



Modified Engineering Plastics

High Performance Polymers | 2017

PENTAMID



Modified Engineering Plastics

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PENTAMID

PENTAC since 1988



PENTAC Polymer GmbH, a mid-sized, independent and family owned company, is known for innovation, reliability and quality of their engineering plastics.

PENTAC develops and manufactures tailor made products for a wide range of applications. Especially the automotive industry has certified and approved our materials for high end use.

Our customers benefit from our longterm experience in high end compounds fulfilling all requirements of a challenging market.

Polyamide injection molding compounds form the core of our business model.

Significant growth of our business during the last years were the base for substantial investments in our production and logistics facilities. PENTAC's actual capacity adds up to about 30,000 tons of compounds annually.



Passion Mission Vision

PENTAC's vision is based on six pillars, that determine our processes, communication, focus and objectives.

- **Innovation**

Innovation begins in our minds. PENTAC's working culture is oriented to new ideas and developments. Together with our customers we create future solutions and answers to new requirements.

- **Performance**

Average quality was yesterday's standard. We are focussed on specialties with superior performance in nowadays markets. Our compounds are the result of long intense work.

- **Reliability**

A modern quality management system contributes significantly to our success. Process control and steady improvement allow consistent conformity with customers' requirements.

- **Satisfaction**

The customer stands in the focus of all our activities. Compliance with ambitious specifications and customer satisfaction are our ultimate aims. PENTAC always makes an additional effort to improve products and services.

- **Competence**

Finding the best individual solution for our customer is PENTAC's challenging business venture. Excellent education of our staff and many years of experience enable us to guarantee the best possible technical service and after sales support.

- **Improvement**

Stagnation means regression and does not fit into PENTAC's business model. Our philosophy demands continuous improvement process for products, processes, employees' expertise.

Polyamides are:

- semi-crystalline
- tough
- abrasion resistant
- moisture absorbing
- chemical resistant
- temperature resistant
- insulating

Polyamides

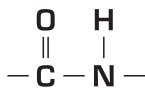


At the beginning there was the protein!

Polyamides – an engineering plastic family making history.

Already in the early 1930's the first polyamides have been used industrially by polycondensation of dicarboxylic acid with diamine and hydrolytic polymerization of circular poly lactame.

Despite many possible other molecules with a theoretical chance, the market was conquered by Polyamide 6 and Polyamide 6.6 with their well-balanced properties and their convenient feedstock and production costs. In case of special requirements for heat distortion temperature (HDT) and chemical resistance polyamide 4.6 and PPA might be of interest. The replicated amide group is characteristic for all types of polyamides.

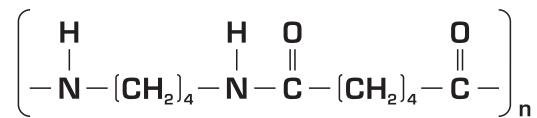


Properties of thermoplastic molding materials are affected by the used monomers.

As for many other polymers mineral oil is the production base of the underlying raw materials.

▪ Polyamide 4.6 = PENTAMID® AHT

is characterized by a higher melting temperature, a higher crystallinity and a higher velocity of crystallization compared to Polyamide 6 and Polyamide 6.6. The material provides excellent temperature, water and chemical resistance combined with low friction and better fatigue behaviour. There is a loss in dimensional stability because of higher water adsorption.



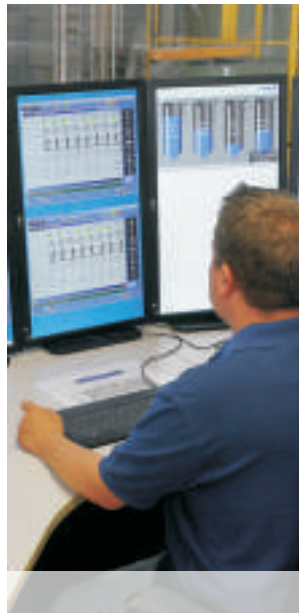
▪ PPA = PENTAMID® AHT1 and AHT2

Partially aromatic polyamides, abbreviated PPA (polyphthalamides), close the gap between polyamide 6.6, polyamide 6 and expensive high performance polymers. Here aromatic groups are incorporated into the (linear) aliphatic polymer chains. Number and type of aromatic bicarboxylic acids account for varying property profiles of these high performance polymers.

Mineral oil → Benzene → Cyclohexanone →

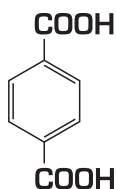
aliphatic bicarboxylic acid (here adipic acid) + TMD Polycondensation → PA 4.6

aromatic bicarboxylic acid + aliphatic bicarboxylic acid + HMD Polycondensation → PPA

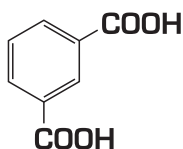


Product positioning High Performance Polymers

Aromatic dicarboxylic acids



Terephthalic acid (→ PA 6T)

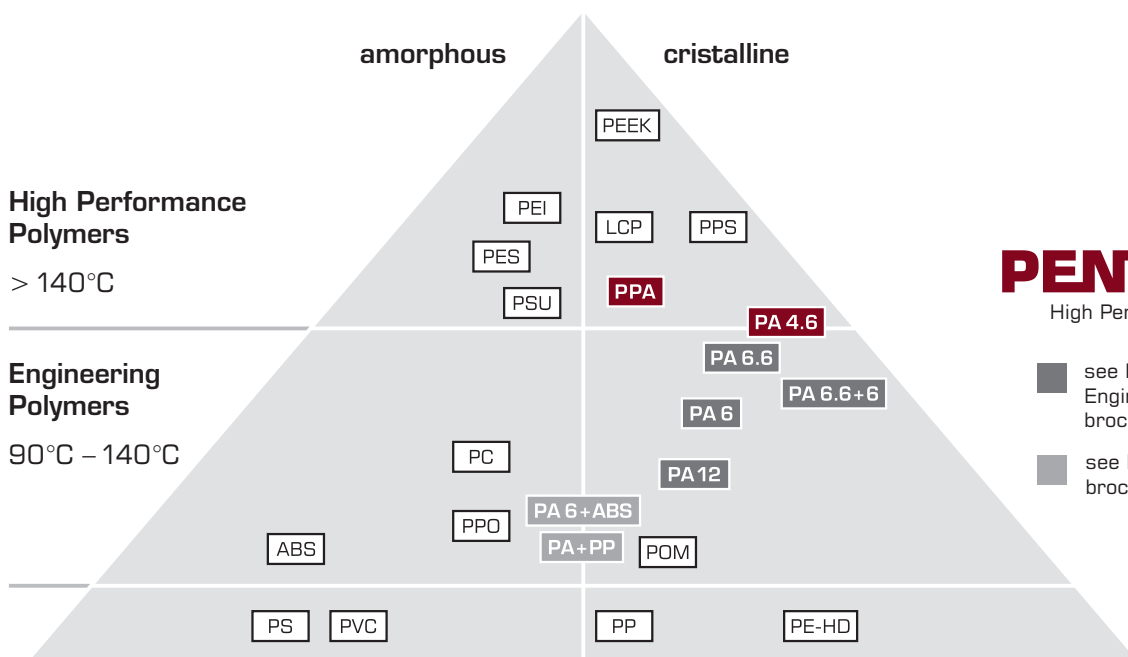


Isophthalic acid (→ PA 6I)

Higher shares of terephthalic acid generate higher glass transition temperatures and thus higher application temperatures.

▪ Polyamide 6.6 + PPA = PENTAMID® AHS

stands for a polymer blend of PPA and polyamide 6.6. This product group provides property profiles in between PPA and classic technical polyamides. Therefore it is very well suited for applications in the field of metal replacement.



PENTAMID

High Performance Polymers

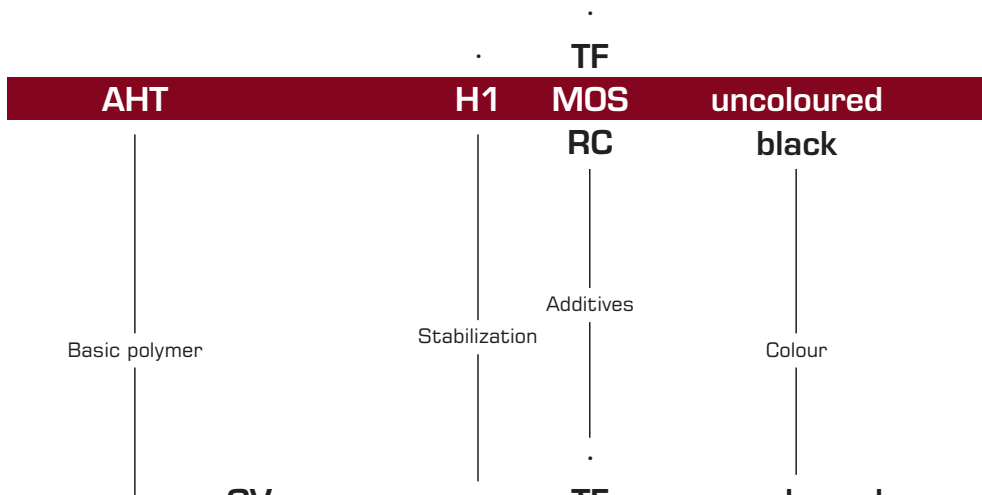
- see PENTAMID® Engineering Polymers brochure
- see PENTALLOY® brochure

Nomenclature



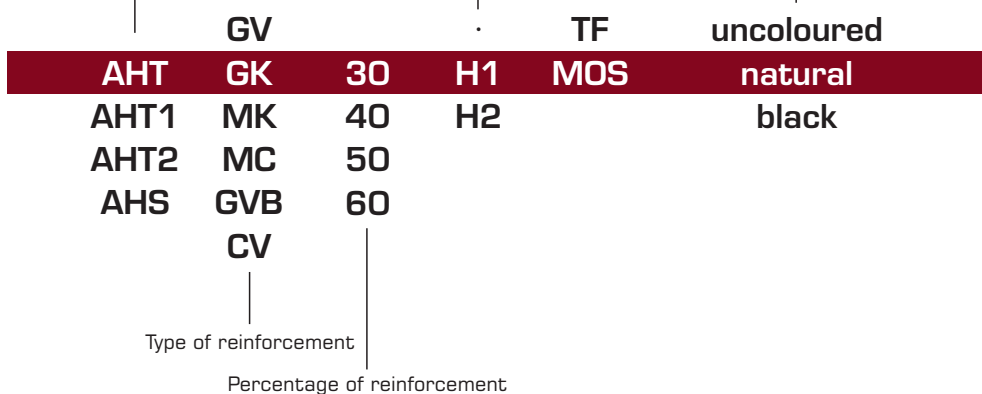
PENTAMID

non-reinforced grades



PENTAMID

reinforced grades



- Type of reinforcement: **GV** glass fiber reinforced | **GK** glass bead reinforced | **MK** „classic“ mineral reinforced | **MC** „special“ mineral reinforced | **GVB** glass fiber / hollow glass spheres reinforced | **CV** carbon fiber reinforced
- Percentage: **30 - 60** amount of reinforcement from 30 up to 60 wt.-%
- Stabilization: **H1** hot oil resistant | **H2** highly heat resistant
- Additives: **TF** PTFE-additive | **MOS** Molybdenumdisulfide | **RC** recyclate



Portfolio
PENTAMID®
 High Performance
 Polymers

	AHT1 PA 6T/X	AHT2 PA 6T/6.6	AHT PA 4.6 + PA 6.6	AHS PA 6.6 + PA 6T/X
Product family				
non-reinforced			•	
glass fiber reinforced	•	•	•	•
glass bead-, mineral-, hybrid reinforced		[•]		[•]
lubricated			•	

- available
- [•] in preparation



PENTAMID® High Performance Polymers

- efficient at higher temperatures





Applications

- Parts of pumps
- Parts in oil circulation
- Valves
- Connectors
- Head light housings
- Water pumps
- Gear wheels
- Bearing bushes
- Bearing housing

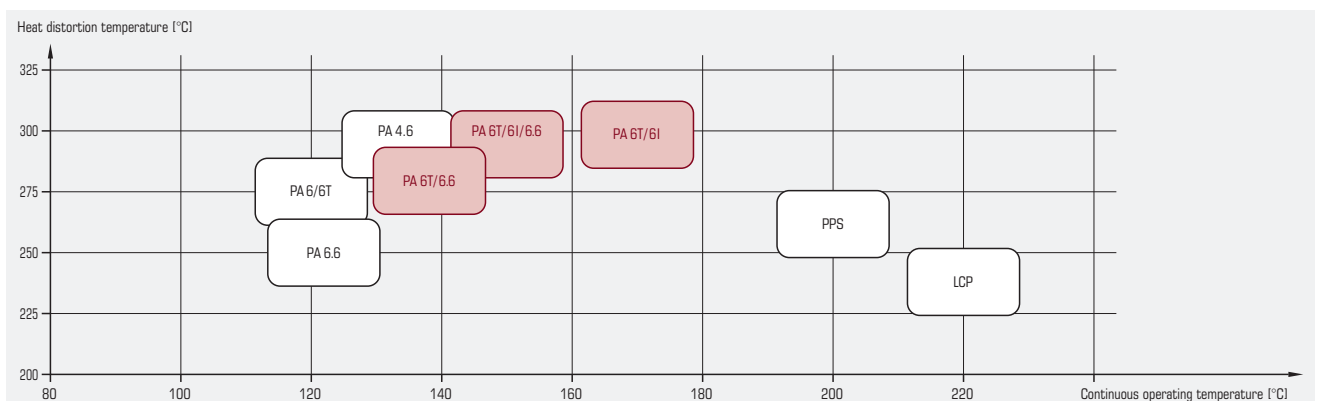
▪ PENTAMID® AHT1

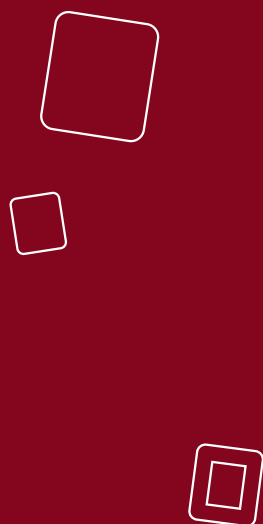
is a group of partially aromatic polyamides based on PA 6T/X accounting for very high glass transition temperatures of 120°C to 130°C. PENTAMID® AHT1 materials provide excellent dimensional stabilities even at high application temperatures.

▪ PENTAMID® AHT2

This product group is based on PA 6T/6.6 and offers improved processing properties versus PENTAMID® AHT1 grades at comparable sets of properties. Slightly lower glass transition temperatures are very often sufficient for many applications.

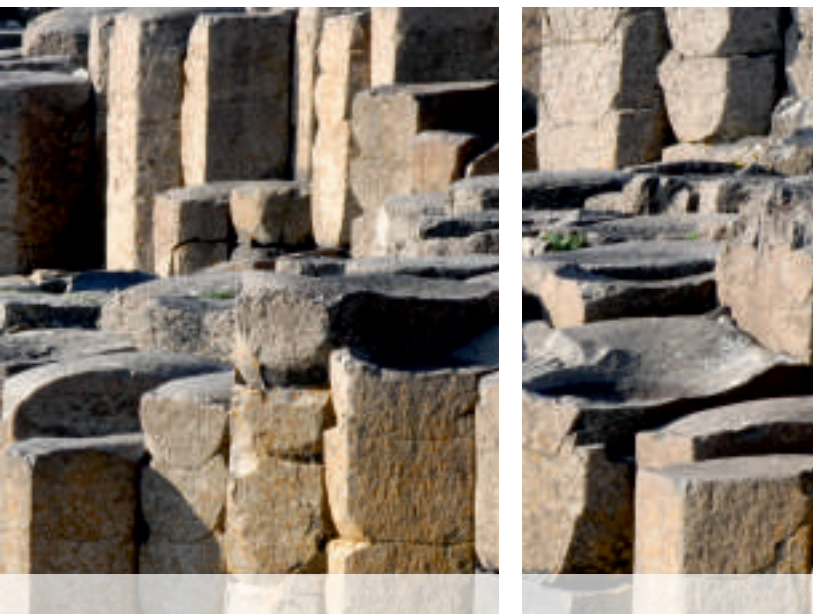
Heat distortion temperature (HDT) versus continuous operating temperature of various GF reinforced, partially aromatic polyamides in comparison to other high performance polymers.





PENTAMID® High Performance Polymers

- efficient at higher temperatures
- closes the gap
to engineering polymers



Applications

- Operation carrier
- Gearbox housing
- Fan wheels
- Steering lock housing
- Sliding rails
- Valves

non-reinforced
glass fiber reinforced
lubricated

▪ PENTAMID® AHT

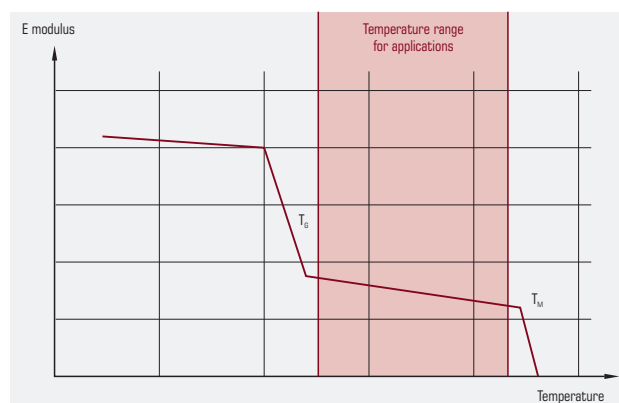
Entirely new polyamide 4.6 compounds: the new PENTAMID® AHT grades are composed of PA 4.6 and PA 6.6 blends. Special attention was turned on improved processability, flowability, and surface quality.

▪ PENTAMID® AHS

This product family, based on PA 6.6 including a share of partially aromatic PPA, is established in the market and predestined for applications in the field of pressure casting. High stiffness, excellent dimensional stability and delayed moisture pickup are quality marks for PENTAMID® AHS.

Type	Polymer	Melting temperature T_M	Glass transition temperature T_G	Tool temperature
PENTAMID® AHT1	PA 6T/X	325°C	120°C – 130°C	125°C – 160°C
PENTAMID® AHT2	PA 6T/6.6	310°C	95°C – 105°C	100°C – 140°C
PENTAMID® AHT	PA 4.6 + PA 6.6	285°C	75°C	80°C – 120°C
PENTAMID® AHS	PA 6.6 + PA 6T/X	265°C	80°C	90°C – 120°C

E modulus of semicrystalline materials versus temperature
 T_G = glass transition temperature
 T_M = melting temperature



non-reinforced

glass fiber reinforced

lubricated

Quality	Standards	Unit	
Color			
Physical properties			
Density	ISO 1183	g/cm ³	d. a. m.
Viscosity number	ISO 307	ml/g	d. a. m.
Water absorption (saturation)	ISO 62	%	-
Moisture absorption (23°C 50% r.h.)	ISO 62	%	-
Molding shrinkage parallel	ISO 294-4	%	d. a. m.
Molding shrinkage normal	ISO 294-4	%	d. a. m.
Coefficient of friction – static			
Coefficient of friction – dynamic			
Mechanical properties			
Tensile modulus	ISO 527-2 (1 mm/min)	MPa	d. a. m. cond.
Tensile strength at yield	ISO 527-2 (50 mm/min)	MPa	d. a. m. cond.
Elongation at yield	ISO 527-2 (50 mm/min)	%	d. a. m. cond.
Stress at break	ISO 527-2 (5 mm/min)	MPa	d. a. m. cond.
Strain at break	ISO 527-2 (5 mm/min)	%	d. a. m. cond.
Flexural strength at break	ISO 178	MPa	d. a. m. cond.
Flexural modulus	ISO 178	MPa	d. a. m. cond.
Impact strength (Charpy @ 23°C)	ISO 179/1eU	kJ/m ²	d. a. m. cond.
Notched impact strength (Charpy @ 23°C)	ISO 179/1eA	kJ/m ²	d. a. m. cond.
Thermal and other properties			
Melting point (DSC)	ISO 11357	°C	d. a. m.
Heat deflection temperature HDT/A	ISO 75 (1.80 MPa)	°C	d. a. m.
Heat deflection temperature HDT/B	ISO 75 (0.45 MPa)	°C	d. a. m.
Flammability class (UL 94)	ISO 1210 (1.6 mm)	Rating	d. a. m.

AHT H1	AHT GV30 H1	AHT GV40 H1	AHT GV30 H RC	AHT1 GV50 H2	AHT1 GV60 H2	AHT2 GV30 H2	AHT2 GV40 H2	AHT2 GV50 H2	AHT2 GV60 H2	AHS GV30 H2	AHS GV40 H2	AHS GV50 H2	AHS GV60 H2	AHT GV30 H TF15
virgin	virgin	virgin	RC	virgin	virgin	virgin	virgin	virgin	virgin	virgin	virgin	virgin	virgin	virgin
+	+	+	+++	+++	+++	++	++	++	++	++	++	++	++	++
1.18	1.41	1.51	1.41	1.62	1.74	1.42	1.5	1.62	1.74	1.38	1.48	1.57	1.68	1.51
140	140	140	130											140
10	7.5	6.3	7.5	4	3.8	4.5	4.3	4.1	3.9	5.2	4.7	4.2	3.7	6.2
3.6	2	1.8	2	1.4	1.3	1.8	1.5	1.4	1.3	1.6	1.5	1.4	1.3	1.4
2	0.5	0.5	0.65	0.2	0.2	0.25	0.2	0.15	0.1	0.25	0.2	0.15	0.1	0.55
2.1	0.8	0.75	1	0.6	0.5	0.8	0.7	0.6	0.5	0.7	0.6	0.5	0.4	0.75
														0.19
														0.26
3000	10000	13000	8900	18500	20900	11100	15800	19100	21000	10800	14700	18850	22800	8600
1000	6150	6900	5750	17800	19500	10600	15200	18600	20500	10000	13900	17950	21800	5700
100														
55														
15														
25														
	175	210	180	245	255	180	220	245	260	230	240	250	260	150
	115	120	110	240	250	175	210	235	250	210	220	230	240	100
	3	3	4	1.9	1.8	2	1.9	1.8	1.7	2.8	2.5	2.2	1.9	3
	7	6	8	2	1.9	2	2	1.9	1.8	2.9	2.6	2.3	2	6
125														
3250														
n.b.	55	85	50	80	90	60	75	85	95	80	85	90	95	48
n.b.	90	85	80	85	95	65	80	90	100	85	90	95	100	65
10	12	12	10	11	13	10	12	13	14	14	16	18	20	8
30	22	22	15	12	14	11	13	14	15	15	17	19	21	12
285	285	285	285	325	330	310	310	310	310	265	265	265	265	285
160	270	270	265	310	320	270	280	290	300	220	225	230	235	265
270	280	280	280											280
HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB

Quality



Our customers expect the best quality from us. Therefore a complete and accurate analysis of the used raw materials is essential. Defined effective control procedures for incoming raw materials and production parameters secure high quality standards for our clients.

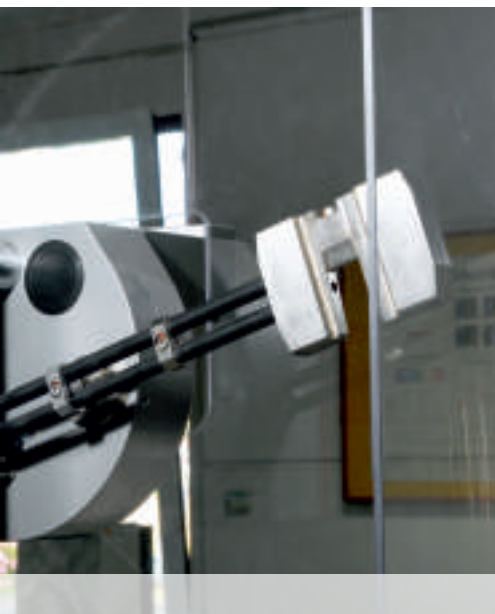
Compliance with European standards (ISO 9001, ISO 14001, ISO 50001) guarantee quality as well as responsible handling of environment and resources.

To cope with the high standards of our customers, we are using state of the art technologies in our plant. A very well equipped laboratory with fully automatic analysis devices and a continuous control system, as well as a quick and easy recording of all data by using high-tech communication devices provides the basis for an extensive and complete control and documentation system.

Certificates of analysis acc. EN 10204 3.1, permanent evaluation of suppliers and regular audits are part of our regular work.

Last but not least the longtime experience of our staff supports the consequent quality-, environment- and energy policy of PENTAC.





Processing Handling Service

Processing recommendations for PENTAMID®

■ Preparation | Drying

PENTAMID® will be delivered for immediate use. To avoid moisture condensation on the pellets you should store the product 24 hours before processing at ambient temperature. It is recommended to dry the pellets at a temperature of 80°C for 2 – 12 hours in a dry air dryer. Please carefully attend to the recommended moisture level between 0.01% and 0.09%. In case of open or destroyed packaging a pre-drying is mandatory.

Recommended processing moisture [%]

PENTAMID® AHT1	0.01 – 0.05
PENTAMID® AHT2	0.01 – 0.05
PENTAMID® AHT	0.05 – 0.09
PENTAMID® AHS	0.04 – 0.08

■ Recommended processing parameters

Please find the recommended melt temperatures for our different grades in the following table:

PENTAMID®	Recommended processing temperatures					
	Zone 5	Zone 4	Zone 3	Zone 2	Zone 1	Feed zone
AHT1	320°C	335°C	325°C	325°C	325°C	80°C
AHT2	310°C	320°C	315°C	310°C	310°C	80°C
AHT	310°C	315°C	310°C	305°C	295°C	80°C
AHS	295°C	300°C	295°C	290°C	285°C	80°C

■ Plasticizing | Dosing

Polymers should always be plasticized as gently as possible. For this, adjust the screw speed at such a level, that the available cooling time is used by about 80% to allow the polymer to be molten by the heaters. For processing our engineering resins, we recommend dosing screws with a compression ratio of about 1: 2.2 – 2.8. The feeding zone should be relatively long (50 – 60% L), compression zone rather short (20 – 25% L), to avoid excessive wear in the compression zone itself (L/D-ratio 20±2).

We also recommend the use of high-alloy steels which are corrosion resistant. A regular maintenance of the check-valve is recommended.

The High Performance PENTAMID® grades should be processed at a mold temperature between 80°C and 160°C. The higher the temperature of the mold the higher the crystallinity and therefore the higher the dimension stability and smoother the surface quality.

Please find all relevant data for our process parameters on our recommendations at www.pentac.de.



▪ Shrinkage

The shrinkage of polymer material is no constant value. Besides the formulation, the shrinkage depends on:

- Wall thickness of the part
- Holding pressure
- Cooling time
- Mold temperature
- Fiber orientation

Therefore stated shrinkage data are only indicative.

Please find additional and individual information on our technical data sheets at www.pentac.de.

Post-processing recommendations for PENTAMID®

There are different possibilities to finish parts made of PENTAMID®. We want to give a basic recommendation for that:

▪ Painting

Polyamides are usable for painting due to their excellent resistance against most solvents. As usually the procedure of post-processing have to be adjusted to the respective PENTAMID®-grade.

Most PENTAMID®-grades cannot be powder coated; in those cases we recommend our conductive PENTAMID®-grades.

▪ Printing

Contrary to the painting process PENTAMID®-grades are easy to imprint with most common print technologies without any pretreatment. The molded parts must be free of any mold release agent.

▪ Welding

Parts made from PENTAMID® can be welded by all known and common methods, e.g. ultra-sonic-, diode-, friction-, and infrared-welding. The best method depends mainly on the geometry of the part, mechanical strength is excellent.

▪ Plating

Mineral reinforced PENTAMID® with their outstanding surface quality can be easily galvanized. Mechanical properties might be changed in the process.

▪ Laser marking

One of the smartest labeling procedures is the marking of our laser sensitive and markable polyamides. PENTAC offers a variety of PENTAMID®-LS-grades, which can be labeled permanently and fraud resistant by controlled laser beams. Due to the contactless labeling there is no negative influence on the mechanical properties.

It is our specialty to label bright surfaces as well as dark surfaces made of reinforced polyamide.



▪ Bonding

Because of their outstanding chemical resistance polyamides do not respond well to bonding. Special surface treatments can facilitate adhesion.

Reactive adhesives (e.g. multi-component systems) are preferred versus solvent adhesive glues due to their very aggressive and harmful ingredients.

Imprint

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