.4	O
260	+1.0/+11.0	65.2	O
270		70.0	O
280		75.0	O
290	+1.5/+12.0	80.7	O
300		86.3	O

Nominal size	Tolerance	1,000	
Ø in mm	in mm	kg/m	
310		92.0	O
320		98.0	O
330	+1.5/+13.5	104.0	O
340		113.0	O
350		117.5	O
360		124.0	O
370	+1.5/+15.0	131.0	O
380		140.0	O
390		151.5	O
400		153.0	O
410	+1.5/+16.5	165.0	O
420		173.8	O
430		183.0	O
440		187.0	O
450		195.0	O
460	+1.5/+18.0	205.0	O
470		216.6	O
480		226.0	O
490		233.0	O
500		242.0	O
510	+3.0/+21.0	251.0	O
520		262.4	O
530		274.5	O
540		284.8	O
550		294.0	O
560		309.0	O
570		323.5	O
580		329.0	O
590		343.7	O
600		352.9	O
610	+3.0/+25.0	360.0	O
620		377.6	O
625		383.6	O
630		386.0	O
640		397.0	O
650		415.6	O
660		425.7	O
670		441.1	O
680		454.1	O
690		468.7	O
700		488.9	O
710		498.5	O

O = On request

Length tolerance: +0 %/+3 %

Alternative colours and versions in 600 FR and 1200 FR in accordance with DIN 45545 are available on request.

$\rho = 1.03\ g/cm^3$

LiNNOTAM HiPERFORMANCE 1200
Round bars

Nominal size	Tolerance	3,000		500	
Ø in mm	in mm	kg/m		kg/m	
20	+0.1/+0.2	0.36	O		
25		0.55	O		
30	+0.1/+0.3	0.78	O		
35	+0.1/+0.4	1.0	O		
40	+0.1/+0.5	1.3	O		
45	+0.1/+0.6	1.7	O		
50	+0.1/+0.7	2.1	O		
55	+0.1/+0.8	2.5	O		
60	+1.0/+0.9	3.0	O		
70	+1.0/+2.0			4.4	O
80				5.7	O
90				7.2	O
100	+1.0/+2.5			8.9	O
110				10.2	O
120	+1.0/+3.0			12.9	O
130				15.1	O
140				17.4	O
150				19.7	O
160	+1.0/+3.5			22.8	O
170				25.6	O
180				28.7	O
190				31.9	O
200				35.3	O

O = On request

Length tolerance: +0 /+30 mm

Alternative colours and versions in 600 FR and 1200 FR in accordance with DIN 45545 are available on request.

ρ = 1.03 g /cm³ (1200)

LiNNOTAM HiPERFORMANCE 1200
Hollow bars

Nominal size		500	
Ø in mm		kg/m	
OD	ID		
80	30	5.1	O
90	30	6.5	O
100	30	8.2	O
100	50	7.0	O
100	60	6.2	O
110	30	9.9	O
110	50	8.8	O
110	60	7.9	O
120	30	11.9	O
120	50	10.7	O
120	60	9.9	O
130	30	14.1	O
130	40	13.5	O
130	50	12.9	O
130	60	12.0	O
130	80	9.9	O
140	30	16.3	O
140	50	15.1	O
140	60	14.3	O
140	80	12.1	O
150	30	18.8	O
150	50	17.6	O
150	60	16.8	O
150	80	14.6	O
150	90	13.2	O
160	30	21.4	O
160	50	20.2	O
160	60	19.4	O

Nominal size		500	
Ø in mm		kg/m	
OD	ID		
160	80	17.2	O
160	90	15.9	O
170	30	24.2	O
170	50	23.0	O
170	60	22.2	O
170	80	20.0	O
170	90	18.7	O
170	120	13.7	O
180	30	27.2	O
180	50	26.0	O
180	60	25.2	O
180	80	22.9	O
180	90	21.6	O
180	120	16.6	O
190	30	30.3	O
190	50	29.1	O
190	60	28.3	O
190	80	26.1	O
190	90	24.8	O
190	120	19.8	O
190	140	15.6	O
200	30	33.6	O
200	50	32.4	O
200	60	31.6	O
200	80	29.4	O
200	90	28.1	O
200	120	23.1	O
200	140	18.9	O

O = On request

Length tolerance: +0/+30 mm

Alternative colours and versions in 600 FR and 1200 FR in accordance with DIN 45545 are available on request.

LiNNOTAM DRiVE
The drive wonder

Round bars with metal core p. 31

ρ = 1.03 g /cm³

LiNNOTAM DRiVE 612 Fe und 1200 Fe
Round bars with metal core

612 Fe		
Nominal size	Steel core 9SMn28 (1.0715)	
Ø in mm	in mm	
115	45	O
120	50	O
125	50	O
130	55	O
135	60	O
140	60	O
145	60	O
150	70	O
155	70	O
160	80	O
165	80	O
170	90	O
180	90	O
190	100	O
200	110	O
210	120	O
220	130	O
230	140	O
240	150	O
255	160	O
280	180	O
305	200	O
335	220	O
375	250	O

1200 Fe		
Nominal size	Steel core 9SMn28 (1.0715)	
Ø in mm	in mm	
50	20	O
50	30	O
60	30	O
70	40	O
80	30	O
80	40	O
90	40	O
90	50	O
100	40	O
100	50	O
110	40	O
110	50	O
110	60	O
120	50	O
120	60	O
120	70	O
130	60	O
130	70	O
130	80	O
140	60	O
140	70	O
140	80	O
150	60	O
150	60	O
150	70	O
150	80	O
160	70	O
160	80	O
170	80	O
170	90	O
170	100	O
180	80	O
180	90	O
180	100	O
190	80	O
190	90	O
190	100	O
200	80	O
200	45	O
200	90	O
200	100	O

O = On request

Length tolerance: +0 %/+3 %

LiNNOTAM DRiVE is also available in the following core materials:
stainless steel V2A (1.4305) and V4A (1.4571), aluminium, brass

Customised cuts are available on request.

Engineering plastics
The extruded ones

$\rho = 1.13\ g/cm^3$

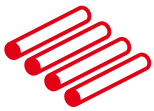
PA 6 E
Plates

Thickness	Tolerance	2,000 × 1,000		
in mm	in mm	kg/m		
1	-0.1/+0.1	1.1	O	
2	-0.15/+0.15	2.3	O	O
3	-0.2/+0.2	3.5	O	O
4	-0.2/+0.2	4.7	O	O
5	+0.2/+0.7	5.9	O	O
6		7.0	O	O
8	+0.2/+1.1	10.7	O	
10		13.2	O	
12	+0.3/+1.5	16.3	O	
15		19.9	O	
20		26.0	O	
25		32.0	O	
30	+0.5/+2.5	38.1	O	
35		45.3	O	
40		51.4	O	
50		63.5	O	
60	+0.5/+3.5	76.8	O	
70		88.9	O	
80	+0.5/+5.0	100.9	O	
100		124.5	O	

O = On request

ρ = 1.13 g/cm³

PA 6 E
Round bars



Nominal size	Tolerance	3,000			1,000	
Ø in mm	in mm	kg/m			kg/m	
6	+0.1/+0.6	0.04	O	O	0.04	O
8	+0.1/+0.7	0.07	O	O	0.07	O
10		0.10	O	O	0.10	O
12	+0.2/+0.8	0.15	O	O	0.15	O
15		0.23	O	O	0.23	O
16		0.26	O		0.26	O
18		0.33	O		0.33	O
20		0.40	O	O	0.40	O
22	+0.2/+1.0	0.49	O		0.49	O
25		0.62	O	O	0.62	O
30		0.88	O	O	0.88	O
35	+0.2/+1.2	1.2	O	O	1.2	O
40		1.5	O	O	1.5	O
45	+0.3/+1.3	1.9	O	O	1.9	O
50		2.4	O	O	2.4	O
55		2.9	O	O	2.9	O
60	+0.3/+1.6	3.5	O	O	3.5	O
65		4.0	O	O	4.0	O
70		4.7	O	O	4.7	O
75	+0.4/+2.0	5.4	O	O	5.4	O
80		6.2	O	O	6.2	O
85	+0.5/+2.2	6.9		O	6.9	O
90		7.8	O	O	7.8	O
95	+0,6/+2,5				8.6	O
100		9.6	O	O	9.6	O
110	+0.7/+3.0	11.7	O	O	11.7	O
120	+0.8/+3.5	14.0	O	O	14.0	O
125		15.2	O		15.2	O
130	+0.9/+3.8	16.4	O	O	16.4	O
140		19.0	O	O	19.0	O
150	+1.0/+4.2	21.7	O	O	21.7	O
160	+1.1/+4.5	24.8	O	O	24.8	O
170	+1.2/+5.0	28.0	O	O	28.0	O
180		31.5	O	O	31.5	O
190	+1.3/+5.5	35.0	O	O	35.0	O
200		38.8	O	O	38.8	O
250	+1.5/+6.2				60.5	O
280	+1.5/+6.6				75.5	O
300	+1.5/+7.5	86.7	O		86.7	O

O = On request

ρ = 1.13 g/cm³

PA 6 E
Hollow bars

Nominal size		Tolerance		3,000		
Ø in mm		in mm		kg/m		
OD	ID	OD	ID			
25	12	+0.4/+1.1	-0.4/-1.1	0.50	O	O
25	15			0.41	O	O
30	15	+0.6/+2.0	-0.6/-2.0	0.68	O	O
35	15			1.0	O	O
35	20			0.95	O	O
40	20			1.2	O	O
40	25			1.0	O	O
40	30			0.81	O	O
45	20			1.6	O	O
45	25			1.4	O	O
50	20			2.1	O	O
50	25			1.9	O	O
50	30			1.7	O	O
50	35			1.4	O	O
55	30	+0.8/+2.5	-0.8/-2.5	2.1	O	O
60	35			2.5	O	O
60	40			2.2	O	O
60	50			1.4	O	O
70	50	+0.8/+3.0	-0.8/-3.0	2.6	O	O
80	30			5.4	O	O
80	50			4.1	O	O
90	40	+1.2/+3.6	-1.6/-5.0	6.4	O	O
90	60			4.7	O	O
100	60			6.6	O	O
100	70			5.4	O	O
125	80	+1.5/+4.5	-2.0/-6.5	10.0	O	O

O = On request

$\rho = 1.14\ g/cm^3$

PA 66
Plates

Thickness	Tolerance	3,000 × 610		2,000 × 1,000	
in mm	in mm	kg/m		kg/m	
1				1.1	O
2				2.3	O
3				3.8	O
4				4.8	O
5	+0.2/+0.7			6.3	O
6				7.5	O
8	+0.2/+1.1	6.5	O		
10		8.0	O		
12	+0.3/+1.5	9.9	O		
15		12.1	O		
20		15.8	O		
25		19.5	O		
30	+0.5/+2.5	23.2	O		
35		27.6	O		
40		31.3	O		
50		38.7	O		
55	+0.5/+3.5	42.9	O		
60		46.8	O		

O = On request

ρ = 1.14 g/cm³ | ρ = 1.35 g/cm³

PA 66 and PA 66-GF
Round bars

PA 66			
Nominal size	Tolerance	3,000	
Ø in mm	in mm	kg/m	
6	+0.1/+0.6	0.04	O
8	+0.1/+0.7	0.07	O
10		0.10	O
12	+0.2/+0.8	0.15	O
15		0.23	O
16		0.26	O
18		0.33	O
20		0.40	O
25	+0.2/+1.0	0.62	O
28		0.77	O
30		0.88	O
35	+0.2/+1.2	1.2	O
40		1.5	O
45	+0.3/+1.3	1.9	O
50		2.4	O
55		2.9	O
60	+0.3/+1.6	3.5	O
65		4.0	O
70		4.7	O
75	+0.4/+2.0	5.4	O
80		6.2	O
85	+0.5/+2.2	6.9	O
90		7.8	O
100	+0.6/+2.5	9.6	O
110	+0.7/+3.0	11.7	O
120	+0.8/+3.5	14.0	O
130	+0.9/+3.8	16.4	O
140		19.0	O
150	+1.0/+4.2	21.7	O

PA 66-GF					
Nominal size	Tolerance	3,000		1,000	
Ø in mm	in mm	kg/m		kg/m	
10	+0.1/+0.7	0.12	O	0.12	O
12	+0.2/+0.8	0.17	O	0.17	O
15		0.27	O	0.27	O
20		0.47	O	0.47	O
25	+0.2/+1.0	0.73	O	0.73	O
30		1.0	O	1.0	O
40	+0.2/+1.2	1.8	O	1.8	O
50	+0.3/+1.3	2.8	O	2.8	O
60	+0.3/+1.6	4.1	O	4.1	O
70	+0.4/+2.0	5.5	O	5.5	O
80		7.2	O	7.2	O
100	+0.5/+2.2	11.3	O	11.3	O
120	+0.8/+3.5	16.4	O	16.4	O
150	+1.0/+4.2	25.5	O	25.5	O

O = On request

ρ = 1.41 g/cm³

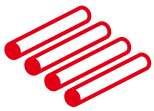
POM-C
Plates

Thickness	Tolerance	3,000 × 1,220		3,000 × 610			2,000 × 610			2,000 × 1,000		
in mm	in mm	kg/m		kg/m			kg/m			kg/m		
1	-0.1/+0.1									1.5	O	O
2	-0.15/+0.15									2.9	O	O
3	-0.2/+0.2									4.5	O	O
4										6.0	O	O
5	+0.2/+0.7									7.5	O	O
6										8.9	O	O
8	+0.2/+1.1	16.2	O	7.8	O	O	7.8	O	O	13.1	O	O
10		19.8	O	9.4	O	O	9.4	O	O	16.0	O	O
12	+0.3/+1.5	24.6	O	12.0	O	O	12.0	O	O	19.0	O	O
15		30.1	O	14.5	O	O	14.5	O	O	23.7	O	O
20		39.2	O	18.6	O	O	18.6	O	O	31.1	O	O
25		48.3	O	23.6	O	O	23.6	O	O	39.0	O	O
30	+0.5/+2.5	57.4	O	27.9	O	O	27.9	O	O	46.3	O	O
35		68.4	O	33.4	O	O	33.4	O	O	55.1	O	O
40		77.5	O	37.8	O	O	37.8	O	O	62.3	O	O
45		86.6	O	42.4	O	O	42.4	O	O	71.5	O	O
50		95.7	O	46.8	O	O	46.8	O	O	77.5	O	O
60	+0.5/+3.5	115.8	O	56.5	O	O	56.5	O	O	92.0	O	O
70		131.9	O	66.0	O	O	66.0	O	O	104.0	O	O
80	+0.5/+5.0	149.8	O	74.0	O	O	74.0	O	O	120.0	O	O
90		169.6	O	84.8	O	O	84.8	O	O	138.0	O	O
100		189.3	O	95.0	O	O	95.0	O	O	154.0	O	O
110	+0.5/+6.0	207.3	O	103.7	O	O	103.7	O	O			
125		235.1	O	117.4	O	O	117.4	O	O			
150	+0.5/+7.0	280.0	O	140.0	O		140.0	O	O			

O = On request

ρ = 1.41 g/cm³

POM-C
Round bars



Nominal size	Tolerance	3,000			1,000		
Ø in mm	in mm	kg/m			kg/m		
6	+0.1/+0.6	0.05	O	O			
8	+0.1/+0.7	0.08	O	O	0.08	O	O
10		0.12	O	O	0.12	O	O
12	+0.2/+0.8	0.18	O	O	0.18	O	O
15		0.27	O	O	0.27	O	O
16		0.32	O	O			
18		0.40	O	O	0.40	O	O
20		0.47	O	O	0.47	O	O
22	+0.2/+1.0	0.57	O	O	0.57	O	O
25		0.74	O	O	0.74	O	O
28		0.93	O	O	0.93	O	O
30		1.0	O	O	1.0	O	O
32	+0.2/+1.2	1.2	O	O	1.2	O	O
35		1.4	O	O	1.4	O	O
40		1.9	O	O	1.9	O	O
45	+0.3/+1.3	2.4	O	O	2.4	O	O
50		2.9	O	O	2.9	O	O
55		3.5	O	O	3.5	O	O
60	+0.3/+1.6	4.2	O	O	4.2	O	O
65		5.0	O	O	5.0	O	O
70		5.7	O	O	5.7	O	O
75	+0.4/+2.0	6.6	O	O	6.6	O	O
80		7.5	O	O	7.5	O	O
85	+0.5/+2.2	8.5	O	O	8.5	O	O
90		9.4	O	O	9.4	O	O

Nominal size	Tolerance	3,000			1,000		
Ø in mm	in mm	kg/m			kg/m		
95	+0.6/+2.5	10.8	O	O	10.8	O	O
100		11.6	O	O	11.6	O	O
110	+0.7/+3.0	14.4	O	O	14.4	O	O
120	+0.8/+3.5	17.0	O	O	17.0	O	O
125		18.7	O	O	18.7	O	O
130	+0.9/+3.8	20.1	O	O	20.1	O	O
140		22.9	O	O	22.9	O	O
150	+1.0/+4.2	26.6	O	O	26.6	O	O
160	+1.1/+4.5	30.5	O	O	30.5	O	O
170	+1.2/+5.0	34.6	O	O	34.6	O	O
180		38.8	O	O	38.8	O	O
190	+1.3/+5.5	43.6	O	O	43.6	O	O
200		47.7	O	O	47.7	O	O
210	+1.3/+5.8	52.2	O	O	52.2	O	O
220		57.0	O	O	57.0	O	O
230	+1.5/+6.2	62.4	O	O	62.4	O	O
250		74.6	O	O	74.6	O	O
260	+1.5/+6.6	80.9	O	O	80.9	O	O
280		93.9	O	O	93.9	O	O
300	+1.5/+7.5	107.0	O	O	107.0	O	O
310					116.0	O	O
350	+1.5/+8.5	147.0	O		147.0	O	O
400	+1.5/+9.5	191.2	O	O	191.2	O	O
450	+1.5/+10.5				243.1	O	O
500	+1.5/+11.5	298.8	O		298.8	O	O

O = On request

ρ = 1.41 g/cm³

POM-C
Hollow bars

Nominal size		Tolerance		3,000			1,000	
Ø in mm		in mm		kg/m			kg/m	
OD	ID	OD	ID					
25	15	+0.4/+1.1	-0.4/-1.1	0.55	O	O	0.55	O
30	15			0.92	O	O	0.92	O
	20			0.70	O	O	0.70	O
35	15	+0.6/+2.0	-0.6/-2.0	1.3	O	O	1.3	O
	20			1.1	O	O	1.1	O
	25			0.93	O	O	0.93	O
40	20			1.5	O	O	1.5	O
	25			1.4	O	O	1.4	O
	30			1.1	O	O	1.1	O
45	20			2.0	O	O	2.0	O
	25			1.8	O	O	1.8	O
	30			1.5	O	O	1.5	O
50	20			2.6	O	O	2.6	O
	25			2.4	O	O	2.4	O
	30			2.1	O	O	2.1	O
	35			1.8	O	O	1.8	O
55	30	+0.8/+2.5	-0.8/-2.5	2.8	O	O	2.8	O
	35			2.4	O	O	2.4	O
60	30			3.4	O	O	3.4	O
	35			3.1	O	O	3.1	O
	40			2.7	O	O	2.7	O
	50			1.8	O	O	1.8	O
65	30	+0.8/+3.0	-0.8/-3.0	4.2	O	O	4.2	O
70	30			5.0	O	O	5.0	O
	50			3.4	O	O	3.4	O
80	40			6.1	O	O	6.1	O
	50			5.2	O	O	5.2	O
	60			4.1	O	O	4.1	O
90	40	+1.2/+3.6	-1.6/-5.0	8.1	O	O	8.1	O
	50			7.1	O	O	7.1	O
	60			6.1	O	O	6.1	O
	70			4.8	O	O	4.8	O
100	40			10.3	O	O	10.3	O
	50			9.5	O	O	9.5	O
	60			8.2	O	O	8.2	O
	70			6.9	O	O	6.9	O
	80			5.5	O	O	5.5	O
110	50			12.0	O	O	12.0	O
	60			12.0	O	O	12.0	O
	80			7.8	O	O	7.8	O
	90			5.9	O	O	5.9	O

O = On request

Nominal size		Tolerance		3,000			1,000	
Ø in mm		in mm		kg/m			kg/m	
OD	ID	OD	ID					
120	60	+1.5/+4.5	-2.0/-6.5	13.6	O	O	13.6	O
	80			10.5	O	O	10.5	O
	100			6.6	O	O	6.6	O
125	80			12.0	O	O	12.0	O
130	100	+1.5/+4.5	-2.0/-6.5	9.5	O	O	0.55	O
	110			7.1	O	O	0.92	O
140	100			12.8	O	O	0.70	O
	110			10.7	O	O	1.3	O
150	80			20.3	O	O	1.1	O
	100			16.3	O	O	0.93	O
170	100	+1.8/+5.4	-2.2/-7.5	23.7	O	O	1.5	O
	130			16.5	O	O	1.4	O
180	100			27.9	O	O	1.1	O
	140			18.2	O	O	2.0	O
	160			11.1	O	O	1.8	O
210	160	+2.0/+6.0	-2.5/-8.5	24.7	O	O	1.5	O

ρ = 1.36 g/cm³ | ρ = 1.39 g/cm³

PET and PET-GL
Plates

		PET					PET-GL	
Thickness	Tolerance	2,000 × 1,000		3,000 × 610			2,000 × 610	
in mm	in mm	kg/m		kg/m			kg/m	
8	+0.2/+1.1	13.2	O	7.6	O	O	7.6	O
10		16.1	O	9.4	O	O	9.4	O
12	+0.3/+1.5	20.0	O	11.4	O	O	11.4	O
15		24.5	O	14.0	O	O	14.0	O
20		31.9	O	18.4	O	O	18.4	O
25		39.3	O	22.8	O	O	22.8	O
30	+0.5/+2.5	46.8	O	22.7	O	O	22.7	O
35		55.7	O				32.1	O
40		63.1	O	36.5	O	O	36.5	O
45								
50		78.0	O	45.3	O	O	45.3	O
60	+0.5/+3.5	94.3	O	54.6	O	O	54.6	O
70				63.4	O	O	63.4	O
80	+0.5/+5.0			72.8	O	O	72.8	O
90				81.6	O	O	81.6	O
100				90.4	O	O	90.4	O

O = On request

ρ = 1.36 g/cm³ | ρ = 1.39 g/cm³

PET and PET-GL
Round bars

		PET					PET-GL			
Nominal size	Tolerance	3,000			1,000		3,000		1,000	
ø in mm	in mm	kg/m			kg/m		kg/m		kg/m	
10	+0.1/+0.7	0.12	O	O			0.12	O		
12	+0.2/+0.8	0.17	O	O			0.18	O		
16		0.30	O	O			0.31	O		
18		0.38	O	O			0.38	O		
20		0.47	O	O			0.48	O		
25	+0.2/+1.0	0.73	O	O			0.73	O		
30		1.0	O	O	1.0	O	1.1	O	1.1	O
35	+0.2/+1.2	1.5	O	O	1.5	O	1.5	O		
40		1.8	O	O	1.8	O	1.9	O	1.9	O
45	+0.3/+1.3	2.3	O	O			2.4	O		
50		2.9	O	O	2.9	O	2.9	O	2.9	O
55		3.6	O	O			3.6	O		
60	+0.3/+1.6	4.1	O	O	4.1	O	4.2	O	4.2	O
65		4.8	O	O			4.9	O		
70		5.6	O	O	5.6	O	5.7	O	5.7	O
75	+0.4/+2.0	6.4	O	O			6.4	O		
80		7.3	O	O	7.3	O	7.5	O	7.5	O
85	+0.5/+2.2	8.3	O	O			8.3	O		
90		9.2	O	O	9.2	O	9.4	O	9.4	O
100	+0.6/+2.5	11.4	O	O	11.4	O	11.7	O	11.7	O
110	+0.7/+3.0	13.9	O	O	13.9	O	14.2	O		
120	+0.8/+3.5	16.5	O	O			16.9	O		
130	+0.9/+3.8	19.4	O	O	19.4	O	19.8	O	19.8	O
140	+1.0/+4.2	22.5	O	O			22.9	O	22.9	O
150	+1.1/+4.5	25.8	O	O	25.8	O	26.0	O	26.0	O
160					29.4	O				
180	+1.2/+5.0				37.1	O				
200	+1.3/+5.5				45.8	O				

O = On request

Processing and post-treatment

From semi-finished products to customised components

Machining

The growing variety of engineered plastics and resulting application options has opened up new horizons for designers that used to be out of reach with conventional materials. Besides the limitations of the material, the design potentials are frequently only limited by the production process. If parts to be made from cast polyamides, polyacetal (POM) or polyethylene terephthalate (PET) are bulky, in particular, manufacturing processes such as injection moulding become unfeasible. The same applies to complex functional parts needing to be worked from all sides with tight tolerances.

This is where machining has proven to be advantageous: High-precision functional parts and bulky components can both be produced by machining in small and medium-sized batches with particular cost-effectiveness.

To manufacture high-quality products, a number of plastic-specific features need to be taken into account when selecting the machinery and tools, as well as their application.

Machining equipment/tools

Machining requires no special equipment or processes. Any machines customarily used in the woodworking and metalworking industries and equipped with HSS (high speed steel) or hard metal tools can be used. The use of carbide-tipped saw blades is only principally recommended where plastics need to be cut with circular saws.

Exempted from this is the group of glass fibre reinforced plastics. Although they can be machined with carbide-tipped tools, cost-effective results are hard to come by given the latter's short lifetimes. Recommended here are coated hard metal tools, which are significantly more expensive than conventional tools, but offer a considerably longer service life.

Fig. 1: Complex functional part made from POM

Machining, clamping and dimensional stability of workpieces

In comparison with metallic materials, plastics have a lower thermal conductivity as well as a lower elastic modulus. If not handled properly, workpieces can grow very hot, causing them to greatly expand. Apart from this, the heat generated by machining can also release production-related stresses in semi-finished products. High clamping pressures and blunt tools will cause workpieces to deform in the machining process. The consequence is dimensional and shape deviations outside the tolerance range. Satisfactory results are thus only achievable if a number of materialspecific guidelines are followed in the machining of plastics.

Specifically, this means:

– Annealed semi-finished materials should be used.

– The highest possible cutting speeds should be aimed for.

– Optimal chip removal must be ensured to prevent chips from being pulled in by the tool.

– The cutting edges of the tools used must be absolutely sharp. Blunt cutting edges can generate considerable heat, potentially leading to warping and thermal expansion.

– Consistent takeoff must be ensured from all sides to prevent warping.

– The clamping pressures must not be too high as this would cause the workpiece to deform, with the clamping tools leaving impressions on it.

– Given the low stiffness, the workpiece needs to be adequately supported on the machine table, ideally lying flat across the whole surface.

– Flawless high-quality surfaces are only realizable if machines run with little vibration.

What turns out to be particularly problematic is the production of dimensionally accurate parts calling for a high machining volume or uneven takeoff. Recommended in both cases is to prefabricate the parts down to a residual oversize and then anneal them in between. This and 24 hours of subsequent interim storage will ensure that machining-related thermal and residual stresses in the semi-finished product are largely relieved. After this, the parts can be given their final finish.

As long as these guidelines are followed, even tight plastic-appropriate tolerances can be unproblematically realized with a high repeating accuracy.

Machining

In-process cooling

Cooling is not generally mandatory in the processing. If cooling is desirable, the use of compressed air is recommended. Besides the cooling effect, this has the advantage that the chips are removed from the working area, preventing them from being pulled into the tool or circulating around it.

Customary drilling emulsions and cutting oils can also be used for cooling. Their application is particularly recommended where deep bores are required or threads need to be cut. In addition, they also help to achieve higher feed rates and thus shorter run times. Bear in mind, however that some plastics may be attacked and irreversibly damaged by the ingredients of drilling emulsions and cutting oils. This is why it is advisable to check the resistance of the plastic before applying them. Alternatively, the manufacturer of the emulsion or oil can provide information and advice on any known incompatibilities with plastics. Workpieces that are stained with emulsion or cutting oil should moreover be thoroughly cleaned after the machining. Any adhesive residues must be completely removed to make possible downstream processes such as glueing or coating unproblematic. Particularly with polyamides, this will prevent the water contents of emulsions from causing components to change by moisture absorption.

Parameters for individual machining processes

Sawing

Plastics can either be sawn with band saws or circular saws. The choice depends on the shape of the semi-finished product. The use of a band saw is particularly recommended when a “support groove” (prism) is used to solid cut rods and tubes and has the advantage that the generated processing heat is dissipated well by the long saw blade. The teeth of the blade must be adequately set to prevent it from jamming, however.

Circular saws on the other hand are mainly used for cutting sheets and blocks with straight edges. In this respect there is a need to work with adequate feed rates to ensure chip removal, prevent saw blades from jamming, and plastics from overheating in the sawing process. Table 1 lists reference values for the blade geometry of saw blades.

Milling

Milling with conventional machining centres is no problem. High cutting speeds at medium feed rates enable high chipping outputs attended by a good surface quality and accuracy. Care must be taken to use tools with enough chip space. This ensures reliable chip removal and avoids heat congestion. We recommend the values shown in the table for the blade geometry.

Turning

Since most plastics produce flow chips, the chip removal must be particularly good as they would get stuck and circulate with the lathed part otherwise. The sagging risk moreover grows with longer parts given the plastic’s low stiffness, making the use of a bezel advisable. The values in the table apply to the blade geometry.

Drilling

Bores can be realized with a conventional HSS drill. When drilling deep bores, good chip removal needs to be ensured, as the plastic at the bore wall will heat up to melting point otherwise, and the drill will “clog”. This especially applies to deep bores. To drill thin-walled workpieces, selecting a high cutting speed and neutral cutting angle (0°), where applicable, is recommended. This prevents the drill from sticking in the workpiece and avoids the attendant tearing of the bore or workpiece being pulled up the drill. Recommended values for the drill blade geometry are shown in the table.

Drilling large diameters in round rod sections

Drilling generates high temperatures at the cutting edges, especially with highly crystalline materials like LiNNOTAM, that cannot be adequately dissipated given the plastic's good insulation properties. The heat leads to an internal expansion of the material, which causes compressive strains inside the rod section. These can become so high that the blank tears and breaks apart. This can be largely avoided by an appropriate processing of the material.

It is advisable to drill a pilot hole and finish off with a boring tool. The diameter of pilot holes should not exceed 35 mm for this. Bores in long rod sections must meanwhile be drilled from one side only as the meeting of bores at the centre of the blank would lead to unfavourable stress ratios otherwise, encouraging the rod section to tear. Extreme cases may require the blank to be heated to ca. 120 -150 °C and the pilot hole to be drilled in this condition. The finish can then be provided once the blank has completely cooled down and reached a uniform temperature inside.

Advice for reinforced and filled plastics

Plastics reinforced or filled with glass fibres, carbon fibres, glass beads, minerals or other substances have higher residual stresses than unreinforced and/or unfilled plastics. The reinforcement and filler materials additionally make the products harder and more brittle and reduce their impact strength. This makes these products particularly susceptible to cracking. Residual stresses can be released by the machining, which may be indicated by extensive warping up to cracking, or full breakage.

This is why the following advice below should be observed in the machining and processing:

– Semi-finished products should ideally be heated to ca. 120 °C before drilling or sawing (suggested time period: ca. 5-6 minutes per mm of cross-section).

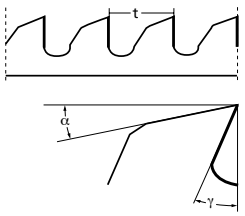
– Carbide-tipped tools should be used for the processing as a minimum, but coated carbide tools are preferable.

– Any clamping and fixing must be non-warping and the material should be exposed to the slightest possible bending, tensile or compressive forces.

As long as the processing guidelines above are followed, machining will unproblematically enable the creation of complex products from engineered plastics, even with the most exacting quality standards for accuracy and functionality.

Table

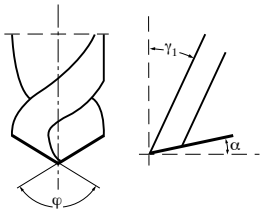
Sawing



α = Clearance angle (°)
γ = Cutting angle (°)
v = Cutting speed (m/min)
t = Clearance angle
Values for circular saw without ( )
Values for band saw with ( )

Use straight-set bandsaw blades!

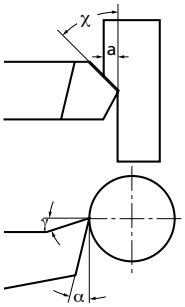
Drilling



α = Clearance angle (°)
γ = Cutting angle (°)
φ = Point angle (°)
v = Cutting speed (m/min)
s = Forward feed (mm/U)

The drill's angle of twist should be 12-16°.

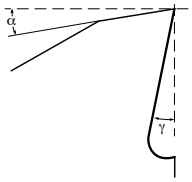
Turning



α = Clearance angle (°)
γ = Cutting angle (°)
ξ = Setting angle (°)
v = Cutting speed (m/min)
s = Forward feed
a = Jaw depth (mm)

The point radius should be 0.5 mm.

Milling



α = Clearance angle (°)
γ = Cutting angle (°)
v = Cutting speed (m/min)

Feed up to 0.5 mm per tooth, cutter angle of twist from 0-40°.

Legend

- Do not use cooling lubricants/cutting oils. Risk of stress cracks!
- The use of carbide/diamond tools is recommended
- Pre-heat semi-finished products to ca. 120°C! Suggested heating period: ca. 5-6 min/mm cross-section

		PA	POM	PET	PE/PP-H	PVC	PVDF	PTFE	PSU	PEI	PEEK	Reinforced materials
	α	30 – 40 (10 – 20)	30 – 40 (10 – 20)	30 – 40 (10 – 20)	20 – 30 (20 – 30)	5 – 10 (30 – 40)	30 – 40 (10 – 20)	10 – 15 (10 – 30)	10 – 15 (10 – 30)	10 – 15 (15 – 30)	10 – 15 (15 – 30)	15 – 30 (15 – 30)
	γ	0 – 10 (0 – 8)	0 – 10 (0 – 8)	0 – 10 (0 – 8)	6 – 10 (2 – 8)	0 – 6 (0 – 5)	0 – 10 (0 – 8)	0 – 15 (0 – 4)	0 – 15 (0 – 4)	10 – 15 (15 – 30)	0 – 15 (0 – 5)	15 – 30 (10 – 15)
	v	1,000 – 3,500 (200 – 1,000)	1,000 – 3,500 (200 – 1,000)	1,000 – 3,500 (200 – 1,000)	1,000 – 3,500 (500 – 800)	3,000 – 4,000 (800 – 1.200)	1,000 – 3,500 (200 – 1,000)	1,800 – 2,000 (300 – 500)	1,800 – 2,000 (300 – 500)	1,800 – 2,000 (300 – 500)	1,800 – 2,500 (500 – 800)	500 – 1,500 (200 – 300)
	t	24 – 80 (3 – 5 / Zoll)	24 – 80 (3 – 5 / Zoll)	24 – 80 (3 – 5 / Zoll)	24 – 80 (3 – 8 / Zoll)	36 – 80 (3 – 5 / Zoll)	24 – 80 (3 – 5 / Zoll)	24 – 80 (2 – 5 / Zoll)	24 – 80 (2 – 5 / Zoll)	24 – 80 (2 – 5 / Zoll)	24 – 80 (3 – 5 / Zoll)	24 – 80 (3 – 5 / Zoll)
	α	5 – 15	5 – 10	5 – 10	10 – 20	5 – 10	5 – 15	10 – 15	8 – 15	8 – 15	5 – 15	5 – 10
	γ	5 – 10	5 – 15	5 – 15	10 – 15	0 – 5	5 – 20	5 – 20	10 – 20	10 – 20	10 – 15	5 – 10
	φ	60 – 90	60 – 90	60 – 90	60 – 90	60 – 100	110 – 130	110 – 130	60 – 90	60 – 90	90 – 120	110 – 120
	v	50 – 150	50 – 150	50 – 150	50 – 150	30 – 120	100 – 300	100 – 300	50 – 100	50 – 100	50 – 200	80 – 100
	s	0.1 – 0.5	0.1 – 0.3	0.1 – 0.3	0.1 – 0.5	0.1 – 0.5	0.1 – 0.3	0.1 – 0.3	0.1 – 0.4	0.1 – 0.4	0.05 – 0.3	0.1 – 0.3
	α	5 – 15	5 – 10	5 – 10	5 – 10	8 – 10	5 – 15	5 – 10	5 – 10	5 – 10	5 – 10	6 – 8
	γ	0 – 10	0 – 5	0 – 5	0 – 5	0 – 5	5 – 15	0 – 5	0 – 5	0 – 5	0 – 5	2 – 8
	χ	0 – 45	0 – 45	0 – 45	0 – 60	30 – 60	0 – 45	0 – 45	0 – 45	0 – 45	0 – 45	45 – 60
	v	200 – 500	200 – 500	200 – 500	250 – 500	250 – 750	150 – 200	200 – 500	150 – 400	150 – 400	200 – 500	150 – 200
	s	0.05 – 0.5	0.05 – 0.5	0.05 – 0.5	0.1 – 0.5	0.3 – 0.5	0.1 – 0.3	0.05 – 0.5	0.1 – 0.3	0.1 – 0.3	0.2 – 0.5	0.1 – 0.5
	a	up to 15	up to 15	up to 15	up to 15	up to 10	up to 15	up to 15	up to 10	up to 10	up to 15	up to 10
	α	5 – 15	5 – 10	5 – 10	5 – 20	5 – 10	5 – 15	10 – 15	10 – 20	10 – 20	5 – 15	15 – 30
	γ	0 – 15	0 – 10	0 – 10	5 – 15	0 – 15	5 – 15	15 – 20	5 – 15	5 – 15	5 – 10	5 – 10
	v	up to 1,000	up to 1,000	up to 1,000	up to 1,000	up to 1,000	up to 1,000	up to 600	up to 400	up to 400	up to 500	up to 100

Machining advice

For the following dimensions/materials, we recommend heating before sawing:

from Ø 50: PA 66 GF
from Ø 60: PEEK-GF, PEEK-GL, POM-GF
from Ø 100: PA 6 GF, PA 12 GF, PET

For the following dimensions/materials, we recommend heating before drilling in the centre:

from Ø 60: PEEK-GF, PEEK-GL, POM-GF
from Ø 80: PA 66 GF
from Ø 100: PA 66, PA 6 GF, PA 12 GF, PET
from Ø 180: LiNNOTAM, LiNNOTAM HiPERFORMANCE 612, LiNNOTAM HiPERFORMANCE 1200

Aftertreatment methods

Conditioning

Conditioning is defined as a post-processing of dry polyamide products aimed at the fastest possible moisture accumulation. This may be required to protect polyamide components from dimensional changes caused by water absorption, if parts are to be used in permanent contact with water or underwater, or where the specific material changes brought about by water absorption are to be purposefully induced.

The following moisture conditions are customarily distinguished in polyamide products:

– dry (moisture content < 0.2 %)

– air-humid (weight constancy when stored in 23 °C/50 % rel. humidity standard climate)

– wet (weight constancy even after prolonged storage in water)

Besides processes using hot air and air humidity, the available conditioning options also include storage in hot water (water temperature ca. 80 °C-100 °C max). This method is the simplest in terms of effort, but harbours a decisive disadvantage: With thick-walled parts, the water will first of all diffuse into the surface regions and saturate them. Whereas the deeper layers have not even reached the desired water content by the end of the conditioning period. Part of the water will be released to the environment again once the parts are taken out of the water bath. The water content of the layers near the surface will reach the desired level, while the deeper layers fall below it. This is why it is advisable to leave components in the water bath a little longer and follow the conditioning with a few days of storage in normal room air. This way, the water content can even out almost perfectly again throughout the part after moisture being released from the layers near the surface.

Key factors for the water absorption of polyamides

The water absorption process only takes place very slowly in general and is influenced by various factors. The most important factors for this can be outlined as follows:

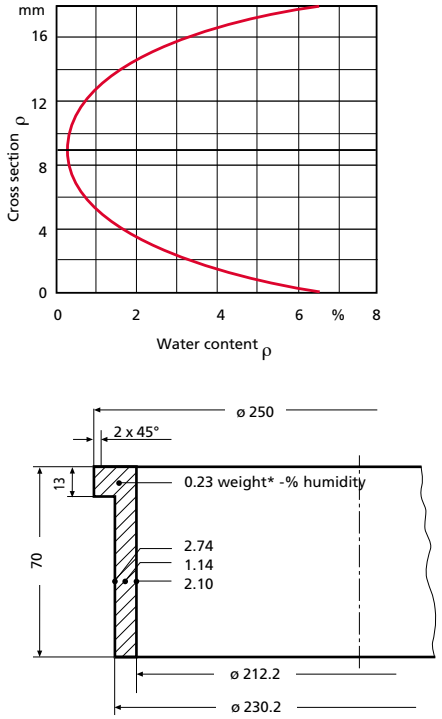
1. Water absorption rate

Polyamide will only absorb water and/or moisture very slowly until a state of equilibrium is reached. Once this equilibrium is reached, the moisture content can only be influenced by changing the environmental conditions, e.g. to a higher moisture content and/or temperature. The tendency of the water molecules to diffuse into solids will grow considerably as temperatures rise. This is why the time required to have a specific quantity of water penetrate a polyamide component shortens as ambient temperatures rise. In addition, the size of the component's specific surface (surface area per volume unit) is crucial. The larger the specific surface of a component is, the larger the water molecules' area of attack will be, and the higher the absorption rate. This permits the conclusion for practical polyamide applications that short-term humidity fluctuations in the environment will merely have a limited impact on the material's properties, while long-term humidity fluctuations, possibly in tandem with higher temperatures, can indeed cause them to change as previously described.

2. Water absorption in air

Water absorption from the air primarily depends on the latter's relative humidity and not its temperature. Please note for thick-walled components that water will only be absorbed from the air in areas near the surface, with no water absorption and detailed consequences normally expectable inside them (Fig.2).

Fig. 2 Moisture distribution in thick-walled components from cast polyamide



3. Influence of crystallinity

With water only being absorbed by the amorphous portions of the polyamide, its intake also significantly depends on the degree of crystallinity. With increasing crystallinity, the saturation concentration (depending on the polyamide's chemical composition and type), absorption rate and absorption capacity will all decline. Cast polyamides have a higher degree of crystallinity than extruded ones. This is why they absorb much less water and take much longer to do so.

Annealing

The annealing process is defined as the heat-treatment of moulded parts or semi-finished products in order to

– largely reduce residual stresses from the manufacturing or machining process

– increase the crystallinity and thereby improve the material's mechanical parameters

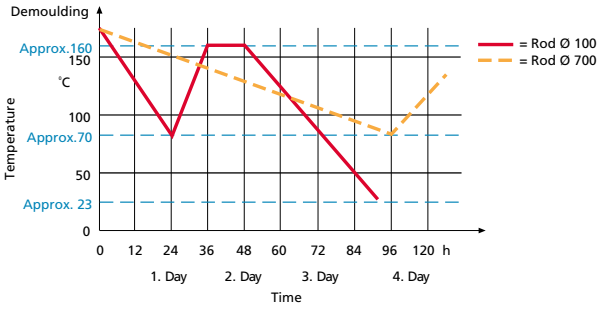
– prevent warping and dimensional changes during or after the processing

– improve the long-term dimensional stability

Semi-finished products and moulded parts are customarily annealed in a heat cabinet by way of hot circulating air. But hot oil baths based on paraffin or silicone oil are also commonly used. The process follows the same scheme regardless of the heat transfer medium applied: The products are slowly and evenly heated to the material-specific annealing temperature in a heating cabinet (in the medium). Once it is reached, the products need to be kept at this temperature for several hours. Heating the products all the way through is meanwhile essential and crucial for successful annealing. The necessary holding period depends on the product's dimensions, shape and mass, and is thus aligned with these parameters. Once the holding period is over, the annealed material needs to cool down to room temperature slowly, draught-free and in a controlled manner. This will ensure the development of a highly crystalline structure inside the material, and that uneven heat losses in the cooling phase will only leave minimal residual stresses.

The temperature range for commonly used engineered plastics is usually from 130 °C to 170 °C. Some materials (such as the high-temperature plastics) require higher temperatures.

In special cases, engineered plastics can also be annealed at higher temperatures. Specific process conditions must be met for this, however, while continuously ensuring that the maximum temperature stays 30 to 40 °C below the melting point. A general specification of the required heating, holding and cooling times is only possible with some reservations. The interdependencies between the product shape, mass and dimensions of the goods to be annealed are very great. Large masses will for example need significantly more heat and time to be evenly heated through than small ones. They also take much longer to cool down as the heat quantity absorbed is only released slowly again due to the large mass. The following diagram illustrates these differences using newly cast solid LiNNOTAM rods as an example.



This shows that a solid rod with Ø 100 mm has cooled off enough for annealing one day after demoulding. A solid rod with Ø 700 mm on the other hand needs at least four days until it has cooled down sufficiently for the annealing process to start.

The product shape has a considerable impact on the annealing times as well, however: Pipes, for example, are completely heated through faster than solid rods because they offer the heat a greater surface area to be absorbed by given the inner and outer diameter. Accordingly, they will also cool down faster again after the annealing than solid rods.

If components are to be intermediately annealed in the manufacturing process, their geometric ratios, existing wall thicknesses and the latter's distribution on the workpiece all need to be considered in addition to the aforementioned parameters.

Taking the above into account, the following data can serve as an approximate guideline:

Material	Temperature in °C	Heating rate in °C/hr	Holding period in min/mm	Cooling rate in °C/hr
Polyamid (PA):	ca. 160-165	ca. 10-15	ca. 5-6	ca. 15-20
Polyacetal (POM):	ca. 150-152	ca. 10-15	ca. 5-6	ca. 15-20
Polyethylenterephthalat (PET):	ca. 170-175	ca. 10-15	ca. 5-6	ca. 15-20
Polyetheretherketon (PEEK):	ca. 220-225	ca. 10-15	ca. 5-6	ca. 15-20

More detailed information on the annealing of our products is available upon request.

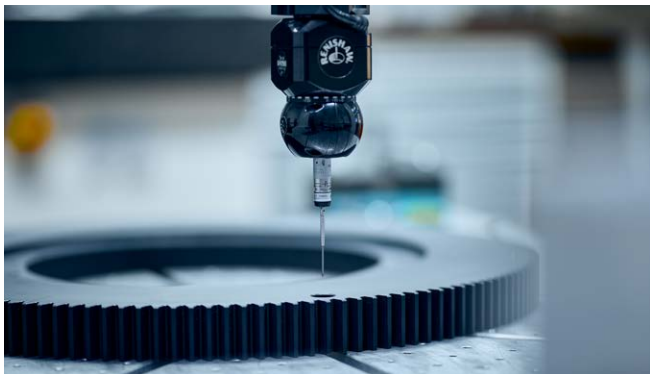
Physical material properties

Properties that make the difference

All key figures at a glance – compare various essential plastics directly. Get an idea of the performance of our products based on the practical properties of our materials and compare them with many standard values of common plastics.

Notes and conditions for the table

The information in the list is intended to provide an overview of the properties of our products and allow you to quickly compare materials. They reflect the current state of our knowledge and do not claim to be complete. Due to the strong dependence on environmental influences and processing, the values given are only to be understood as guidelines. They do not constitute a legally binding assurance regarding the properties of our products or their suitability for use in a specific application. All values mentioned were determined as average values from many individual measurements and refer to a temperature of 23 °C and 50% RH. For a specific application, we recommend proving suitability by means of a practical test.



The conditions under which the individual values, or their characteristics, were determined are indicated in the following list with the corresponding footnotes:

Characteristic value	Condition	Footnote
Impact strength DIN EN ISO 179	measured with pendulum impact tester 0.1 DIN 51 222	1
Creep stress DIN 53 444	Stress leading to 1% total elongation after 1,000 hours	2
Coefficient of sliding friction	hardened and ground against steel, P = 0.05 MPa, V = 0.6 m/s, t = 60 °C near the running surface	3
Linear coefficient of thermal expansion	for a temperature range from +23 °C to +60 °C	4
Temperature range	Empirical values determined on finished parts without load in heated air, depending on the type and form of heat exposure, short term = max. 1 h, long term = months	5
Dielectric constant IEC 250	at 10^6 Hz	6
Colours	POM-C natural = white PET natural = white PVDF natural = white to ivory (translucent) PE natural = white PP-H natural = white (translucent) PP-H grey ≈ RAL 7032 PVC grey ≈ RAL 7011 PEEK natural ≈ RAL 7032 PSU natural = honey yellow (translucent) PEI-natural = amber (translucent)	7
Units and abbreviations	o. B. = without snapping 1 MPa = 1 N/mm² 1 g/cm³ = 1,000 kg/m³ 1 kV/mm = 1 MV/m	without

					Mechanical values											
No.	Product	Material	Colour (standard)	Test specimen condition	Density DIN EN ISO 1183	Tensile stress DIN EN ISO 527	Elongation at break DIN EN ISO 527	Modulus of elasticity (tension) DIN EN ISO 527	Modulus of elasticity (bending) DIN EN ISO 178	Flexural strength DIN EN ISO 178	Impact resistance DIN EN ISO 179	Notch impact strength DIN EN ISO 179	Ball pressure hardness $H_{358/30}$ DIN EN ISO 2039-1	Creep stress 1% elongation DIN EN ISO 899-1	Coefficient of sliding friction against steel (dry running) [3]	Sliding wear against steel (dry running) [3]
					1 ρ g/cm³	2 σ_{zS} MPa	3 ε_{zR} %	4 E_t MPa	5 E_{B3} MPa	6 σ_{bB} MPa	7 a_{cU} kJ/m²	8 a_{cN} kJ/m²	9 H_K MPa	10 $\sigma_{1/1,000}$ MPa	11 μ –	12 V µm/km
1	LiNNOTAM	PA 6 C	natural/ black/ blue	dry/ humid	1.15	80/60	40/100	3,100/1,800	3,400/2,000	140/60	o. B.	> 4/> 15	160/125	> 7	0.36/0.42	0.10
2	LiNNOTAM MoS	PA 6 C + MoS_2	black	dry/ humid	1.15	85/60	40/100	3,200/1,850	3,300/2,000	130/50	o. B.	> 5/> 15	150/115	> 7	0.32/0.37	0.10
3	LiNNOTAM HS	PA 6 C-WS	black	dry/ humid	1.15	90/60	30/80	2,500/2,000	3,000/2,300	120/40	o. B.	> 4/> 12	170/130	> 7	0.36/0.42	0.10
4	LiNNOTAM GLiDE	PA 6 C + oil	natural/ black/ yellow/ green/red	dry/ humid	1.14	80/55	50/120	2,800/1,700	3,000/1,900	135/55	o. B.	> 5/> 15	150/100	> 7	0.15/0.20	0.03
5	LiNNOTAM GLiDE Pro T	PA 6 C + solid lubricant	grey/red/ green	dry/ humid	1.14	80/60	40/100	3,100/1,800	3,300/2,000	110/60	o. B.	> 4/> 15	160/125	> 7	0.15/0.23	0.03
6	LiNNOTAM DRiVE 600 Fe	PA 6 C + im-pact-mod-ified	–	dry/ humid	1.15	90	20	2,800	2,500	160/130	o. B.	> 15	175	> 7	0.36/0.42	–
7	LiNNOTAM HiPERFORMANCE 612	PA 6/12 C	natural	dry/ humid	1.12	80/55	55/120	2,500/1,500	2,800/1,800	135/55	o. B.	> 12	140/100	> 15	0.36/0.42	0.12
8	LiNNOTAM HiPERFORMANCE 1200	PA 12 C	natural	dry	1.03	60/50	55/120	2,200/1,800	2,400	90	o. B.	> 15	100	> 11	0.4	–
9	LiNNOTAM HiPERFORMANCE HPI	PA 6 C + im-pact-mod-ified	light yellow	dry/ humid	1.15	90/70	40/100	3,000/1,900	3,100/2,200	130/60	o. B./ –	> 8/ –	145/120	> 7	0.36/0.42	–
10	Polyamide 6	PA 6	natural/ black	dry/hu-mid	1.14	70/45	50/180	2,700/1,800	2,500/1,400	130/40	o. B.	> 3/o. B.	160/70	> 8	0.38/0.42	0.23
11	Polyamide 66	PA 66	natural/ black	dry/ humid	1.14	85/65	30/150	3,000/1,900	2,900/1,200	135/60	o. B.	> 3/> 15	170/100	> 8	0.35/0.42	0.1
12	Polyamide 66 + glass fibre	PA 66 GF 30	black	dry	1.35	160	3	11,000	–	–	50	6	240/200	40	0.45/0.5	–
13	Polyamide 12	PA 12	natural	dry	1.02	50	>200	1,800	1,500	60	o. B.	> 15	100	> 4	0.32	0.8
14	Polyacetal copolymer	POM-C	natural[7]/ black	dry	1.41	65	40	3,000	2,900	115	o. B.	> 10	150	13	0.32	8.9
15	Polyacetal copolymer glass fibre	POM-C GF 30	black	dry	1.59	125	3	9,300	9,000	150	30	5	210	40	0.50	–
16	Polyethylene terephthalate	PET	natural[7]/ black	dry	1.38	80	40	3,000	2,600	125	82	14	140	13	0.25	0.35
17	Polyethylene terephthalate + lubricant	PET-GL	light grey	dry	1.38	75	5	2,230	–	–	23	10	–	–	0.2	0.1
18	Polytetrafluoroethylene	PTFE	natural	dry	2.18	25	380	750	540	6	o. B.	16	30	1.5	0.08	21.0
19	Polyvinylidene fluoride	PVDF	natural[7]	dry	1.78	56	22	2,000	2,000	75	o. B.	> 15	120	3	0.3	–
20	Polyethylene 1000	PE-UHMW	natural[7]/ black/ green	dry	0.94	22	350	800	800	27	o. B.	o. B.	40	–	0.29	0.45
21	Polypropylene homopolymer	PP-H	natural[7]/ grey[7]	dry	0.91	32	70	1,400	1,400	45	o. B.	7	70	4	0.35	11.0
22	Polyvinyl chloride	PVC-U	grey[7]/ black/ red/white	dry	1.42	58	15	3,000	–	82	o. B.	4	130	–	0.6	56.0
23	Polyether ether ketone	PEEK	natural[7]/ black	dry	1.32	95	45	3,600	4,100	160	o. B.	7	230	–	0.34	–
24	Polyether ether ketone (modified)	PEEK-GL	black	dry	1.48	118	2	8,100	10,000	210	25	2.5	215	–	0.11	–
25	polysulfone	PSU	natural[7]	dry	1.24	75	>50	2,500	2,700	106	o. B.	4	150	22	0.4	–
26	polyetherimide	PEI	natural[7]	dry	1.27	105	>50	3,100	3,300	145	o. B.	–	165	–	–	–

All values stated were determined as average values from many individual measurements and refer to a temperature of 23 °C and 50% RH.

Thermal values							Electrical values								Other data
Melting temperature DIN EN ISO 3146	Thermal conductivity DIN 52 612	Specific heat capacity	linear expansion coefficient [4]	Temperature range (long term) [5]	Temperature range (short term) [5]	Fire behaviour in accordance with UL 94 IEC 60695	Dielectric constant [6] IEC 60250	Dielectric loss factor [6]	Specific contact resistance IEC 60093	Surface resistance IEC 60093	Dielectric strength IEC 60243	Creep resistance IEC 60112	Moisture absorption in NK DIN EN ISO 62	Water absorption DIN EN ISO 62	Special properties
13 T_m °C	14 λ W/(K·m)	15 c J/(g·K)	16 α 10^{-5}·K^{-1}	17 – °C	18 – °C	19 – –	20 ε_R –	21 tan δ –	22 ρ_D Ω·cm	23 R° Ω	24 E_d kV/mm	25 – –	26 w(H_2O) %	27 W_s %	
+220	0.23	1.7	7-8	-40 to +105	+170	HB	3.7	0.03	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	2.2	6.5	hard, pressure and abrasion-resistant, largest dimensions can be manufactured
+220	0.23	1.7	7-8	-40 to +105	+160	HB	3.7	0.03	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	2.2	6.5	like PA 6 C, but with increased crystallinity
+220	0.23	1.7	7-8	-40 to +105	+180	HB	3.7	0.03	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	2.2	7	same as PA 6 C, but heat ageing stabilised
+220	0.23	1.7	7-8	-40 to +105	+160	HB	3.7	0.03	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	1.8	5.5	high abrasion resistance, low sliding friction
+220	0.23	1.7	7-8	-40 to +105	+160	HB	3.7	0.03	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	2.2	6.5	low stick-slip, very low sliding friction
+225	0.23	1.7	7-8	-40 to +105	+160	HB	3.7	0.03	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	1.9	5.8	high impact and shock resistance, with steel core
+220	0.23	1.7	7-8	-40 to +105	+160	HB	3.7	0.03	10^{15}	10^{13}	50/20	KA 3c	1.9	5.8	like PA 6 C, but with high impact resistance
+190	0.23	1.7	10-11	-60 to +110	+150	HB	3.7	0.03	10^{15}	10^{13}	50/20	CTI 600	0.9	1.4	low water absorption, very good time stability
+225	0.23	1.7	7-8	-40 to +105	+160	HB	3.7/–	0.03/–	$10^{15}/10^{12}$	$10^{13}/10^{12}$	50/20	CTI 600	1.9	5.8	like PA 6 C, but with increased crystallinity and impact resistance
+218	0.23	1.7	8-9	-30 to +100	+140	HB	7.0	0.3	$10^{15}/10^{12}$	$10^{13}/10^{10}$	50/20	CTI 600	3.0	10.0	tough, good vibration dampening
+265	0.23	1.7	9-10	-30 to +100	+150	HB	5.0	0.2	$10^{15}/10^{12}$	$10^{12}/10^{10}$	50/20	CTI 600	2.5	9.0	high abrasion resistance (similar to PA 6 C)
+255	0.3	1.5	2-3	-30 to +120	+180	HB	3.7	0.02	$10^{14}/10^{13}$	$10^{13}/10^{12}$	60/30	CTI 475	1.5	5.5	high strength, low thermal expansion
+178	0.30	2.09	11-12	-70 to +70	+140	HB	3.1	0.03	2×10^{15}	10^{13}	30	CTI 600	0.8	1.5	tough, resistant to hydrolysis, low moisture absorption
+168	0.31	1.45	9-10	-30 to +100	+140	HB	3.9	0.003	10^{15}	10^{13}	20	CTI 600	0.2	0.8	high strength, impact resistant, low creep tendency
+168	0.40	1.21	3-4	-30 to +110	+140	HB	4.8	0.005	10^{15}	10^{13}	65	KA 3C/ KC > 600	0.17	0.6	high strength, low thermal expansion
+255	0.24	1.1	7-8	-20 to +100	+160	HB	3.6	0.008	10^{16}	10^{14}	50	CTI 600	0.25	0.5	tough, hard, low cold flow, dimensionally stable
+245	0.23	–	6-7	-20 to +110	+160	HB	3.6	0.008	10^{16}	10^{14}	–	CTI 600	0.2	0.5	like PET, aditional maximum wear resistance
+327	0.23	1	18-20	-200 to +260	+280	V-0	2.1	0.0005	10^{18}	10^{17}	40	CTI 600	0.01	< 0.01	high chemical resistance, low strength
+178	0.19	0.96	13	-40 to +140	+160	V-0	8.0	0.165	5×10^{14}	10^{13}	25	CTI 600	< 0.04	< 0.04	Resistance to UV, beta and gamma radiation, abrasion-resistant
+133	0.38	1.84	18	-260 to +50	+80	HB	3.0	0.0004	$> 10^{16}$	10^{14}	44	CM 600	0.01	< 0.01	like PE-HMW, but more abrasion-resistant, low coefficient of friction
+162	0.22	1.7	16	0 to +80	+100	HB	2.25	0.00033	$> 10^{16}$	10^{14}	52	CM 600	< 0.01	< 0.01	similar to PE-HD, but with higher heat resistance
–	0.156	1.05	8	0 to +50	+70	V-0	3.3	0.025	10^{16}	10^{13}	39	KA 3b	< 0.01	< 0.01	good chemical resistance, hard and brittle
+340	0.25	1.06	4-5	-40 to +250	+310	V-0	3.2	0.002	10^{16}	10^{16}	24	CTI 150	0.2	0.45	resistant to high temperatures and hydrolysis, dimensionally stable
+340	0.24	–	3	-40 to +250	+310	V-0	3.2	–	10^{5}	–	24.5	–	0.14	0.3	like PEEK, but with a higher PV value, better sliding properties
–	0.26	1	5-6	-40 to +160	+180	V-0	3.0	0.002	10^{17}	10^{17}	30	CTI 150	0.4	0.8	steam sterilisable, hydrolysis and radiation resistant
–	0.22	–	5-6	-40 to +170	+200	V-0	3.0	0.003	10^{18}	10^{17}	33	CTI 175	0.75	1.35	high strength and rigidity, high heat resistance

Chemical resistance
The reliable force against chemical influences

When it comes to the resistance of parts and components to chemical influences, engineering plastics can be superior to many metallic materials. The following table provides a broad overview of how strong and durable our plastics are in chemical and industrial environments.

Notes on using the list

The information on chemical resistance in the following list refers to tests in which the test specimens were exposed to the respective media without external stresses and loads. Added to this is our experience from the practical and, in some cases, long-standing use of synthetic materials in contact with the media. Due to the diversity of media, this list represents only an excerpt from the data available to us. If the medium you use is not included, we will be happy to provide you with information on the resistance of the plastics we supply upon request.

When applying the list, it should be noted that factors such as:

– Different degree of purity of the medium

– Deviating concentration of the medium

– Temperatures other than those specified

– Alternating temperatures

– Mechanical stress

– Part geometries, especially those that result in thin wall thicknesses or significant differences in wall thickness

– Tensions generated by processing

– Mixtures composed of different media

– Combinations of the above factors

may affect chemical resistance.

Despite being classified as 'conditionally resistant', a plastic component may be superior to a material consisting of metallic components and make more sense economically.

In the case of oxidising media, such as nitric acid and polar organic solvents, there is a risk of stress cracking in many thermoplastics, despite their chemical resistance to the medium. For the manufacture of parts that come into contact with such media, such a manufacturing process should therefore be selected that generates as little mechanical stress as possible in the workpiece. An alternative is to relieve the tension by tempering the semi-finished products before and during the manufacture of the product.

For mixtures of different media, resistance cannot usually be predicted, even if the plastic is resistant to the individual components of the mixture. We therefore recommend attempting storage with the appropriate mixed medium under the expected environmental conditions in this case. It should be noted that parts intended for use in areas where two or more media come into direct contact may also be subject to additional temperature stress due to the reaction heat generated.

Despite being classified as 'stable', contact with the medium may cause surface changes in some cases, such as matting or discolouration, and clouding in transparent plastics. However, despite this surface change, the resistance remains intact.

The information contained in the lists corresponds to our current state of knowledge and should be understood as a recommendation and guideline. For specific applications or in cases of doubt, we recommend testing the resistance by storing the product under the expected conditions of use.

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Concentration	Temperature °C	LiNNOTAM	LiNNOTAM HS	LiNNOTAM MoS	LiNNOTAM GLiDE	LiNNOTAM GLiDE Pro T	LiNNOTAM HiPERFORMANCE HPI	LiNNOTAM HiPERFORMANCE 612	LiNNOTAM HiPERFORMANCE 1200	PA 6 – polyamide 6	PA 66 – polyamide 66	PA 12 – polyamide 12	POM-C – polyacetal copolymer	PET – polyethylene terephthalate	PET-GL – polyethylene terephthalate/lubricant	PTFE – polytetrafluoroethylene	PVDF – polyvinylidene fluoride	PE-UHMW – polyethylene 1000	PP-H – polypropylene homopolymer	PVC-U – polyvinyl chloride un-plasticised	PEEK – polyether ether ketone	PEEK-GL – modified polyether ether ketone	PSU – polysulfone	PEI – polyetherimide
1 acetaldehyde	40	20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	+	+	–	+	+	–	+
2 acetamide	50	20	+	+	+	+	+	+	+	+	+	+	+	+	/	/	+	–	+	+	/	+	+	/	+
3 acetone	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	O	O	+	–	+	+	–	+	+	–	–
4 acrylonitrile	UD	RT	+	+	+	+	+	+	+	+	+	+	+	/	/	/	+	+	+	+	/	+	+	–	/
5 allyl alcohol	UD	RT	O	O	O	O	O	O	O	O	O	O	O	/	+	+	+	/	+	+	–	+	+	O	/
6 aluminium chloride	10	RT	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	+	+	+	+	+	+	+
7 formic acid	2	RT	O	O	O	O	O	O	O	O	O	O	O	+	+	+	+	+	+	+	+	+	+	/	+
8 formic acid	UD	RT	S	S	S	S	S	S	S	O	S	S	O	–	O	O	+	+	+	+	+	O	O	–	/
9 ammonia	10	RT	+	+	+	+	+	+	+	+	+	+	+	+	–	–	+	+	+	+	+	O	O	–	–
10 ammonium hydroxide	30	RT	+	+	+	+	+	+	+	+	+	+	+	–	–	–	+	–	+	+	/	+	+	+	–
11 ammonium nitrate	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	–
12 aniline	UD	RT	–	–	–	–	–	–	–	O	–	–	O	O	+	+	+	+	+	O	–	+	+	–	/
13 antimony trichloride	10	RT	–	–	–	–	–	–	–	–	–	–	–	/	/	/	+	+	+	+	+	+	+	/	/
14 benzaldehyde	UD	RT	O	O	O	O	O	O	O	O	O	O	O	+	+	+	+	O	+	+	–	+	+	–	–
15 petrol (premium)	CA	40	+	+	+	+	+	+	+	+	+	+	+	+	/	/	+	+	O	O	–	+	+	O	–
16 benzene	UD	RT	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	O	O	–	+	+	–	–
17 benzoic acid	UD	RT	–	–	–	–	–	–	–	+	–	–	+	O	+	+	+	+	+	+	+	+	+	/	/
18 benzyl alcohol	UD	RT	O	O	O	O	O	O	O	O	O	O	O	+	+	+	+	+	+	+	/	+	+	O	–
19 bleaching lye (12.5% AC)	CA	RT	–	–	–	–	–	–	–	O	–	–	O	–	+	+	+	+	+	+	+	+	+	–	+
20 borax	AS	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	/	/	+	+	/	/
21 boric acid	10	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
22 hydrobromic acid	10	RT	–	–	–	–	–	–	–	–	–	–	–	–	O	–	+	+	+	+	+	+	+	+	/
23 hydrobromic acid	50	RT	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	O	O	/	/
24 butanol	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+
25 butyl acetate	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	/	/	+	+	–	O
26 calcium chloride	5	RT	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	+	+	+	+	+	O	+
27 calcium chloride in alcohol	20	RT	–	–	–	–	–	–	–	–	S	S	–	–	+	+	+	+	+	+	/	+	+	O	+
28 calcium hypochloride	SS	RT	–	–	–	–	–	–	–	–	–	–	–	–	O	O	+	+	+	+	+	+	+	/	/
29 chlorobenzene	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	O	–	+	+	S	–
30 chloroacetic acid	UD	RT	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	/	+	+	/	/
31 chloroform	UD	RT	O	O	O	O	O	O	O	O	O	O	O	–	–	–	+	+	O	O	–	+	+	S	–
32 chromic acid	1	RT	O	O	O	O	O	O	O	O	O	O	O	O	+	+	+	+	+	+	+	+	+	O	+
33 chromic acid	50	RT	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	O	O	+	+	+	O	/
34 cyclohexane	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	/
35 cyclohexanol	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	–
36 cyclohexanone	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	–	–	+	O	+	+	+	+	+	S	/
37 dibutyl phthalate	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	O	/	/	+	+	+	O
38 dichloroethane	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	–	–	+	+	O	O	–	+	+	S	–
39 dichloroethylene	UD	RT	+	+	+	+	+	+	+	+	+	+	+	S	S	S	+	+	–	O	–	+	+	/	/
40 iron(II) chloride	SS	RT	–	–	–	–	–	–	–	–	–	–	–	O	/	/	+	+	+	+	+	+	+	–	+
41 iron(III) chloride	SS	RT	–	–	–	–	–	–	–	–	–	–	–	O	/	/	+	+	+	+	+	+	+	–	+
42 vinegar	CA	RT	–	–	–	–	–	–	–	+	–	–	+	+	+	+	+	O	+	+	+	+	+	/	/
43 acetic acid	5	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
44 acetic acid	10	RT	O	O	O	O	O	O	O	+	O	O	+	O	+	+	+	+	+	+	+	+	+	+	+
45 acetic acid	10	50	–	–	–	–	–	–	–	O	–	–	O	–	+	+	+	+	+	+	+	+	+	+	+
46 acetic acid	95	RT	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	O	+	+	–	–
47 acetic acid	95	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	O	O	O	–	+	+	–	–
48 ethyl ether	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	O	–	+	+	O	+
49 hydrofluoric acid	AS	RT	S	S	S	–	S	S	S	S	S	S	S	–	–	–	+	+	+	+	+	S	S	–	O
50 formaldehyde	UD	RT	O	O	O	O	O	O	O	O	O	O	O	+	+	+	+	+	+	+	+	+	+	–	–

UD = undiluted
AS = aqueous solution
SS = saturated solution
CA = commercially available
RT = room temperature
\+ = stable
O = conditionally stable
– = not constant
S = soluble
/ = not tested

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Concentration	Temperature °C	LiNNOTAM	LiNNOTAM HS	LiNNOTAM MoS	LiNNOTAM GLiDE	LiNNOTAM GLiDE Pro T	LiNNOTAM HiPERFORMANCE HPI	LiNNOTAM HiPERFORMANCE 612	LiNNOTAM HiPERFORMANCE 1200	PA 6 – Polyamide 6	PA 66 – Polyamide 66	PA 12 – Polyamide 12	POM-C – polyacetal copolymer	PET – polyethylene terephthalate	PET-GL – polyethylene terephthalate/lubricant	PTFE – polytetrafluoroethylene	PVDF – polyvinylidene fluoride	PE-UHMW – polyethylene 1000	PP-H – polypropylene homopolymer	PVC-U – polyvinyl chloride unplasticised	PEEK – polyether ether ketone	PEEK-GL – modified polyether ether ketone	PSU – polysulfone	PEI – polyetherimide
51 glycerine	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+
52 fuel oil	CA	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	/	+	+	+	+	+	+	+
53 heptane	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	O	+
54 hexane	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	+
55 isopropanol	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	O	O	+	+	+	+	+	+	+	O	/
56 potash lye	10	RT	+	+	+	+	+	+	+	+	+	+	+	+	–	–	+	+	+	+	+	+	+	O	+
57 potash lye	10	80	+	+	+	+	+	+	+	+	+	+	+	+	–	–	+	O	–	+	–	+	+	O	–
58 potash lye	50	RT	O	O	O	O	O	O	O	+	O	O	+	+	–	–	+	+	+	+	+	+	+	O	–
59 ketones (aliphatic)	UD	RT	O	O	O	O	O	O	O	O	O	O	O	+	–	–	+	/	+	/	/	+	+	/	/
60 methanol	50	RT	+	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	+	+	+	+	O	+
61 methanol	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	+	+	+	+	O	+
62 methylene chloride	UD	RT	–	–	–	–	–	–	–	O	–	–	O	–	–	–	+	+	O	O	S	+	+	S	S
63 mineral oil	CA	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
64 sodium hypochloride	10	RT	–	–	–	–	–	–	–	–	–	–	–	–	O	O	+	+	+	O	+	+	+	+	/
65 Caustic soda	10	RT	+	+	+	+	+	+	+	+	+	+	+	+	O	O	+	O	+	+	+	+	+	+	O
66 Caustic soda	10	80	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	O	O	+	O	+	+	+	–
67 Caustic soda	50	RT	O	O	O	O	O	O	O	O	O	O	O	+	–	–	+	O	+	+	+	+	+	+	–
68 Caustic soda	50	80	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	O	O	+	O	+	+	+	–
69 nitrobenzene	UD	RT	–	–	–	–	–	–	–	–	–	–	–	O	O	O	+	+	+	+	–	+	+	–	–
70 nitrotoluene	UD	RT	O	O	O	O	O	O	O	O	O	O	O	O	+	+	+	/	+	+	–	+	+	/	/
71 oxalic acid	10	RT	O	O	O	O	O	O	O	O	O	O	O	–	+	+	+	+	+	+	+	+	+	+	+
72 phenol	90	RT	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	+	+	+	O	+	+	–	–
73 phenol	UD	40	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	+	+	+	–	+	+	–	–
74 phenol	UD	60	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	O	–	–	–	+	+	–	–
75 phenol	UD	80	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	O	–	–	–	+	+	–	–
76 phosphoric acid	10	RT	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
77 phosphoric acid	25	RT	–	–	–	–	–	–	–	–	–	–	–	O	+	+	+	+	+	+	+	+	+	+	+
78 phosphoric acid	85	RT	S	S	S	S	S	S	S	S	S	S	S	–	+	+	+	+	+	+	+	+	+	O	–
79 propanol	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
80 Nitric acid	10	RT	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+
81 Nitric acid	10	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	+	+	/	/
82 Nitric acid	50	RT	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	+	–	–	–	O	O	+	/
83 Nitric acid	80	RT	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	O	–	–	–	O	O	+	/
84 hydrochloric acid	10	RT	–	–	–	–	–	–	–	–	–	–	–	–	O	O	+	+	+	+	+	+	+	+	+
85 hydrochloric acid	20	RT	–	–	–	–	–	–	–	–	–	–	–	–	O	O	+	+	+	+	+	+	+	+	+
86 hydrochloric acid	30	RT	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	+	+	+	+	+	+	O	+
87 Sulphuric acid	40	RT	–	–	–	–	–	–	–	–	–	–	–	–	O	O	+	+	+	+	+	O	O	+	+
88 Sulphuric acid	40	60	–	–	–	–	–	–	–	–	–	–	–	–	O	O	+	+	+	+	O	–	–	O	O
89 Sulphuric acid	96	RT	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	+	O	O	+	S	S	S	–
90 Sulphuric acid	96	60	S	S	S	S	S	S	S	S	S	S	S	–	–	–	+	+	–	–	O	S	S	S	–
91 carbon tetrachloride	UD	RT	+	+	+	+	+	+	+	+	+	+	+	O	+	+	+	+	–	–	–	+	+	+	+
92 toluene	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	O	–	+	+	–	–
93 trichloroethylene	UD	RT	O	O	O	O	O	O	O	O	O	O	O	O	O	O	+	+	O	O	–	+	+	S	–
94 hydrogen peroxide	10	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
95 hydrogen peroxide	20	RT	–	–	–	–	–	–	–	O	–	–	O	+	+	+	+	+	+	+	+	+	+	+	+
96 hydrogen peroxide	30	RT	–	–	–	–	–	–	–	–	–	–	–	O	+	+	+	+	+	+	+	+	+	+	+
97 hydrogen peroxide	30	60	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	/	O	O	O	+	+	/	/
98 xylene	UD	RT	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	O	O	–	+	+	O	O
99 citric acid	10	RT	O	O	O	O	O	O	O	+	O	O	+	+	+	+	+	+	+	+	+	+	+	O	+
100 citric acid	10	50	O	O	O	O	O	O	O	O	O	O	O	–	+	+	+	+	+	+	+	+	+	O	+

UD = undiluted
AS = aqueous solution
SS = saturated solution
CA = commercially available
RT = room temperature
\+ = stable
O = conditionally stable
– = not constant
S = soluble
/ = not tested

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