Ensinger

Semi-finished products
Direct Forming

TECASINT Handbook

TECASINT high temperature polyimides for special applications

Semi-finished products and direct formed finished parts made of TECASINT have excellent long-term thermal stability. The broad temperature application spectrum of these materials ranges from -270°C to +300°C. Even when heated briefly to 350°C, TECASINT materials will not melt or soften. Strength, dimensional stability and creep strength remain high under mechanical stress even during long-term usage.

The trend towards space and weight saving in modern mechanical and plant engineering applications results in higher density performance and consequently in increased thermal and wear resistance expectations in the materials used. The characteristic profile of polyimides addresses these stringent demands with outstanding success:

TECASINT from Ensinger is a range of non-melting high temperature polyimides which are characterized by the following properties:

→ High strength over a wide temperature range from -270°C to +300°C
→ Extremely good long-term thermal stability
→ Glass transition temperature depending on type between +260°C to +400°C
→ Good cryogenic properties
→ Inherently flame retardant (UL 94 V0)
→ Minimal thermal expansion
→ Outstanding durability
→ Excellent resistance to wear under high surface area pressure, high sliding speeds
→ High pressure and creep strength
→ High radiation resistance
→ High purity, low outgassing in vacuum
→ Good chemical resistance to acids, fats and solvents
→ Excellent electrical insulation properties
→ Good thermal insulation

Fields of application

The fields of application are many and varied: the mechanical engineering, automotive and gear manufacturing industries appreciate the outstanding sliding properties of the graphite/PTFE-modified TECASINT product types. In vacuum technology, or for use in dry gas atmospheres, the unreinforced or MoS2-modified product types (for sliding applications) are used. Its electrical insulating effect at high temperatures makes TECASINT also ideally suited for applications in the electrical and electronics industry. TECASINT has a very low ion content and is used in particular for applications in the field of ultra-clean-room technology, for example in the production of wafers.

Forms of delivery and production processes

TECASINT is available as:

→ Semi-finished products (rods, plates, short tubes)
→ Machined parts according to drawing
→ Volume parts using the direct forming process

Precision components made of TECASINT are produced in small production runs using machining processes in accordance with customer drawings. For larger volumes, components can be cost-effectively pressed and sintered using the direct forming process.

TECASINT materials

TECASINT 1000
Extremely good dimensional stability. Good sliding properties and wear resistance as well as excellent radiation resistance.

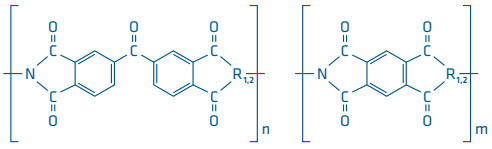
TECASINT 2000
Enhanced thermal resistance. Lower moisture absorption. Enhanced sliding friction behaviour. High creep strength. Very good machining properties. Higher degree of toughness. Ideally suited for the direct forming method.

TECASINT 3000
Extreme thermostability. High degree of toughness. Easy to machine. Low water absorption. Currently only using the direct forming method. Semi-finished products in the development stage.

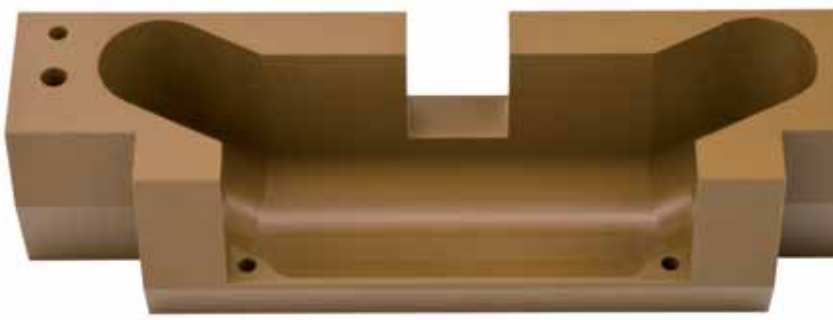
TECASINT 4000
Extreme toughness, minimal water absorption. Good tribological properties. Maximum stability against oxidation through air exposure. Improved chemical resistance.

TECASINT 5000
Non-melting high temperature polyamidimide (PAI). Extremely good dimensional stability and load capacity up to +300°C.

TECASINT 8000
PTFE material reinforced with organic HT plastics (PI powder). Reduced creep under load. Excellent sliding and friction properties. High chemical resistance and very good machining properties. Suitable for mating partners in soft materials (stainless steel, brass, aluminium, bronze).



Chemical structure



TECASINT
semi-finished products – product overview

TECASINT 1000

TECASINT 1011 (unfilled)
→ Maximum strength and elongation
→ Optimum electrical insulation
→ Minimal thermal conductivity
→ Application: Insulators, switch components, valve seats, chain guides, wear pads, static seals, wearing elements

TECASINT 1021 (15% graphite)
→ Enhanced wear resistance and thermal ageing
→ Self-lubricating
→ For lubricated and dry applications
→ Application: Valve seats, sliding rails, chain guides, piston rings, bearing discs, bearing bushes

TECASINT 1031 (40% graphite)
→ Reduced thermal elongation
→ Maximum creep strength
→ Application: For bearings under extreme loads, where reduced strength is possible, e.g. bearing bushes, thrust washers

TECASINT 1041 (30% MoS_2)
→ Enhanced wear characteristics in dry environments
→ Used in vacuum in inert gases (techn. dry)
→ Application: Vacuum seals, valve seats, slide rails, chain guides, piston rings, bearing bushes in high vacuum

TECASINT 1061 (15% graphite + 10% PTFE)
→ Lowest static friction
→ For applications involving low friction and wear characteristics at medium temperatures and loads (< 200°C)
→ Application: Valve seats, slide rails, chain guides, piston rings, guide elements, thrust washers, bearing discs, bearing bushes

TECASINT 1101 (unfilled type)
→ High purity
→ No ionic impurities, no condensable outgassing
→ For applications in the semi-conductor industry, high vacuum and space travel

TECASINT 1411 (30% carbon fibre)
→ Extreme hardness and rigidity
→ Electrically conductive
→ Extremely high thermal stability
→ Applications: Vacuum seals, valve seats, friction rings, chain guides, gears, bearing disks

TECASINT 1501 (glass beads)
→ Low thermal elongation
→ Thermal shock resistant
→ Use as thermal insulator

TECASINT 1611 (30% PTFE)
→ Very low friction value
→ Self-lubricating
→ For applications with low friction and wear properties at medium temperatures and loads (< 200°C) such as valve seats, piston rings, chain guides, bearing bushes

TECASINT 2000

TECASINT 2011 (unfilled type)
→ Maximum strength and elongation
→ Optimum electrical insulation
→ Minimal thermal conductivity.
→ Application: Insulators, switch components, valve seats, chain guides, hot glass grippers, friction washers

TECASINT 2021 (15% graphite)
→ Enhanced wear resistance and thermal ageing
→ For lubricated and dry applications
→ Application: Valve seats, friction rings, slide rails, chain guides, piston rings, hot glass grippers, bearing discs, bearing bushes

TECASINT 2031 (40% graphite)

→ Reduced thermal elongation
→ Maximum creep strength
→ Application: For bearings under extreme load, where reduced strength is possible, e.g. bearing bushes, thrust washers

TECASINT 2061 (15% graphite + 10% PTFE)

→ Lowest static friction
→ For applications requiring low friction and wear properties at medium temperatures and loads
→ Application: Valve seats, slide rails, chain guides, piston rings, guide elements, thrust washers, bearing discs, bearing bushes

TECASINT 2391 (15% MoS_2)

→ Optimum sliding friction properties and low wear specifically for applications in vacuum or inert gases (techn. dry)
→ Outer benefits: Low outgassing
→ Applications: Vacuum seals, valve seats, slide rails, chain guides, piston rings, bearing bushes in high vacuum or for aerospace applications.

TECASINT 4000

TECASINT 4011 (ungefüllte Type)

→ Maximum strength and elongation
→ Optimum electrical insulation
→ Highest modulus and lowest thermal conductivity
→ Application: Insulators, switch components, valve seats, chain guides, hot glass grippers, friction washers

TECASINT 4021 (15% Graphit)

→ Enhanced wear resistance and thermal ageing
→ For lubricated and dry applications
→ Application: Valve seats, friction rings, slide rails, chain guides, piston rings, hot glass grippers, bearing discs, bearing bushes

TECASINT 5000

TECASINT 5011 (PAI,unfilled type)

→ Maximum mechanical strength and elongation
→ Optimum electrical insulation, minimal thermal conductivity
→ Application: Switch components, seals, plugs, housings, test sockets

TECASINT 5051 (PAI, 30% GF)

→ Reduced thermal elongation
→ High thermal-mechanical load properties
→ Good electrical insulation
→ Application: Switch components, plugs, housings, test sockets

TECASINT 5201 (PAI, glass fibre + carbon fibre)

→ Reduced thermal elongation
→ Static dissipative
→ Surface resistance $10^9 – 10^{11}$ Ω
→ Application: Explosion-proof equipment, switch components, seals, plugs, housings, test sockets

TECASINT 5311 (PAI, graphite + PTFE)

→ Enhanced friction and wear properties
→ Dimensionally stable and creep resistant
→ Application: Bearing bushes, slide elements

TECASINT 8000

TECASINT 8001 (PTFE + PI)

→ Low coefficient of friction
→ Low creep
→ Wear resistant
→ For mating partners in soft materials (brass, aluminium, stainless steel, bronze etc.)

Other TECASINT 8000 products are available on request.

TECASINT
for direct formed parts

For low-cost manufacture of volume parts using the direct forming process, the following products are currently available:

TECASINT 2000 DF
TECASINT 2012 (unfilled)
TECASINT 2022 (15% graphite)
TECASINT 2032 (40% graphite)
TECASINT 2062 (15% graphite, 10% PTFE)

TECASINT 3000 DF
TECASINT 3012 (unfilled)
TECASINT 3022 (15% graphite)
TECASINT 3032 (40% graphite)
TECASINT 3062 (15% graphite, 10% PTFE)

Applications: Valve seats, sliding rails, chain guides, piston rings, guides, wear rings, axial sealing rings, shaft end seals, bearing discs, bearing bushes, collar bushes, sliding bearings, hot glass grippers

Direct forming technique

Low-cost manufacturing method for high volume precision components

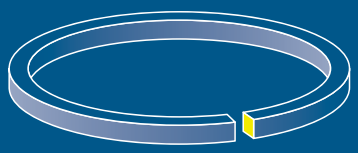
Fast-running vertical automatic presses (mechanical or hydraulic) compress the powder in the die. The part geometry must permit the part to be ejected from the press die. Blanks are then sintered for a number of hours at high temperature. This brings about a degree of shrinkage, the dimensions of which are allowed for in the design of the die.

Condition for direct forming

Min. part thickness	~ 1 mm
Max. part thickness	30 mm
Max. outside diameter	160 mm
Min. inside diameter	~ 2 mm
Max. surface	~ 2000 mm²
Surface quality	~ 1 µm (Ra)
Flattening at chamfers	0,1 – 0,3 mm

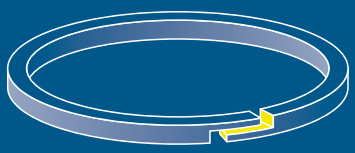
General design guidelines

→ No undercuts possible.
→ Collar bushes require a radius between the flange and hub.
→ A minimum wall thickness of 1 mm is recommended.
→ The wall thickness is a function of the part height. This should not exceed the value of 1:10.
→ Bevelled edges up to an angle of 30 degrees starting from the horizontal level are possible.
→ Larger phase angles require flattening by up to 0.3 mm around the die periphery.
→ Sharp edges in the female die increase tool wear.
→ Holes should be at least 2 mm in diameter.
→ Flattening (appr. 0.3 mm) is required at the base of all 45 - 60 degree phases.



Butt joint:
suitable for direct forming

Scarf joint: unsuitable
for direct forming



Stepped join: suitable for direct forming
depending on geometry

Seal rings made of TECASINT are suitable for continuous application temperature ranges of – 270°C to + 300°C. Compared to seal rings made of metal, they offer greater yield, and their higher degree of elasticity makes them more resistant to permanent deformation.

Shape and position tolerance

Diameter	
0 – 20 mm	± 0,03 mm
20 – 40 mm	± 0,05 mm
40 – 60 mm	± 0,075 mm

Heights	
0 – 5 mm	± 0,1 mm
5 – 15 mm	± 0,2 mm
15 – 40 mm	± 0,25 mm

Diameter	Concentricity	Roundness	Parallelism	Flatness
0 – 25 mm	0,04	0,05	0,04	0,05
25 – 50 mm	0,05	0,125	0,075	0,125
> 50 mm	0,05	0,130	0,076	0,130

Benefits of TECASINT

verification.

Benefits of TECASINT – bushings and slide bearings

TECASINT offers a characteristic profile combining ceramic, plastic and metal. TECASINT combines the characteristic profiles of ceramic, plastic and metal. Bushings and slide bearings made of TECASINT are tough, abrasion and creep resistant over a continuous application temperature of – 270°C to 300°C, and often exceed the performance of other bearing materials.

Benefits of slide bearings made of TECASINT compared to needle and roller bearings

Due to their good tribological characteristics, no external lubrication is required. Applications are possible in temperature ranges at which lubricants are ineffective. Good functionality in dirty environments. Noise, weight and cost reduction.

Comparison with bronze, brass and sintered metal

Extended life of other components due to marked reduction in wear compared to metal-to-metal mating. Reliable functionality in applications where unlubricated metals fail as a result of combined pressure, heat and surface speed. Impact and creep resistant. No problems due to lubricant loss where textile or paper dust are produced.

Benefits of slide bearings made of TECASINT compared to other plastic bearings:

Applications possible at pressure levels, surface speeds and temperature ranges where technical thermoplastics are unable to function. Higher impact, compression and creep strength. Very high abrasion resistance.
Very good cutting properties and lower tolerances are possible.

Sintered parts compared to extruded semi-finished products

Pressing

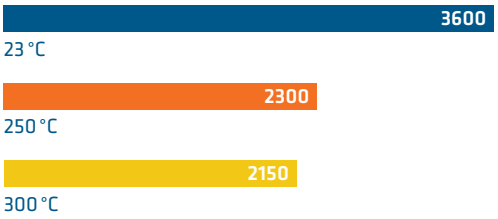
→ Semi-finished part geometries close to finished measurement
→ Extreme economy due to material savings
→ Low tendency to warp due to almost isotropic characteristics
→ Consequently also easier to machine
→ Discontinuous production process
→ High semi-finished product costs

Extrusion

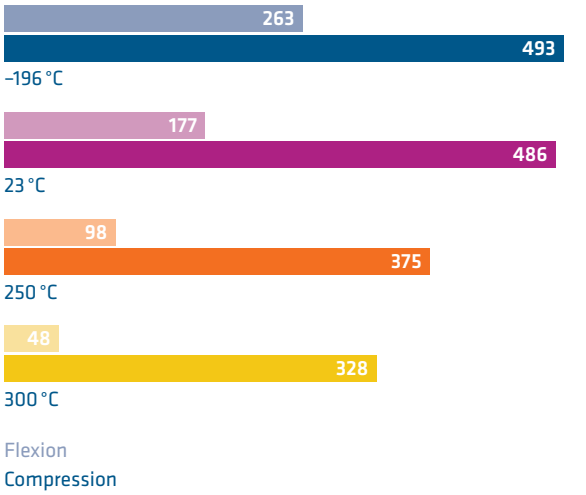
→ Continuous production process
→ Lower semi-finished product costs
→ High tension levels due to orientations during production
→ More difficult to machine

Mechanical properties

Flexural modulus
TECASINT 2011 [MPa] depending on temperatures
between 23 °C and 300 °C
EN ISO 178

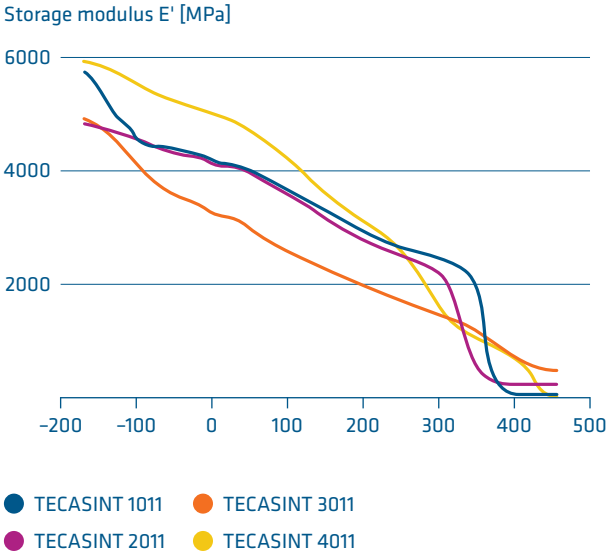


Flexural and compressive strength TECASINT 2011
[MPa] depending on temperatures
between –196 °C and +300 °C
EN ISO 178 / EN ISO 604

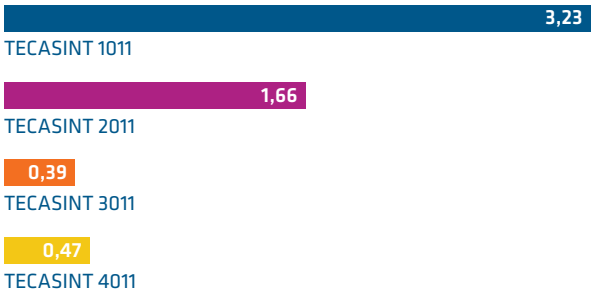


Thermal properties

DMA 3Point- bending test, 1Hz, 2K/min



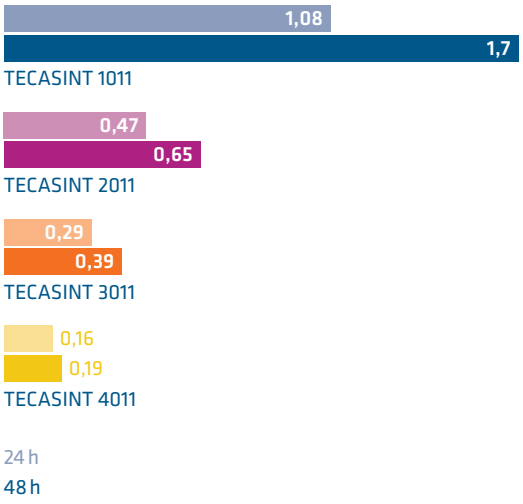
Thermal stability TECASINT at 370 °C / 100 hours
Weight loss [%]



Water absorption

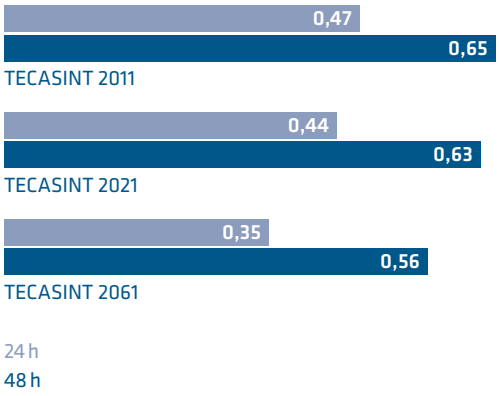
Water absorption TECASINT at 23 °C [%]

EN ISO 62



Water absorption TECASINT 2000 at 23 °C [%]

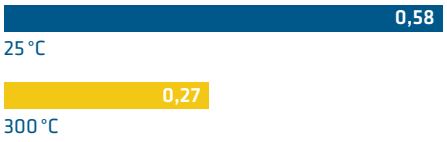
EN ISO 62



Tribology

Coefficient of friction μ TECASINT 2021 depending on temperatures

Pin on disc, load: 5 N, V= 0,25 m/s



Coefficient of friction μ TECASINT 2031 depending on temperatures

Pin on disc, load: 20 N, V= 0,5 m/s

Chemical resistance

Parts made of TECASINT are characterized by good resistance to a wide range of chemical substances.

Polar organic solvents	+
Nonpolar organic solvents	+
Chlorinated hydrocarbons	+
Oil	+
Grease	+
Petrol	+
Diesel	+
Acids	+
Acids	+
Inorganic water-based saline solutions (diluted)	(+)
Oxidation agents	(+)
Water > 100°C / water vapour	–

\+ resistant
(+) conditionally resistant
– not resistant

It should be noted that chemical resistance is dependent upon concentration, time, load and temperature and consequently these are guideline values only. For more concrete information, we recommend producing your own

Purity

Ionic impurities

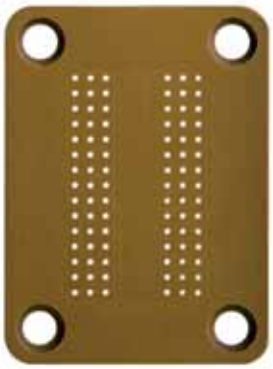
The materials TECASINT 1000, 2000, 3000 can be classed in the "high purity" category.
Outgassing

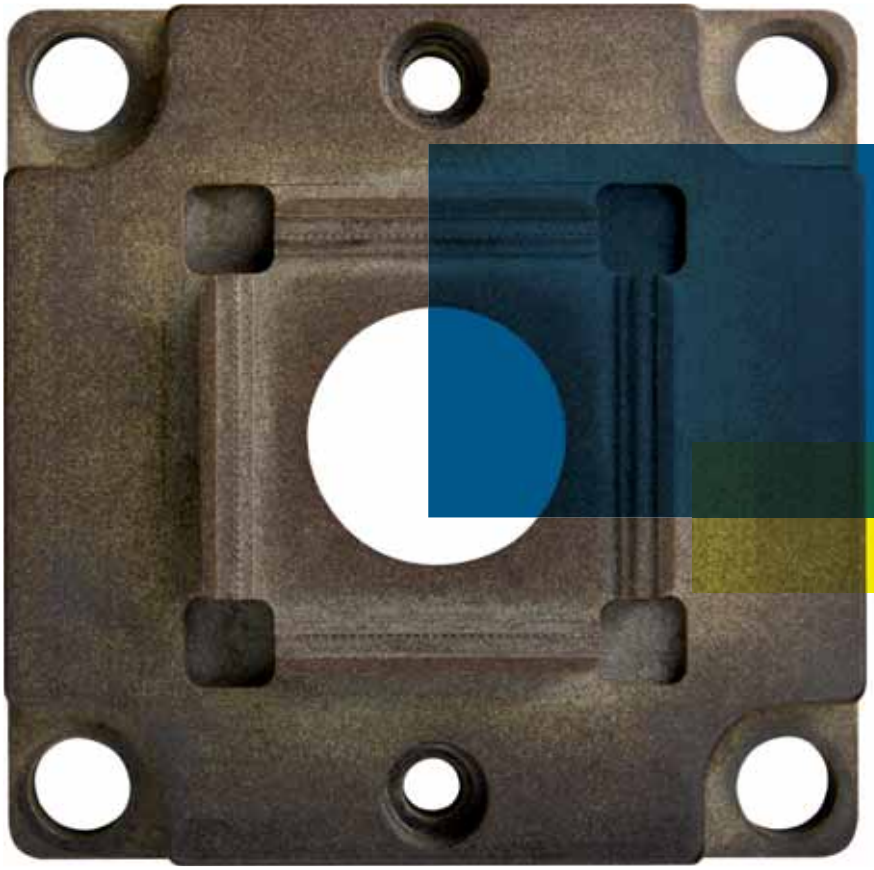
Outgassing

Tests in compliance with the ESA regulation indicate no condensable impurities in TECASINT 1000 and 2000. These products can consequently be used in high vacuum / space applications.

Low outgassing according to ESA regulations ECSS-Q-70-02

Pur	1011	2011	3011	4011
15% MoS_2	1391	2391		
30% MoS_2	1041			4041





Machining guidelines

General

TECASINT products can be machined wet or dry on all machine tools suitable for metal machining. The use of cutting tools made of carbide with a cutting edge angle for aluminium machining has proven the most successful for machining these materials. To avoid machining errors, it is important to detect and exchange worn indexable inserts in good time, and to use the recommended cutting and feed rates for the individual machining processes. Deformation as a result of excessively high clamping pressure, in particular when machining thin-walled parts, must be avoided. Preferably, clamping sleeves, clamping mandrels or vacuum clamping fixtures should be used. The use of four-jaw chucks is recommended. A higher number of jaws results in improved distribution of the clamping force.

Dimensional stability

For machined parts with extremely close tolerances, the material should preferably be machined dry due to its hygroscopic behaviour. However, in this case, attention should be paid to ensuring good heat dissipation during the machining operation.

PI and PAI parts with large diameters tend to spring back slightly immediately after piercing due to the high cutting pressure. Consequently it is advisable to always produce these in the lower tolerance band. Semi-finished products for the manufacture of extremely precise parts must be annealed prior to machining. An additional intermediate annealing process is generally not required during machining.

In order to prevent dimensional changes to the finished parts due to their hygroscopic behaviour, it is advisable to seal high-quality components in vacuum barrier film if they are expected to remain in storage for an extended period.

Turning

For all machining steps, the use of carbide cutting edges, of the type customary for machining aluminium, offers the best solution. The indexable insert tip should have a radius of between 0.2 and 0.4 mm. As a result of wet machining, the cutting pressure at the workpiece increases, which can give rise to increased burr formation. The service life of the cutting tools is substantially extended by wet machining.

If all the essential machining instructions are taken into account during turning, high quality products with a good surface finish can be achieved during the machining of PAI / PI products. (Ra ≥ 1.6) cutting speed for face, longitudinal, cylindrical turning / grooving and parting off

V = 100 – 130 m / min

f = 0.05 - 0.25 mm / rev.

Milling

Milling is performed exclusively using the synchronous milling process. For all machining steps, the use of carbide indexable inserts with the same cutting geometry as that customarily used for aluminium is the best solution. Individual grinding of indexable inserts can result in improved results with certain work steps. Dry and wet machining is possible. As a result of wet machining, the cutting pressure at the workpiece increases, which can give rise to increased burr formation. The service life of the cutting tools is substantially extended by wet machining. Excessive single-sided application of heat into the material should be avoided. Alternating two-sided machining is recommended as the preferable method.

Face milling: V = 90 -100 m / min.

f = 0.04 – 0.08 mm I tooth

Dimensions of standard semi-finished products

Drilling

Carbide drill bits are recommended for machining PAI and PI materials. The exception to this is boreholes less than 1.5mm dia. These should be produced exclusively using HSS drill bits which should be ground to a pointed angle of 120°. To counteract the effects of heat generation, adequate chip removal and wet machining are recommended for all drilling processes.
HM drill
V = 100 m / min.
f = 0.02 - 0.1 mm / U
HSS drill
V = 15 - 40 m / min
f = 0.02 - 0-1 mm / rev.

For detailed instructions on machining, please refer to our technical information sheet “Machining guidelines for TECASINT”.

Bonding TECASINT

TECASINT components can also be bonded to each other or to other plastics, metals and elastomers. In order to ensure a good glue joint, the components must be matched precisely to each other. The contact surfaces should be roughened in advance either mechanically or by blasting. Oils, greases and dirt must be removed using solvents. Suitable glues include adhesion glues based on epoxy resin, polyurethane, rubber or cyanacrylate.

- → Rods from Ø 6 mm to max. Ø 100 mm, max. length 1000 mm
- → Panels from 5 mm to max. 100 mm thickness
- → Maximum panel formats up to 395 x 795 mm / 300 x 1000 mm (max. dimensions depend on type)

Extensive stocked range

- → Fast and flexible: All product types and dimensions shown on the stock list are available immediately.
- → Large panel formats for high cutting efficiency (395 x 795 / 300 x 1000 mm) Max. thickness up to 100 mm.

Cutting service

- → This is a low-cost alternative as there is no need to buy complete panels or rods (low capital tie-up)
- → A convenient option permitting need-driven order placement
- → Fast availability. Generally within 2 - 3 days.

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