Stock shapes

Plastics used in aerospace technology

Content

Technical plastics contribute to making applications more efficient and competitive in many industrial areas. The aerospace industry places high demands on materials. The impressive properties of high-performance plastics include their low weight and fire behaviour.

Benefits at a glance

- → Weight savings of up to 60 % compared to aluminium reduce energy consumptions
- → Plastics can be processed better than other materials
- → Greater freedom in component design re-sults in reduced production and installation costs
- → Good chemical resistance
- → Inherent flame-resistance: High-performance plastics meet the requirements of UL 94 -V0 and fire behaviour standards in accordance with FAR 25.853
- → Fire behaviour with regard to: smoke gas density, smoke gas toxicity, heat release
- → High specific strength due to fibre-reinforced plastics
- → Convincing gliding properties with outstanding dry-running characteristics and freedom from maintenance in the application
- → Low outgassing in vacuum
- → Good radiation resistance

The characteristics of our plastics products fulfil the detailed requirements of material specifications of final customers and system suppliers in the aerospace industry. Safety aspects and reduced energy consumption are of primary importance.

Ensinger quality in aerospace engineering

As requested by our customers, we have checked and qualified a large share of our materials against required specifications. We can qualify additional materials on request.

Due to the special requirements of the aerospace industry, Ensinger takes on responsibility for: raw materials receipt inspections, raw materials specifications, composition specifications for individual articles, final inspections, issuing of inspection certificates, and much more.

In addition, Ensinger can offer the complete documentation and traceability for all materials and manufacturing processes. The reliability of these processes is documented through all production procedures, such as compounding, semi-finished product extrusion and finished product production through injection moulding or machining.

Ensinger is certified in accordance with ISO 9001:2008 and has a quality management system that follows international standards, implements them and anchors them permanently in procedures.

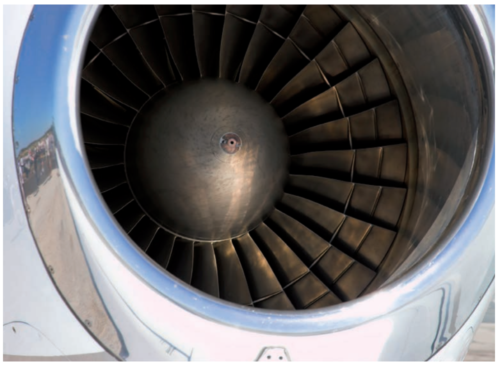
Plastics in application

Engineering and high-performance plastics used in aerospace engineering are required to comply with extremely stringent requirements.

Working in close cooperation with companies in the aviation industry, our specialists have already developed a range of optimum solutions.

Aircraft components

The airframe, aircraft fairing components, wings, nose, fuselage and tailplane are made of a number of components. The materials used for these must have good thermal and mechanical properties as well as good resistance to aging.



Material and parts

Plastics used for such functions as fixing elements, ball bearings, seals or sliding bearings have excellent mechanical properties.

Equipment and systems

For materials used in the propulsion elements, control units or landing gear, good electrical and thermal properties are essential. Controlled fire behaviour, low fume toxicity, good sliding properties and high chemical resistance are also a requirement.

Cabin interior

Because plastics are used in lighting systems, seats, the on-board kitchen and cooling systems, in the oxygen supply, drinking water and disposal systems, as well as freight loading facilities, in some cases supplementary specifications such as FDA, fungus test and drinking water approvals are additionally required.

Propulsion systems

For applications in machines, components or housings, materials are required above all to offer good thermal resistance and sliding properties.

		TECAFORM AH natural (POM-C)	TECAFORM AD natural (POM-H)	TECAMID 66 natural (PA 66)	TECAFLON PTFE natural (PTFE)	TECATRON GF40 natural (PPS)	TECAPEEK PVX black (PEEK)	TECAPEEK GF30 natural (PEEK)	TECAPEEK natural (PEEK)	TECATOR natural (PAI)	TECASINT (PI)
Aviation	**Aerostructure**										
	Door fairings			●							
	Fuselage and tailplane components								●		
	Wings: Slats and flaps, boxes, panels		●	●					●		
	Airframe: Doors, components, electrics, pipes and leads, cable ducts	●				●	●	●	●		
	Components										
	Fasteners	●	●	●					●		
	Bearings						●		●		●
	Sealings	●	●	●	●				●		
	Bushings						●		●		●
	Refuelling and fuel systems	●	●		●	●	●	●	●		●
	Equipment, system & support										
	Actuation & Control Systems: Air management, thermal and power management, engine control, electrical landing system (ISR), sensors, actuators and integration lighting, de-icing, flight control, door opening/closing control	●	●	●	●		●		●		●
	Landing Gear: Main and nose landing gear, steering system, extension/ retraction system, kneeling system, wheels and brakes	●	●	●	●				●		
	Cabin interior										
	Seating, cabin lighting, galley, chilling systems, oxygen systems, drinking water systems, vacuum waste systems, cargo equipment	●	●	●					●		
	Propulsion systems										
	Engines and components: Propeller system, turbines	●	●	●	●					●	●
	Bearing bushes for engine guide vanes										●
	Nacelles								●	●	●
Space	**Satellites**										
	Antenna covers (radomes), bearing bushes, sliding elements (vacuum)	●	●	●	●				●	●	●
	Construction and insulation components										
	Wire coils, sealing rings								●	●	●
	Radar cover										●
	Torque cylinder				●	●			●		
	Fixing elements				●	●			●		
	Pipe holders	●	●		●	●			●		●

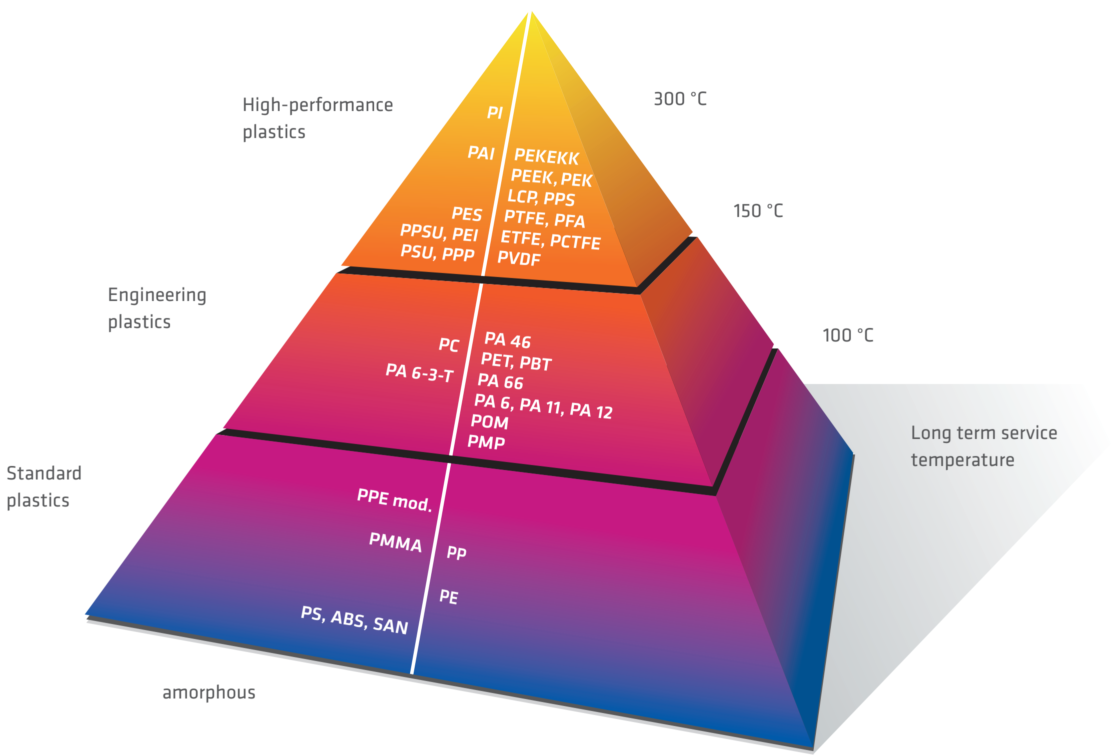
Key facts at a glance

Due to their beneficial material properties, technical plastics offer wide-ranging application possibilities for the aerospace industry.

Product portfolio
The basis for wide-ranging applications

Over recent years, the significance of technical plastics has increased at an astounding speed. We offer a broad spectrum of engineering and high-performance materials from our standard product range for applications in the aerospace industry.

- → TECAFINE (PE)
- → TECAFORM (POM)
- → TECAPET (PET)
- → TECAMID (PA 6/66, PA 11/12)
- → TECAST (PA 6 C)
- → TECANAT (PC)
- → TECAFLON (PTFE, PVDF)
- → TECASON (PSU, PPSU)
- → TECAPEEK (PEEK)
- → TECATRON (PPS)
- → TECATOR (PAI)
- → TECASINT (PI)



Classification of plastics

Special materials for aerospace technology

TECASINT 4121 / TECASINT 2021 (PI)
→ Low friction and wear
→ HDT / A up to 470 °C

TECASINT 4111 (PI)
→ High stiffness, modulus 6.700 MPa
→ Heat distortion temperature HDT / A = 470 °C
→ Low outgassing in vacuum

TECASINT 2391 (PI)
→ Modified with MoS_2
→ Best gliding properties in vacuum
→ Low outgassing in vacuum

TECASINT 2011 natural (PI)
→ Maximum strength and elongation
→ Optimum electrical insulation
→ Highest modulus and minimal thermal conductivity

TECAPEEK natural (PEEK)
→ High long-term service temperature (260 °C)
→ Excellent mechanical properties even at high temperatures

TECAPEEK CF30 black (PEEK CF)
→ Very high strength value due to carbon fibre reinforcement
→ Very abrasion-resistant

TECAPEEK GF30 natural (PEEK GF)
→ Glass-fibre reinforced
→ Increased strength
→ Outstanding chemical resistance

TECAPEEK ELS nano (PEEK CNT)
→ Electrically conductive
→ Outstanding chemical resistance
→ Good machinability

TECATRON GF40 natural (PPS GF)
→ Extremely high strength due to glass-fibre reinforcement
→ Very good chemical resistance

TECASON P natural (PPSU)
→ High thermal dimensional stability
→ Highly durable

TECAPEI natural (PEI)
→ Long-term service temperature up to 170 °C
→ Resistance to high-energy radiation

TECAFLON PTFE natural (PTFE)
→ Exceptional chemical resistance
→ Particularly low coefficient of friction
→ Ideally suited for soft mating partners

TECAMID 66 natural (PA 66)
→ Easily glued and welded
→ Electrically insulating and good machining properties

TECAMID 66 MO black (PA 66 MoS_2)
→ Good UV-resistance
→ Low abrasion

TECAMID 66 GF35 natural (PA 66 GF)
→ Glass-fibre reinforced
→ High strength

TECAFORM AH natural (POM-C)
→ Good chemical resistance
→ High resilience

TECAFORM AH ELS (POM-C, conductive carbon)
→ Electrically conductive

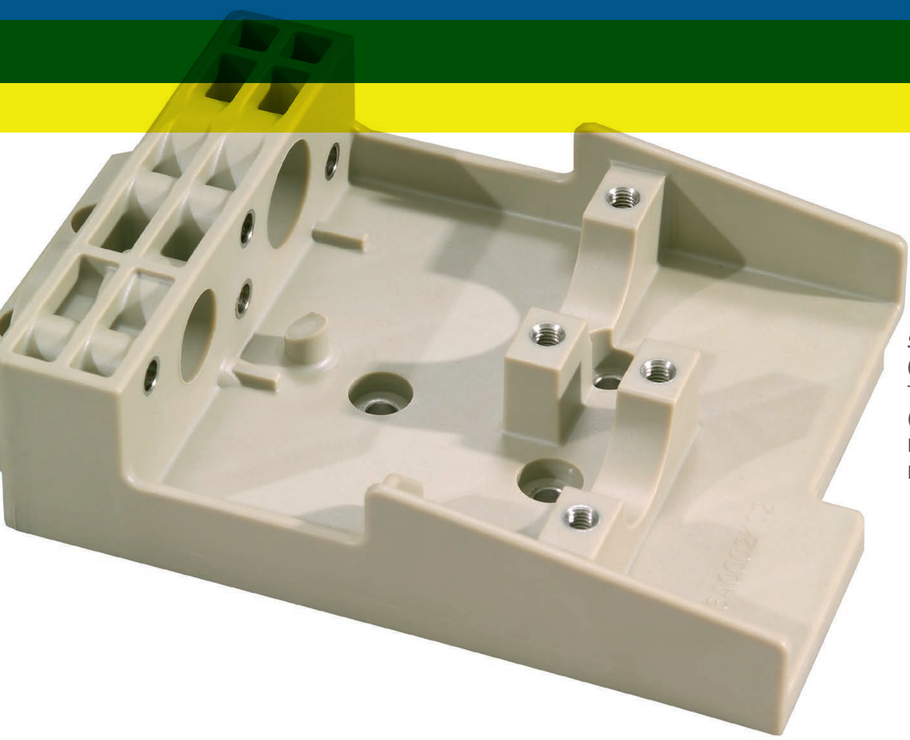
TECAFORM AH SD (POM-C, antistatic)
→ Static dissipating, carbon-free
→ Inherently effective, permanently non-contaminating anti-static agent

TECAFORM AD natural (POM-H)
→ High mechanical strength
→ Very good machining properties

TECAFORM AD AF (POM-H TF)
→ Very good slide friction properties
→ Low water absorption

Application examples

Wire coil for solar panel
TECASINT 2391 black
(PI)
Low outgassing in accordance with ESA standard.
High rigidity with low weight.



Sensor Plate
(Component of aircraft air conditioning system)
TECAPEEK GF30 natural
(PEEK GF)
High temperature resistance.
Dimensionally stable.

Twin Pulley
(Assembly for baggage-tray lift)
TECAPEI GF30 natural mod.
(PEI GF)
High temperature resistance.
Inherently flame-retardant.
Very strong and rigid.

Output Pulley
(Assembly for baggage-tray lift)TECAPEI
GF30 natural mod.
(PEI GF)
High temperature resistance.
Inherently flame-retardant.
Very strong and rigid.

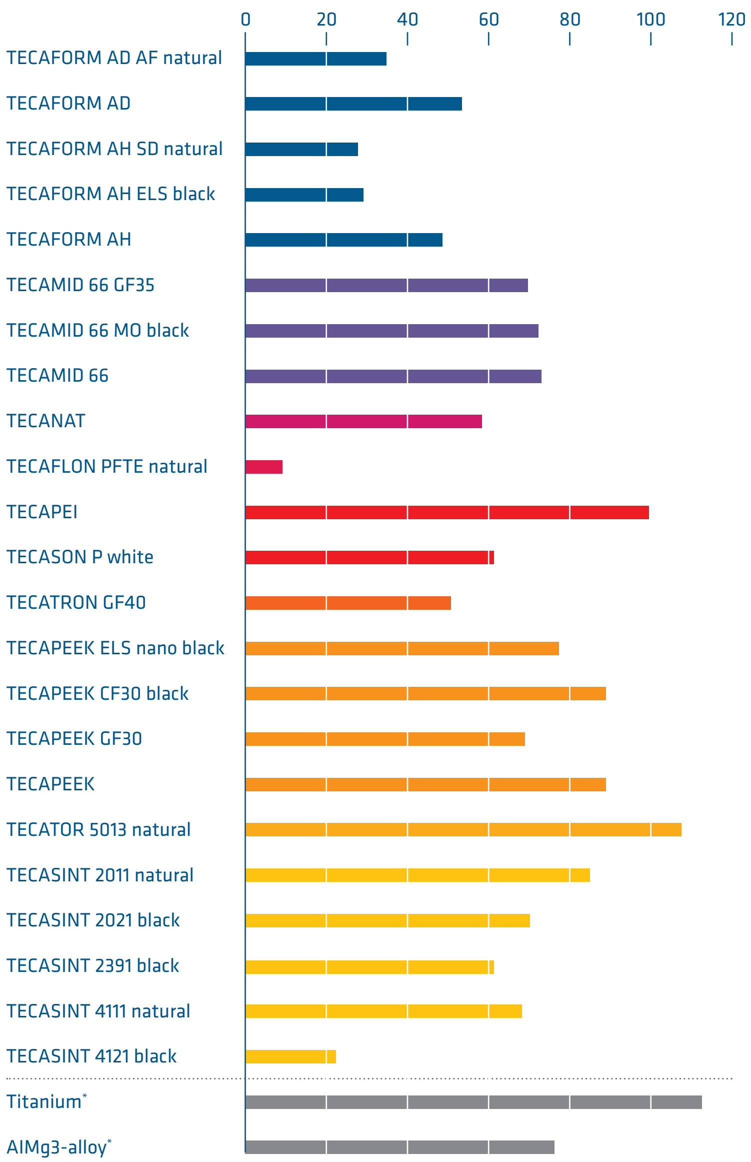
Attenuation Tube
(Used in landing unit)
TECAFORM AH white
(POM-C)
Dimensionally stable.
Grease-resistant.

Mechanical properties

Continuous improvements in performance and fuel cost savings are crucial to success in the aerospace industry. This is why weight reduction and the optimization of mechanical aircraft component properties are key.

When selecting materials, specific strength is a key indicator. This determines the tensile strength of a material relative to its density, and indicates the ratio of strength to weight. In order to assess the potential of thermoplastic or composite materials, this indicator is frequently used as the basis for comparison with low-weight, high-strength metals. In the aerospace industry, these are generally titanium or aluminium.

Specific strength *[MPa / (g/cm³)]*



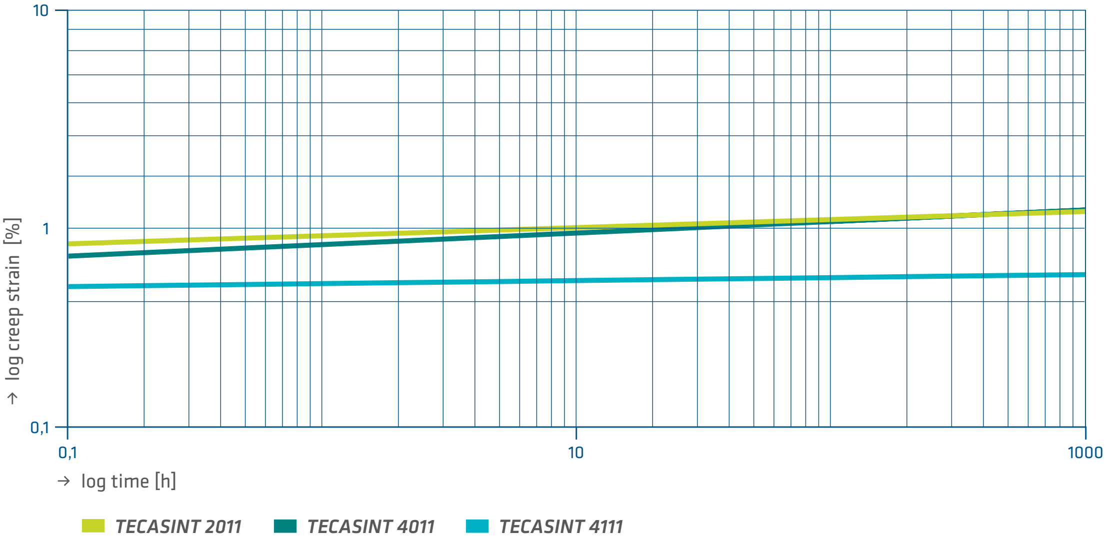
*Source: Mechanical and Metal Trades Handbook

Creep strength

Creep strength is the term given to the deformation increase depending on time and temperature under a constant load. TECASINT is a non-melting material which does not soften even under the influence of high temperatures and demonstrates very low creep tendency under load. The diagrams below demonstrate the creep strain depending on time and temperature under a load of 17 MPa.

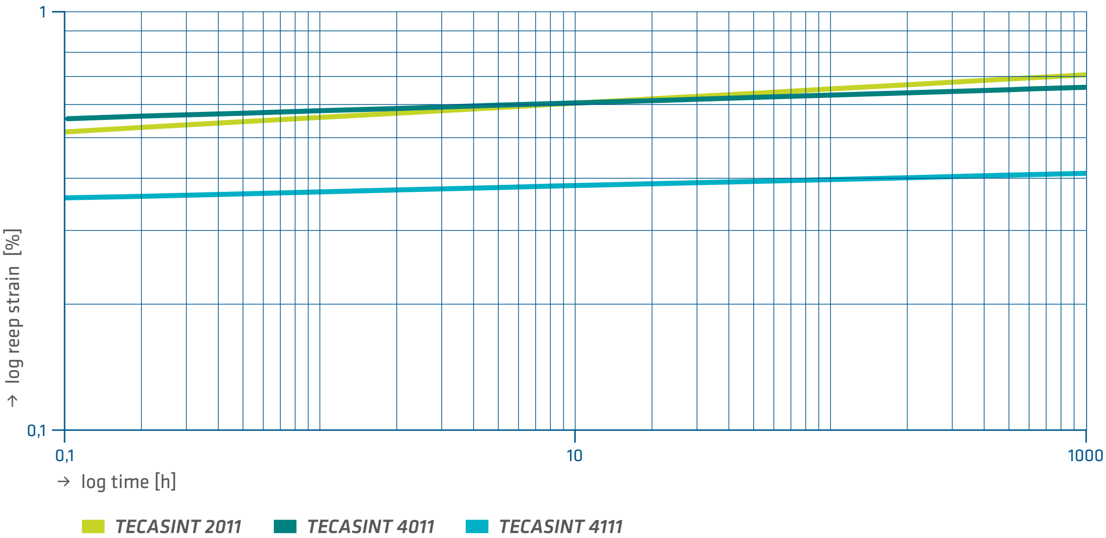
Creep strain TECASINT at 250 °C

17 MPa, ISO 899-1



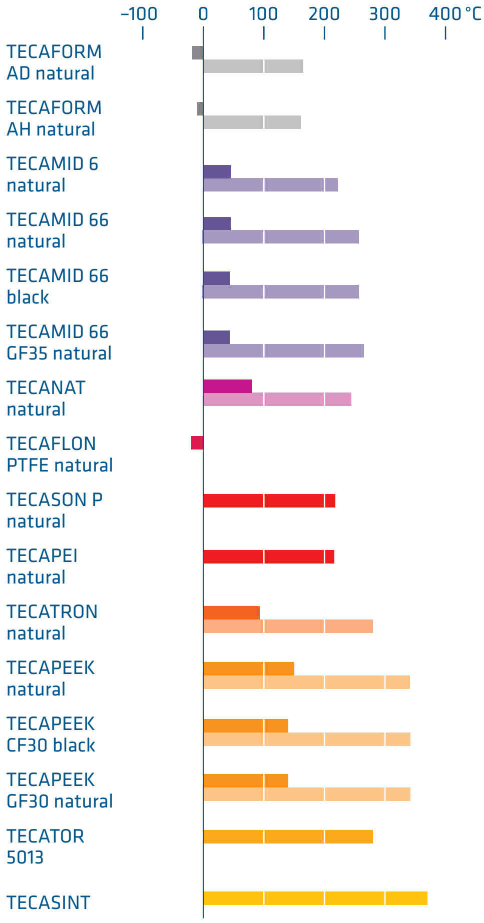
Creep Strain TECASINT at 150 °C

17 MPa, ISO 899-1



Thermal properties

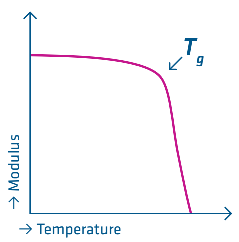
Glass transition temperature [°C]
Melting temperature [°C]



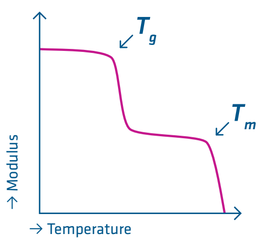
Glass transition temperature [°C]
Melting temperature [°C]

Glass transition temperature

The glass transition temperature T_g is the temperature at which polymers change from a hard elastic and brittle state to a flexible rubbery elastic state. A distinction must be made here between amorphous and partially crystalline thermoplastics.



amorphous



semi-crystalline

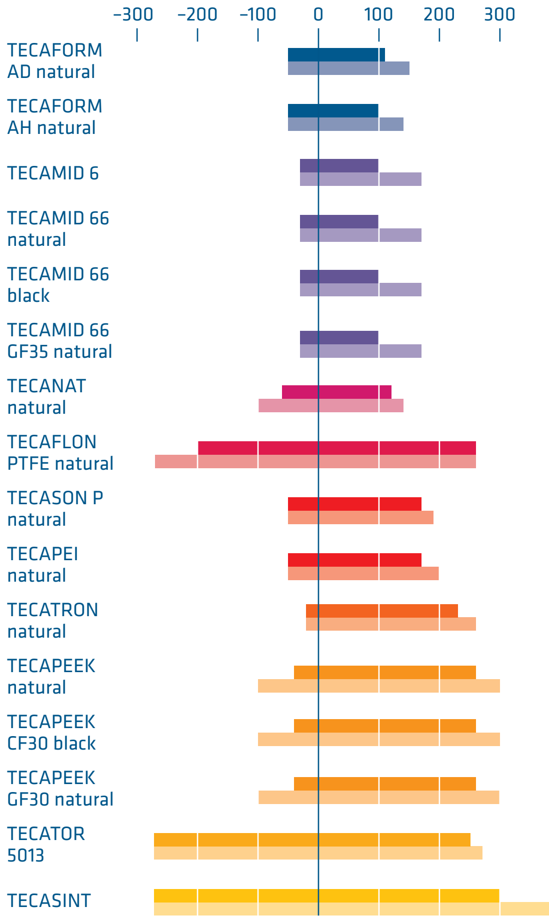
An amorphous material can be subjected to mechanical wear above the T_g, as here its mechanical strength decreases sharply.

Partially crystalline materials, in contrast, still demonstrate a certain mechanical strength beyond the T_g due to their crystalline areas, and are therefore particularly well suited for components exposed to mechanical stress.

Melting temperature

The melting temperature T_m is the temperature at which a material melts, i.e. changes from the solid to the fluid aggregate state and its crystalline structures break down.

Service temperatures [°C]



Negative application temperature ← → Service temperature
long-term long-term
short-term short-term

Long-term service temperature

The long-term service temperature is defined as the maximum temperature at which a plastic has lost no more than 50 % of its initial properties after 20,000 hours of storage in hot air (in accordance with IEC 216).

The maximum service temperature is dependent upon the following factors:

→ Duration of exposure to temperature
→ Maximum admissible deformation
→ Degradation of strength characteristics due to thermal oxidation
→ Ambient conditions

Negative service temperatures

The service temperature in the negative temperature range is not precisely defined and depends largely on different characteristics and ambient conditions:

→ Toughness / brittleness of a material
→ Modifications, i.e. reinforcement fibres
→ Temperature
→ Duration of load
→ Type of load

Short-term service temperature

The short-term service temperature is the short-term peak temperature which the plastic can tolerate over a short period (from minutes to occasionally hours) taking into consideration the stress level and duration, without sustaining damage.

Coefficient of linear thermal expansion

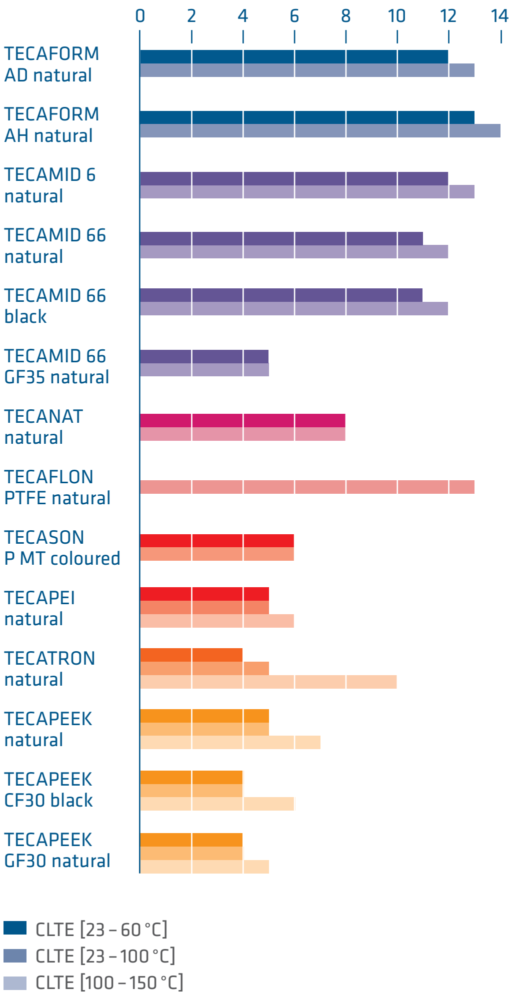
The coefficient of linear thermal expansion specifies the extent of a change in the length of a material due to rising or falling temperature. Due to their chemical structure, plastics generally demonstrate a significantly higher coefficient of linear thermal expansion than metals. This must be considered in the event of:

→ Components with narrow tolerances
→ High temperature fluctuations
→ Composites with metal

The coefficient of linear thermal expansion of plastics can be significantly reduced by adding reinforcing fibres. In this way, values in the range of aluminium can be achieved.

Coefficient of linear thermal expansion, longitudinal

CLTE [10^{-5} 1/K]



Electrical properties

Surface resistance

The specific surface resistance describes the resistance that a material exerts against the flow of electricity at the surface: 1 Ω = 1 V/A
For measurement, a standardized set-up must be used, as the specific surface resistance depends on different factors:

→ Material
→ Humidity
→ Surface contamination
→ Measurement set-up

It is also impossible to prevent volume resistivity from entering the equation to an indeterminable degree when measuring surface resistance.

Specific volume resistivity

The specific volume resistivity describes the electrical resistance of a homogeneous material to the flow of current through the specimen. As the volume resistivity of many materials follows Ohm's law, it is independent of the applied voltage and can be specified proportionally to the length or conversely proportionally to the cross-section of the measured specimen. The unit of specific volume resistivity is consequently Ω cm.

Dielectric strength

Dielectric strength is the resistance of insulating materials to high voltage. The characteristic value is the quotient of the voltage level and the test specimen thickness (unit of measurement kV/mm). Dielectric strength is particularly decisive with thin-walled components.

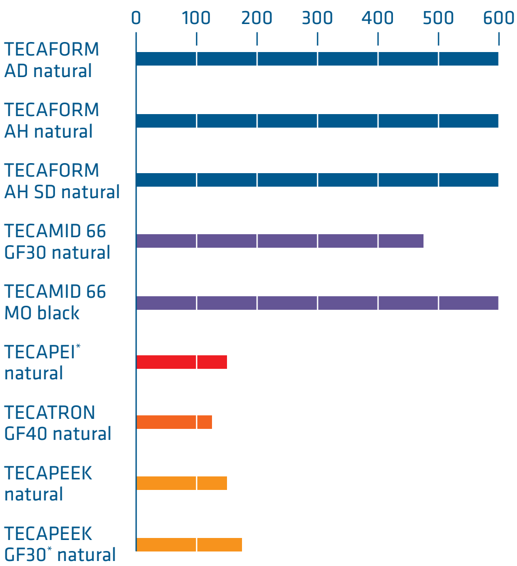
Dissipation factor

A high dissipation factor causes the generation of heat in the plastic part, which acts as a dielectric. The dissipation factor of plastic insulators in high-frequency applications such as radar devices, antenna applications and microwave parts should consequently be as low as possible. The dissipation factor depends on moisture content, temperature, frequency and voltage.

Comparative tracking index

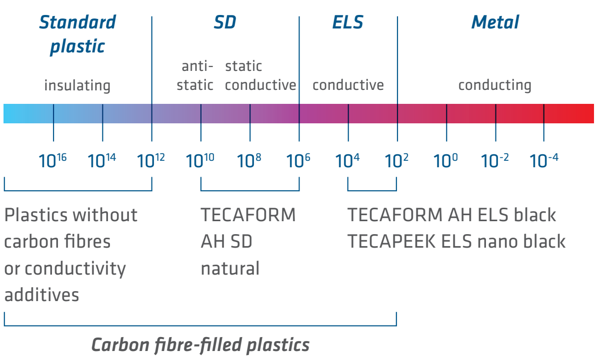
To determine a material's insulating capacity, the comparative tracking index (CTI) is frequently used. This provides a statement on the insulation resistance of the surface (creep distance) of insulating materials. Even in the case of good insulating plastics, however, humidity and contamination on the surface (even temporarily) can result in failure of a component.
The comparative tracking index can be heavily influenced by combination with material additives, in particular colour pigments.

Comparative tracking index [V]



* Published values

Conductivity ranges surface resistance [Ω]



Radiation resistance

Radiation resistance

Depending on their field of application, plastics can come into contact with different types of radiation, which under certain circumstances can permanently influence the structure of the plastics. The spectrum of electromagnetic waves ranges from radio waves with a large wavelength, through normal daylight with its short-wave UV radiation, to extremely short-wave X and gamma rays. The shorter the wavelength of the radiation, the greater the susceptibility of a plastic to damage.

Electromagnetic radiation

The dissipation factor describes the proportion of energy which can be absorbed by the plastic. Plastics with high dissipation factors heat up considerably in alternating electrical fields and are consequently not suitable for use as a material for high-frequency and microwave insulating applications. Polyamides, for example, can fracture or explode when used for a microwave application due to their high moisture absorption.

Ultraviolet radiation

UV radiation from sunlight is decisive in unprotected open-air applications. Plastics which are inherently resistant are to be found in the group of fluorinated polymers, for example PTFE and PVDF. Without suitable protective measures, various other plastics begin to yellow and become brittle depending upon the level of irradiation. UV protection is usually achieved using additives or protective surface coatings. The addition of carbon black is a low-cost and very effective way of stabilizing many plastics.

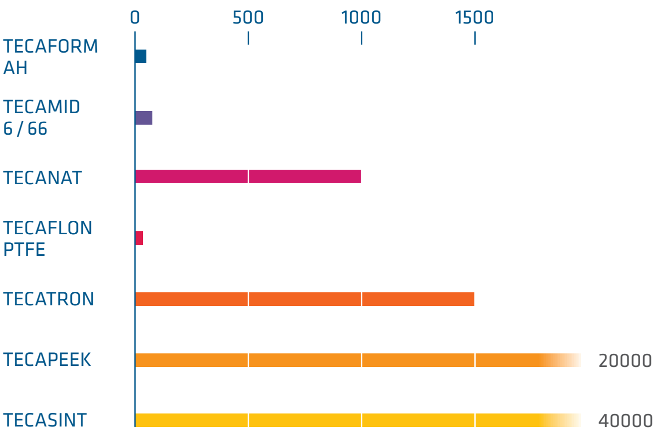
Ionizing radiation

Ionizing radiation such as gamma and X-rays are frequently found in medical diagnostics, radiation therapy, in the sterilization of disposable articles and also in the testing of materials and in test instrumentation, as well as in radioactive and other radiant environments. The high energy radiation in these applications often leads to a decrease in the elongation characteristics and the development of brittleness. The overall service life of the plastic is dependent upon the total amount of radiation absorbed. PEEK, PI and the amorphous sulphur-containing polymers, for example, are proved to have very good resistance towards gamma radiation and X-rays.

The influence of high-energy radiation results in a change to the mechanical characteristics (strength, rigidity, hardness or brittleness). This influence on the mechanical characteristics is reinforced under the influence of the radiation dose. Consequently no sudden return to the prior state takes place.

Information relating to the resistance of plastics should only ever be considered a point of reference, as different parameters play a co-determining role (for instance part geometry, dosing rate, mechanical stress, temperature or ambient medium). For this reason, it is impossible to provide a generalized statement of the different damaging radiation doses for individual plastics.

Radiation resistance [kGy]



Radiation dose in Kilogray [kGy] which reduces elongation by less than 25 %.

Combustibility

With regard to flame retardant classification, a variety of characteristics are of relevance. Requirements imposed on material behaviour are listed in the specifications in the form of fire protection properties.

Combustibility testing to UL94 is generally performed on raw material. Alongside testing in accordance with the specifications of UL or using a UL-accredited laboratory, listing (using so-called yellow cards) is also performed directly by UL itself. For this reason, a distinction must be made between materials with a UL listing and materials which only comply with the requirements of the respective UL classification (without listing).

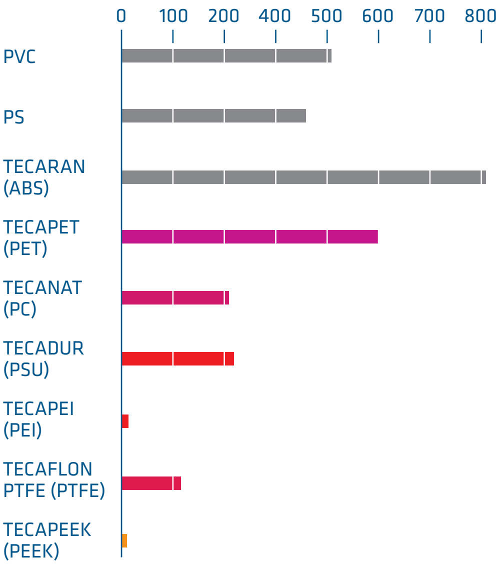
Alongside flame retardant classification in accordance with UL94, a wide range of other industry-specific tests exists which classify the combustion behaviour of plastics. The FAR 25.853 is a typical fire test specification for aerospace applications. In addition to pure combustibility using the vertical test, it also contains tests to determine smoke density and toxicity under the influence of radiant heat and flames.

Behaviour under minimal fire load, smoke and toxicity

TECAPEEK materials from Ensinger perform well when subjected to fire due to being inherently flame retardant. When compared to other plastic materials, TECAPEEK has the lowest value of specific optical density of all the materials tested.

Smoke gas density of plastics

Specific optical density (Dg)



Test conditions: Smoke chamber of the American National Bureau of Standards, sample 3.2 mm thick, flaming mode
Source: Victrex plc.

Outgassing

Tests in compliance with the ESA regulation indicate no condensable impurities in TECASINT. The products listed in the following table can consequently be used in high vacuum / space applications:

Low outgassing

according to ESA regulations ECSS-Q-70-02

Pure	1011	2011	3011	4011	4111
15 % MoS_2	1391	2391		4391	
30 % MoS_2	1041			4041	

Chemical resistance

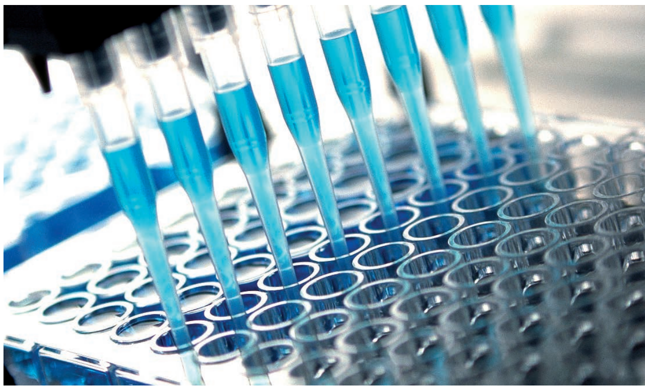
Temperature, the concentration of agents, exposure periods and also mechanical load are all important criteria when testing for chemical resistance. The following table lists resistance to different chemicals. This information is provided to the best of our current knowledge and is designed to provide data about our products and their applications. Consequently it is not intended to provide any legally binding assurance or guarantee of the chemical resistance of our products or their suitability for a concrete application. For a more concrete application, we recommend producing your own verification. Standard tests are performed under normal climatic conditions 23/50 in accordance with DIN 50 014.

		Concentration [%]	*Temperature [°C]*	TECASINT (PI)	TECAPEEK (PEEK)	TECATRON (PPS)	TECASON S (PSU)	TECASON E (PES)	TECASON P white (PPSU)	TECAPEI (PEI)	TECAFLON PTFE natural (PTFE)	TECAFLON PCTFE natural (PCTFE)	TECAFLON PVDF natural (PVDF)	TECAMID 6 (PA 6), TECAST (PA 6 C), TECARIM (PA 6 C)	TECAMID 46, 66 (PA 46, PA 66)	TECAMID 11, 12 (PA 11, PA 12)	TECANAT (PC)	TECAPET (PET), TECADUR PBT natural (PBT)	TECAFORM AH (POM-C)	TECAFORM AD (POM-H)	TECAFINE PP (PP), TECAPRO (PP)	TECAFINE PE natural (PE)	TECARAN ABS (ABS)	TECANYL (PPE)
Acetonitrile	C_2H_3N	UD	RT		+		-				+		+											
Dichloromethane	CH_2Cl_2	UD	RT	+	+	(+)	-	-	-		+	(+)	+	(+)	(+)	(+)	-	-	(+)	(+)	-	(+)	-	-
De-icing fluid		CA	RT		+																			
Aircraft fuel A		CA	RT		+																			
Aircraft fuel A		CA	40		+																			
Aircraft fuel A/A-1		CA	RT		+																			
Hydraulic fluid		UD	RT		+																			
Kerosene		CA	RT		+	+	+		+		+		+	+	+	+	(+)	+	+	+		+		
Kerosene		CA	60		+	+	+	+	+		+		+	+	+	+		+	+			(+)		
Kerosene		CA	85		+		(+)		+		+		+	+	+	+	-	+	+					
Methanol	CH_4O	CA	100		+																			
Sodium hydroxide	NaOH	50	RT		+									(+)	(+)	(+)		-	(+)					
Nitric acid	HNO_3	10	80		+	-	+	(+)	+		+			-	-	-		-	-	-				
Hydrochloric acid	HCl(aq)	20	100		+				+		+		+	-	-	-		-	-	-				
Sulphuric acid	H_2SO_4	20	RT		(+)	+	+		+	+	+		+	-	-	-	+	+		-		+		
Skydrol® LD-4*		CA	RT		+																			
Skydrol® LD-4*		CA	85		+																			
Skydrol® 500B*		CA	RT						+															
Skydrol® 500B*		CA	100										+											
Skydrol® 500B*		CA	boiling						+															
Xylene		CA	125		+																			

+ = resistant
(+) = limited resistance
- = not resistant
RT = Room temperature (15 - 25 °C)
UD = Undiluted
CA = Commercially available

* Skydrol is a registered trademark of Solutia Inc.

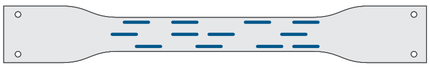
A comprehensive overview of the chemical resistance of our products is provided at www.ensinger-online.com



Influence of processing on test results

The macroscopic characteristics of thermoplastics depend heavily on the relevant processing method used. Because of the higher shear rates typical of the processing method, injection moulded components demonstrate a far more pronounced orientation of macromolecules and any additives in the filling direction than, for instance, semi-finished extruded products which are exposed to rather lower shear rates. Special additives with a high aspect ratio (such as glass or carbon fibres) end to align themselves predominantly in the direction of flow at higher shear rates. The anisotropy which occurs as a result brings about higher strengths in tensile testing, as here the direction of flow corresponds to the direction of testing.

Test specimen made of an extruded and machined semi-finished product
Chaotic alignment of fibres and macromolecules



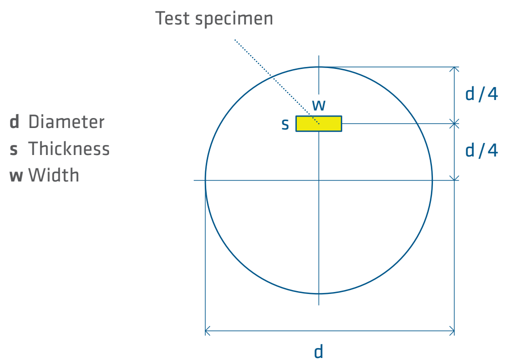
Injection moulded test specimen
Alignment of fibres and macromolecules in the direction of testing (parallel to the direction of flow)

The thermal prior history of a thermoplastic also exerts a considerable influence on the relevant characteristic values. The cooling process of injection moulded components tends to be faster than for extruded semi-finished products. Consequently there is a noticeable difference in the degree of crystallinity, particularly in the partially crystalline plastics.

In the same way as processing methods, the shapes of semi-finished products (rods, plates, tubes) and their different dimensions (diameter and thickness) also exert an influence on the macroscopic properties and determined characteristic values.

The table below provides a schematic overview of the influence exerted by the different processing methods on typical characteristics.

To allow a comparison of the different test results in this context, DIN EN 15 860 “Thermoplastic semi-finished products” stipulates that test specimens must be taken from rods with a diameter of 40 – 60 mm as follows:



Tendential influence of processing on characteristic values

	unreinforced thermoplastics		*fibre-reinforced thermoplastics*	
	Injection Moulding	Extrusion	Injection Moulding	Extrusion
Tensile strength	↓	↑	↑	↓
Modulus of elasticity	↓	↑	↑	↓
Tensile elongation at break	↑	↓	↓	↑

Frequently asked questions

What is the meaning of risk classification to Class I, II or III, and what impact does this have?

Generally speaking, the classification impacts on the processes used for component approval. This is set out in the Basic Regulation 216/2008 under CS – 25; which has been adopted from the FAA. The POA holder (manufacturing company) is responsible for component classification. Here, classification and the necessary agreements / notifications must take place at the Aviation Agency.

Do regulations exist for semi-finished part and component suppliers?

Statutory regulations only apply to aviation approved corporations. Requirements imposed on subcontractors are generally regulated by means of contractual agreements.

What is the difference between the FAA and the EASA?

As a result of bilateral agreements, the two organizations are virtually identical. The American FAA regulation is considered to be the global leader.

For more information on the European Aviation Safety Agency, go to:

www.easa.europa.eu/

Which statutory regulations are we required to adhere to?

Only the contractual rulings between the manufacturing company and supplier have to be adhered to for aviation-specific applications. More information on this is provided in this brochure under Quality Management / Rules and Regulations.

Does a duty to notify exist on the part of the customer in the event of statutory changes?

Statutory regulations only apply to aviation-approved corporations. All other points have to be regulated in supply agreements. Consequently, the customer is required to inform its supplier of a change to the requirements by amending the supply agreements. There is no explicit duty of notification on the part of the customer. However, where applicable, the customer is required to adjust its specifications / supply agreements with the supplier.

Where can I find the relevant information?

The European Aviation Safety Agency and the Society of Aerospace Engineers offer additional useful information on their websites:

European Aviation Safety Agency

Society of Aerospace Engineers

Key facts at a glance

Please do not hesitate to contact our technical service:
techservice.shapes@de.ensinger-online.com or by telephone on +49 7032 819 101

Quality management

Rules and regulations

In the field of civil aviation, manufacturing corporations approved by the German Aviation Agency (LBA) exist. These are known as POA holders. They are approved as manufacturing companies and are subject to the rules and regulations of the German Aviation Agency, which apply directly to these companies. No aviation-specific statutory regulations exist for the field of semi-finished plastic parts which are directly applicable to subcontractors of corporations with aviation approval. It lies within the sphere of responsibility of the manufacturing company to ensure the consistent quality of its suppliers.

Comparable regulations exist in the USA. Here, the government agency (FAA) draws up the rules and regulations which must be adhered to by the aircraft manufacturers. The manufacturers in turn implement these requirements in the form of specifications which have to be adhered to by the suppliers.

Standards

Manufacturing corporations can draw on a series of national and international standards which they can apply in cooperation with suppliers.

In Germany and Europe, the main following standards apply:

- → Material Data Sheets (for instance WL 5.2206.3) list the physical properties of the materials. In most cases, properties of injection moulded test bodies are used as a basis. However, these are not directly comparable with values at the semi-finished product.
- → Aviation Standards (for example LN 9388) describe the dimensions and tolerances for semi-finished products and are comparable with the semi-finished products standard (DIN 15860).

In addition, there is an increasing demand for international standards. The most common international standards are:

- → ASTM (USA): American standard encompassing test methods and so-called material codes which characterize the properties of the raw material.
  - → ASTM D-6778 (POM)
  - → ASTM D-4066 (PA 6 and PA 66)
  - → ASTM D-3965 (PC)
- → Mil Spec (Military Specification / USA): encompasses American test methods in accordance with the ASTM described above.
  - → For example: MIL P-46183 (PEEK)
- → LP (USA – Federal Specification)
  - → For example: L-P-410a for polyamides.

Confirmation of these standards must be clarified in each individual case with Ensinger, as it may happen that special raw materials have to be used.

Specifications

If the specifications in the standards do not comply with the manufacturer's requirements, these are frequently supplemented by additional individual specifications.

Because our customer base includes the biggest manufacturers operating in the aerospace industry, we are familiar with the customary procedures and processes for product qualification and order processing in this sector.

As a manufacturer of semi-finished products, Ensinger is responsible for and capable of complying with the required specifications. The company's organization, starting with an in-house sales team specializing in aviation, through to an efficient compliance management department, ensures that individual customer requirements are taken into account.

Traceability

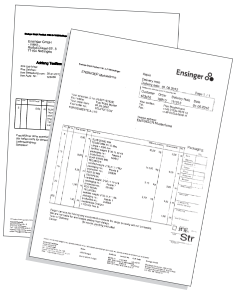
Due to product coding and statements of conformity, Ensinger has direct traceability of the delivered semi finished product.

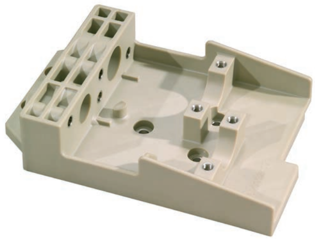
1 *Invoice / delivery note*

The order and invoice number is shown on the invoice / delivery note, for semi-finished products the batch number is also shown on the delivery note. This allows goods to be traced back using these numbers. A certificate to ISO 10204 is issued on an order-specific basis.

Customer · Order · Invoice
988885 · 123456 · DRA12345

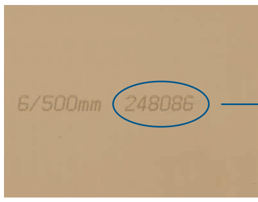
Production number 248086





2 *Semi-finished products*

The production and manufacturing number is located on the semi-finished product. Starting with the production or manufacturing number data from the production process can be traced (production data, production protocol, control cards).



Production number

3 *Compound*

The lot number of the compound can be determined from the production / manufacturing number of the semi-finished product.

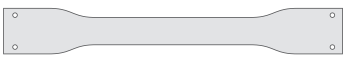
4 *Raw materials*

The lot number of the compound is traceable back to the formulation and so to the delivered raw material batch, the relevant raw material specification and the safety data sheet.

Material standard values

Material		TECASINT 4111 natural	TECASINT 4121 black	TECASINT 2391 black	TECASINT 2011 natural	TECAPEEK natural	TECAPEEK GF30 natural	TECAPEEK CF30 black	TECAPEEK ELS nano black	TECATEC PEEK MT CW50 black	TECATRON GF40 natural
Polymer		PI	PI	PI	PI	PEEK	PEEK	PEEK	PEEK	PEEK	PPS
Fillers			15 % graphite	15 % MoS_2			glass fibres	carbon fibres	CNT		glass fibres
Density (DIN EN ISO 1183)	[g/cm^3]	1.46	1.53	1.54	1.38	1.31	1.53	1.38	1.36	1.49	1.63
Mechanical properties											
Modulus of elasticity (tensile test) (DIN EN ISO 527-2)	[MPa]	6,700	6,600	4,400	3,700	4,200	6,400	6,800	4,800	53,200	6,500
Tensile strength (DIN EN ISO 527-2)	[MPa]	100	34	95	118	116	105	122	106	491	83
Tensile strength at yield (DIN EN ISO 527-2)	[MPa]					116	105	122	106		83
Elongation at yield (DIN EN ISO 527-2)	[%]					5	3	7	4		3
Elongation at break (DIN EN ISO 527-2)	[%]	1.7	0.5	2.9	4.5	15	3	7	4		3
Modulus of elasticity (flexural test) (DIN EN ISO 178)	[MPa]	6,100	6,100	4,136	3,600	4,200	6,600	6,800	4,700	48,900	6,600
Flexural strength (DIN EN ISO 178)	[MPa]	160	113	137	177	175	164	193	178	813	145
Compression modulus (EN ISO 604)	[MPa]	2,500	2,200	2,200	1,713	3,400	4,800	5,000	3,600	4,050	4,600
Compressive strength (1% / 2%) (EN ISO 604)	[MPa]					23 / 43	29 / 52	25 / 47	27 / 47		21 / 41
Impact strength (Charpy) (DIN EN ISO 179-1eU)	[kJ/m^2]	24	11		87.9	n.b.	33	62	58		24
Notched impact strength (Charpy) (DIN EN ISO 179-1eA)	[kJ/m^2]	1.1	1.4		9.3	4					
Ball intendation hardness (ISO 2039-1)	[MPa]	345		265	260	253	316	355	253		333
Thermal properties											
Glass transition temperature (DIN 53765)	[°C]	n.a.	n.a.	370	370	150	147	147	147	143	93
Melting temperature (DIN 53765)	[°C]				n.a.	341	341	341	341	343	280
Service temperature, short term	[°C]				270	300	300	300	300		260
Service temperature, long term	[°C]				250	260	260	260	260	260	230
Thermal expansion (CLTE), 23 – 60 °C (DIN EN ISO 11359-1;2)	[$10^{-5} K^{-1}$]					5	4	4	5		4
Thermal expansion (CLTE), 23 – 100 °C (DIN EN ISO 11359-1;2)	[$10^{-5} K^{-1}$]	3		4	4	5	4	4	5		5
Specific heat (ISO 22007-4:2008)	[J/(g×K)]				0.925	1.1	1.0	1.2	1.1		1.0
Thermal conductivity (ISO 22007-4:2008)	[W/(m×K)]	0.35 [b]			0.22 [b]	0.27	0.35	0.66	0.46		0.35
Electrical properties											
Specific surface resistance (DIN IEC 60093)	[Ω]	10^{16} [c]			10^{15}	10^{15}	10^{14}	> 10^{8} [e]	10^{2} – 10^{4} [e]		10^{14}
Specific volume resistance (DIN IEC 60093)	[Ω×cm]	10^{16} [c]			10^{15}	10^{15}	10^{14}	10^{3} – 10^{11} [e]	10^{3} – 10^{5} [e]		10^{14}
Dielectric strength (DIN EN 60243-1)	[kV/mm]					73	36				
Resistance to tracking (CTI) (DIN EN 60112)	[V]					125					
Miscellaneous data											
Water absorption 24 h / 96 h (23 °C) (DIN EN ISO 62)	[%]	0.01 / 0.02		0.12 / 0.24	0.14 / 0.30	0.02 / 0.03	0.02 / 0.03	0.02 / 0.03	0.02 / 0.03		< 0.01 / 0.01
Resistance to hot water / bases					-	+	+	+	+	+	+
Resistance to weathering						-	-	-	(+)	-	-
Flammability (UL94) (DIN IEC 60695-11-10)		V0 [d]	V0 [d]	V0 [d]	V0 [d]	V0	V0 [d]	V0 [d]	V0 [d]	V0 [d]	V0 [d]

Data generated directly after machining (standard climate Germany). For polyamides the values strongly depend on the humidity content.



Test specimen to DIN EN ISO 527-2

+ good resistance
(+) limited resistance
– poor resistance (depending on concentration, time and temperature)
n.b. not broken
n.a. not applicable

(a) Thermal conductivity testing according to ASTM C 177
(b) Thermal conductivity testing according to ISO 8302
(c) Specific surface resistance and volume resistance to ASTM D 257
(d) No listing at UL (yellow card)
(e) Specific surface resistance and volume resistance testing according to DIN EN 61340-2-3
(f) Dielectric strength testing according to ASTM D 149
(g) Tensile test according to ASTM D 4894

Material		TECASON P white	TECAPEI natural	TECAFLON PTFE natural	TECANAT natural	TECAMID 66 natural	TECAMID 66 MO black	TECAMID 66 GF35 natural	TECAFORM AH natural	TECAFORM AH ELS black	TECAFORM AD natural
Polymer		PPSU	PEI	PTFE	PC	PA 66	PA 66	PA 66	POM-C	POM-C	POM-H
Fillers							MoS_2	glass fibres		conductive carbon black	
Density (DIN EN ISO 1183)	[g/cm³]	1.31	1.28	2.15	1.19	1.15	1.15	1.41	1.41	1.41	1.43
Mechanical properties											
Modulus of elasticity (tensile test) (DIN EN ISO 527-2)	[MPa]	2,300	3,200		2,200	3,500	3,200	5,600	2,800	1,800	3,400
Tensile strength (DIN EN ISO 527-2)	[MPa]	81	127	22 [g]	69	85	84	98	67	42	79
Tensile strength at yield (DIN EN ISO 527-2)	[MPa]	81	127		69	84	83		67	42	79
Elongation at yield (DIN EN ISO 527-2)	[%]	7	7		6	7	10	6	9	11	37
Elongation at break (DIN EN ISO 527-2)	[%]	50	35	220 [g]	90	70	40	9	32	11	45
Modulus of elasticity (flexural test) (DIN EN ISO 178)	[MPa]	2,300	3,300		2,300	3,100	3,100		2,600	1,500	3,600
Flexural strength (DIN EN ISO 178)	[MPa]	107	164		97	110	114		91	56	106
Compression modulus (EN ISO 604)	[MPa]	2,000	2,800		2,000	2,700	2,700		2,300	1,500	2,700
Compressive strength (1% / 2%) (EN ISO 604)	[MPa]	18 / 30	23 / 41		16 / 29	20 / 35	20 / 38		20 / 35	16 / 25	19 / 33
Impact strength (Charpy) (DIN EN ISO 179-1eU)	[kJ/m²]	n.b.	113		n.b.	n.b.	n.b.		n.b.	74	n.b.
Notched impact strength (Charpy) (DIN EN ISO 179-1eA)	[kJ/m²]	13			14	5	5		8		15
Ball intendation hardness (ISO 2039-1)	[MPa]	143	225		128	175	168		165	96	185
Thermal properties											
Glass transition temperature (DIN 53765)	[°C]	218	216	20	149	47	52	48	-60	-60	-60
Melting temperature (DIN 53765)	[°C]	n.a.	n.a.		n.a.	258	253	257	166	169	182
Service temperature, short term	[°C]	190	200	260	140	170	170	170	140	140	150
Service temperature, long term	[°C]	170	170	260	120	100	100	110	100	100	110
Thermal expansion (CLTE), 23 – 60 °C (DIN EN ISO 11359-1;2)	[10^{-5} K^{-1}]	6	5		8	11	10		13	13	12
Thermal expansion (CLTE), 23 – 100 °C (DIN EN ISO 11359-1;2)	[10^{-5} K^{-1}]	6	5		8	12	10		14	14	13
Specific heat (ISO 22007-4:2008)	[J/(g×K)]	1.1	1.2		1.3	1.5	1.5		1.4	1.3	1.3
Thermal conductivity (ISO 22007-4:2008)	[W/(m×K)]	0.25	0.21	0.20 [a]	0.25	0.36	0.36		0.39	0.46	0.43
Electrical properties											
Specific surface resistance (DIN IEC 60093)	[Ω]	10^{14}	10^{14}	10^{16} [c]	10^{14}	10^{14}	10^{14}	10^{14}	10^{14}	10^{2} – 10^{4} [e]	10^{14}
Specific volume resistance (DIN IEC 60093)	[Ω×cm]		10^{14}	10^{17} [c]	10^{14}	10^{14}	10^{14}	10^{14}	10^{13}	10^{3} – 10^{5} [e]	
Dielectric strength (DIN EN 60243-1)	[kV/mm]			80 [f]			35		49		
Resistance to tracking (CTI) (DIN EN 60112)	[V]						600		600		
Miscellaneous data											
Water absorption 24 h / 96 h (23 °C) (DIN EN ISO 62)	[%]	0.1 / 0.2	0.05 / 0.1		0.03 / 0.06	0.2 / 0.4	0.2 / 0.4		0.05 / 0.1	0.05 / 0.2	0.05 / 0.1
Resistance to hot water / bases		+	+		-	(+)	(+)	(+)	(+)	(+)	-
Resistance to weathering		-	-		(+)	-	(+)	(+)	-	(+)	-
Flammability (UL94) (DIN IEC 60695-11-10)		V0 [d]	V0 [d]	V0 [d]	HB [d]	HB [d]	HB [d]	HB [d]	HB [d]	HB [d]	HB [d]

The corresponding values and information are no minimum or maximum values, but guideline values that can be used primarily for comparison purposes for material selection. These values are within the normal tolerance range of product properties and do not represent guaranteed property values. Therefore they shall not be used for specification purposes. Unless otherwise noted, these values were determined by tests at reference dimensions (typically rods with diameter 40-60 mm according to DIN EN 15860) on extruded, cast, compression moulded and machined specimens. As the properties depend on the dimensions of the semi-finished products and the orientation in the component (esp. in reinforced grades), the material may not be used without separate testing under individual circumstances.

Data sheet values are subject to periodic review, the most recent update can be found at www.ensinger-online.com

Technical changes reserved.

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Thermoplastic engineering and high-performance plastics from Ensinger are used in every important sector of industry today. Their economy and performance benefits have seen them frequently supplant classically used materials.

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