Stock shapes
Direct forming

TECASINT Compendium
The trend towards space and weight saving in modern engineering applications results 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
  - Long-term thermal stability up to 300 °C
  - HDT/A up to 470 °C
  - Excellent electrical insulation properties
  - High compressive and creep strength
  - High radiation resistance
  - High purity, low outgassing in vacuum in accordance with ESA regulation ECSS-Q-70-02
  - Minimal thermal expansion
  - Minimal thermal conductivity
  - Excellent friction and wear properties – even without lubrication
  - Good chemical resistance to acids, fats and solvents
  - Good cryogenic properties
  - Inherently flame resistant (UL 94 V0)

Processing methods

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 is available as:
- Stock shapes
  (rods, plates, short tubes, discs)
- Machined parts
- Serial parts using the direct forming process

Parts and shapes 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.
TECASINT – high-temperature polyimides for special applications

Glass industry
The use of polyimides can enhance productivity in the manufacture of glass bottles for the beverage, pharmaceutical and cosmetics industry. Their excellent temperature resistance and low thermal conductivity lend these high-performance plastics key benefits, particularly for hot glass handling, compared to components made of graphite. They also help extend the service life of components and reduce the reject rates. In addition, these materials are economical to process, making them an ever more popular alternative for the production of take-out tongs and bottle grippers.

Electrical/electronics and semiconductor industry
Alongside its excellent electrical insulation, TECASINT also offers a very low ion content, making it ideal for use in the semiconductor industry and in cleanroom environments, for example in test sockets or in chip and wafer manufacture.

Aerospace industry
Low outgassing rates, high purity and good mechanical properties are key requirements in the manufacture of satellites. Excellent tribological properties, a long service life and low wear are essential criteria for the production of bearing bushes used in modern aircraft engines. TECASINT is the ideal material to address all these needs.

Automotive industry
Due to the TECASINT property profile, these materials are frequently superior to other plastics and metals. They can be used to implement applications involving the most extreme conditions, and are used for applications in the automotive industry requiring mechanical stability under high continuous temperatures or high pV values in lubricated and unlubricated environments. Use of the direct forming method allows the economical manufacture of serial parts complying with the narrowest of tolerances.

Mechanical engineering, vacuum technology and cryotechnology
The fields of application are widely varied: in mechanical engineering applications, the excellent sliding properties of graphite or graphite/PTFE-modified TECASINT types are the preferred choice. In vacuum technology and cryogenic applications, unreinforced or MoS2-modified types are used for sliding applications.

Product families stock shapes

TECASINT 1000
→ Very high modulus
→ High rigidity and hardness
→ Previous designation: SINTIMID

TECASINT 2000
→ Very high modulus
→ High rigidity
→ High hardness

Compared to TECASINT 1000, significantly reduced moisture absorption. Higher toughness and improved machining capability.

Ideally suited for direct forming components.

TECASINT 4000
→ Cost-effective materials
→ Extremely good dimensional stability and load capacity up to 300 °C

TECASINT 5000
→ Matrix of PTFE reinforced with PI powder
→ Reduced creep under load
→ Excellent sliding and friction properties

Ideally suited for soft sliding partners (stainless steel, aluminium, brass, bronze)
→ Best chemical resistance and easy machining properties

TECASINT 2011 (PI):
High purity.
Very good electrical insulation.
Thermal resistance up to 300 °C.

TECASINT 5011:
Sensor housing

TECASINT 8000:
Cost-effective materials

TECASINT 5000:
→ Matrix of PTFE reinforced with PI powder
→ Reduced creep under load
→ Excellent sliding and friction properties

Ideally suited for soft sliding partners (stainless steel, aluminium, brass, bronze)
→ Best chemical resistance and easy machining properties

Structural formula PI

Cost-effective materials

High rigidity

Typical applications:
→ Automotive industry
→ Electrical/electronics industry
→ Mechanical engineering
→ Aerospace industry
→ Glass industry
→ Semiconductor industry
Unfilled
- Maximum strength and elongation
- Highest modulus
- Minimal thermal and electrical conductivity
- High purity
- Low outgassing in vacuum in accordance with ESA regulation ECSS-Q-70-20

+ 15 % graphite
- Enhanced wear resistance and thermal ageing
- Self lubricating, for lubricated and unlubricated applications

+ 40 % graphite
- Reduced thermal expansion
- Maximum creep strength and resistance to thermal ageing
- Improved self lubrication
- Reduced strength

+ 15 % graphite / + 10 % PTFE
- Extremely low static friction and low coefficient of friction due to PTFE modification
- Good properties also in dry running conditions due to self lubrication
- For applications involving low friction and wear characteristics at medium temperatures and loads (< 200 °C)

+ 15 % MoS₂
- Best friction and wear properties in vacuum
- Frequently used in space applications, in vacuum or in inert gases (techn. dry)
- Low outgassing in vacuum in accordance with ESA regulation ECSS-Q-70-20

+ 30 % glass fibres
- Reduced thermal expansion
- High thermal-mechanical load properties
- Excellent electrical insulation
- SD: Static dissipative / antistatic, permanently migration free
- Surface resistance 10⁶–10⁸ Ω or 10¹⁰–10¹² Ω
- For explosion-proof equipment and in semi-conductor technology (test sockets)

Overview of modifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Nomenclature</th>
<th>Availability TECASINT</th>
<th>Modifications</th>
<th>B000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure</td>
<td>x011</td>
<td>1000 2000 4000 4100 5100</td>
<td>B0 P/20 PI</td>
<td>B001</td>
</tr>
<tr>
<td>25 % graphite</td>
<td>x021</td>
<td>1021 2021 4021 4121 -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40 % graphite</td>
<td>x031</td>
<td>1031 - - -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25 % graphite / 20 % PTFE</td>
<td>x041</td>
<td>1061 2061 - - -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25 % MoS₂</td>
<td>x051</td>
<td>- 2391 - - -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>30 % GF</td>
<td>x061</td>
<td>- - - - 5051</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SD static dissipative</td>
<td>x071</td>
<td>- - - - 5511</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Customized products available on request.

Overview of nomenclature TECASINT

TECASINT xxxx

1st digit = PI basic material / product family
2nd + 3rd digit = Formulation code / modification
4th digit = Production process
(1 = stock shape, 2 = direct forming)

Direct forming process

Low-cost manufacturing method for high volume precision parts

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 causes a degree of shrinkage, which is accounted for in the original design of the die.

The following types are available for direct forming:

TECASINT 2000 DF
- TECASINT 2012 (unfilled)
- TECASINT 2022 (wear resistant grade)
- TECASINT 2032 (highly filled grade, low friction)
- TECASINT 2062 (15 % graphite, 10 % PTFE)

TECASINT 6000 DF
- TECASINT 6012 (unfilled)
- TECASINT 6022 (wear resistant grade)
- TECASINT 6032 (highly filled grade, low friction)
- TECASINT 6062 (15 % graphite, 10 % PTFE)

Conditions for direct forming

<table>
<thead>
<tr>
<th>Description</th>
<th>Min. part thickness</th>
<th>Max. part thickness</th>
<th>Max. outside diameter</th>
<th>Min. inside diameter</th>
<th>Surface quality</th>
<th>Flattening at the chamfers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>~ 1 mm</td>
<td>30 mm</td>
<td>145 mm</td>
<td>~ 2 mm</td>
<td>~ 1 μm (Ra)</td>
<td>0.15 – 0.3 mm</td>
</tr>
</tbody>
</table>
| Reference value
   | For more information regarding direct forming please have a look on our website: tecasint.com

For more information regarding direct forming please have a look on our website: tecasint.com
Shape and position tolerances can be manufactured off-tool. Depending on the part geometry and component size, deviations to the listed tolerances are possible. Consequently, tolerances have to be considered individually for each component. Undercuts and transverse holes, which cannot be manufactured off-tool, and also narrow tolerances can be realized by a subsequent machining operation.

**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 depends on the material and should not exceed the value of 1:10

**Tolerance guideline for direct formed parts**

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Concentricity</th>
<th>Roundness</th>
<th>Parallellity</th>
<th>Flatness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 14 mm</td>
<td>0.04</td>
<td>0.050</td>
<td>0.040</td>
<td>0.050</td>
</tr>
<tr>
<td>15 – 30 mm</td>
<td>0.05</td>
<td>0.125</td>
<td>0.075</td>
<td>0.125</td>
</tr>
<tr>
<td>31 – 60 mm</td>
<td>0.05</td>
<td>0.125</td>
<td>0.075</td>
<td>0.125</td>
</tr>
</tbody>
</table>

All values in [mm]

Seal rings

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.

**Butt joint**
- Direct formable
- Gap closes when heated and response to pressure without permanent deformation
- Low-cost solution rings with very low constant leakage rates
- Minimum oil pressure required for even contact pressure on the groove flanks
- Maximum wall thickness for straight butt joint sealing rings: 0.5 x (min. shaft diameter – groove base diameter) – 0.05 mm

**Scarf joint**
- Direct formable with subsequent finish machining
- Joint customarily with 20 degree
- Gap clearance effect far lower than with butt joint
- Seal effect less dependent on minimum oil pressure

**Stepped joint**
- Direct formable with subsequent finish machining
- Stepped joint seal created by media pressure at any application temperature
- Behaves on principle in the same way as a butt joint connection with slightly reduced clearance
- Rings with very low constant leakage rates
- Seal less dependent on minimum oil pressure

Diameter | Concentricity | Roundness | Parallellity | Flatness |
---------|---------------|-----------|--------------|----------|
0 – 25.4 mm | 0.04          | 0.050     | 0.040        | 0.050    |
25.4 – 50.8 mm | 0.05          | 0.125     | 0.075        | 0.125    |
> 50.8 mm | 0.05          | 0.125     | 0.075        | 0.125    |

Reference value
Mechanical properties

The determination of mechanical properties by tensile testing provides information about stress-strain behaviour and the resulting modulus. As components made of TECASINT are only seldom used at room temperature, material behaviour at elevated service temperatures is required for successful component design. Even at high temperatures where conventional thermoplastic materials would fail or disintegrate, TECASINT polyimides are characterized by very high strength and modulus levels.

Dynamic Mechanical Analysis (DMA)

DMA measurement is defined as the mechanical response behaviour (storage modulus $E'$ and loss factor tan $\delta$) of a material exposed to minimal oscillating load. Measured values are recorded on a time, temperature and frequency-dependent basis. The storage modulus $E'$ constitutes the proportion of rigidity which allows the energy of a mechanical load to be stored by the material as a result of elastic deformation and then given off again.
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 modulus and creep strain depending on time and temperature under a load of 17 MPa.

**Creep Strain TECASINT at 23 °C / 73 °F**
17 MPa, ISO 899-1

**Creep Strain TECASINT at 250 °C / 482 °F**
17 MPa, ISO 899-1

**Creep modulus E<sub>c</sub> TECASINT at 150 °C / 302 °F**
17 MPa, ISO 899-1
Due to their chemical structure and insusceptibility, polyimides are far superior to thermoplastics for use in high-temperature applications. By ascertaining their thermal oxidation stability, a guideline can be seen for service life and ageing resistance under thermal load.

**Thermal properties**

**Thermal Oxidation Stability at 300 °C / 572 °F**

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight loss [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECAFlon PVDF</td>
<td></td>
</tr>
<tr>
<td>TECapei</td>
<td></td>
</tr>
<tr>
<td>TECaSON 5</td>
<td></td>
</tr>
<tr>
<td>TECaTRON</td>
<td></td>
</tr>
<tr>
<td>TECaPEEK</td>
<td></td>
</tr>
<tr>
<td>TECaTOR PAI</td>
<td></td>
</tr>
<tr>
<td>TECaSN 2011</td>
<td></td>
</tr>
<tr>
<td>TECaSN 4011</td>
<td></td>
</tr>
<tr>
<td>TECaSN 4111</td>
<td></td>
</tr>
</tbody>
</table>

Here, TECaSN 4000 materials demonstrate their excellent properties with minimal weight loss at 300 °C and with additional pressure of 4.8 bar.

**Ageing resistance in air at 340 °C / 644 °F**

Long-term tests performed at 340 °C in air testify to the excellent properties of TECaSN 4000. After 2,000 hours, TECaSN 4011 still attains 50% of its original flexural strength.

**Heat Distortion Temperature**

HDT / A 1.80 MPa

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Flexural strength [σ max] [MPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>180</td>
</tr>
<tr>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>400</td>
<td>120</td>
</tr>
<tr>
<td>500</td>
<td>90</td>
</tr>
</tbody>
</table>

**TECAFlon PVDF**

**TECapei**

**TECaSON 5**

**TECaTRON**

**TECaPEEK**

**TECaTOR PAI**

**TECaSN 2011**

**TECaSN 4011**

**TECaSN 4111**

With its residual flexural strength of 70% after 3,100 hours, TECaSN 4111 sets the benchmark for extreme high-temperature applications.

**TECASINT polyimides benefit from high abrasion resistance and are ideally suited for applications involving minimum lubrication or dry running. For tribological requirements, types containing graphite or graphite/PTFE modifications are used, while in vacuum applications, molybdenum disulphide (MoS₂) is used.**

**Tribological properties**

**TECASINT** polyimides benefit from high abrasion resistance and are ideally suited for applications involving minimum lubrication or dry running. For tribological requirements, types containing graphite or graphite/PTFE modifications are used, while in vacuum applications, molybdenum disulphide (MoS₂) is used.

**The tribological characteristics depend heavily on the ambient conditions. Factors such as sliding speed, load and form of movement (linear, oscillating, rotating) exert a major influence. Because of these complex correlations,**

**Due to their excellent electrical insulating properties, high strength and very good radiation and thermal resistance, components made of TECASINT are ideally suited for electrical applications under difficult conditions. Even at high temperatures, they do not lose their electrical properties. With rising moisture content, the dielectric loss factor and the dielectric constant both increase. The surface and volume resistance are only minimally influenced by increasing moisture content.**
Behaviour under environmental influences

TECASINT components are often exposed to wide-ranging different environmental influences which may result in property changes in the polymer. The combination of different environmental influences results in unpredictable reciprocal effects. It is only by testing under practical conditions that this type of influence can be simulated.

Water absorption ISO 62 at 23 °C / 73 °F [%]

<table>
<thead>
<tr>
<th>TECASINT</th>
<th>0</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2391*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Water absorption 24 h (23 °C / 73 °F) [%]

Drying

Like many other plastics, TECASINT also demonstrates hygroscopic behaviour. This means that the plastic is able to absorb water, generally in the form of air humidity. This absorption of moisture is reversible, i.e. the absorbed water can be fully removed again by drying.

When manufacturing high-precision components, we therefore recommend drying the parts prior to machining in order to eliminate the disturbing influence of water. Even components with an application temperature of over 200 °C should be dried in order to prevent the formation of bubbles in the material as a result of vapour pressure.

Annealing

Due to the sintering process, semi-finished and machined parts made of TECASINT are almost stress free and have low warping tendencies, meaning that they do not require annealing. When producing components with very low tolerances, however, it can make sense to dry TECASINT prior to machining, in order to remove any residual moisture and ensure that the parts are conditioned to a uniform starting status. The dried finished parts then have to be packaged in an airtight sealable PE bag.

Drying process

- Store the component for at least 48 hours at 150 °C
- Then heat to 240 °C within 8 hours and leave to dry for at least 24 hours at this temperature
- Switch off the oven and leave to cool slowly

Hydrolysis

Polyimides are sensitive to hydrolysis at temperatures > 100 °C and are consequently not suitable for use in hot water, steam or for repeated steam sterilization processes.

Flammability and weather resistance

Flammability

Oxygen index LOI in accordance with EN ISO 4589-2

The “Limiting Oxygen Index” (LOI) indicates the minimum oxygen concentration which must prevail in an oxygen/nitrogen mix when a material burns. TECASINT will only burn with an oxygen content of around 50 % and is consequently not burning in normal air with an oxygen content of only 21 %.

Weather resistance

Polyimides are highly radiation resistant. To assess weather resistance, Xenotest weathering in compliance with EN 4892 was selected. This simulates not only radiation with artificial sunlight but also regular rain cycles to test the influence of rain, humidity and temperature in natural weathering. The TECASINT 4000 types emerged particularly well from these tests, demonstrating over 70 % of their flexural strength even after 5000 hours.

Drying process

1. Store the component for at least 48 hours at 150 °C
2. Then heat to 240 °C within 8 hours and leave to dry for at least 24 hours at this temperature
3. Switch off the oven and leave to cool slowly

Hydrolysis

Polyimides are sensitive to hydrolysis at temperatures > 100 °C and are consequently not suitable for use in hot water, steam or for repeated steam sterilization processes.
## Chemical resistance

TECASINT products offer a high level of resistance to many chemical substances, including organic and inorganic solvents, fuels, oils and synthetic lubricants. TECASINT products are susceptible in combination with water and water vapour above 100 °C. Due to their hydrolysis susceptibility, marked cracks can occur here. Important criteria for testing chemical resistance are temperature, concentration of agents, exposure time and mechanical load. In the table below, resistance to different substances is listed. This overview is provided as an aid to orientation. For specific applications, customers are advised to perform their own verification tests.

### Chemical resistance of TECASINT (PI)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Resistance</th>
<th>Resistance</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Formic acid, aqueous solution 10%</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ammonia solution 10%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Benzene</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bitumen</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Butyl acetate</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Calcium chloride, solution 10%</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chloroform</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Cyclohexanone</td>
<td>+</td>
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<td>Dekalin</td>
<td>+</td>
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<td>+</td>
</tr>
<tr>
<td>Diesel oil</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Dimethyl formamide</td>
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<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Dioxane</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Acetic acid, concentrated</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Acetic acid, aqueous solution 10%</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Acetic acid, aqueous solution 5%</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ethanol 96%</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ethyl ether</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ethylene chloride</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Furan, Frigene, liquid</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fruit juices</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Glycol</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Glycol, aqueous solution 0-40%</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Glyptone</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Heating oil</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Heptane, Hexane</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Iso-octane</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Isopropanol</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

### Purity

In ultra-clean production environments such as in the semi-conductor and solar industry, foreign ions can result in contamination and higher reject rates.

#### Ionic purity

<table>
<thead>
<tr>
<th>Substance</th>
<th>TECASINT 5011</th>
<th>TECASINT 4011</th>
<th>TECASINT 4111</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum (Al)</td>
<td>1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>0.43</td>
<td>0.24</td>
<td>0.21</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>&lt; 3</td>
<td>&lt; 3</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
</tr>
</tbody>
</table>

#### Low outgassing

According to ESA regulations ECSS-Q-70-02

<table>
<thead>
<tr>
<th>Substance</th>
<th>TECASINT 5011</th>
<th>TECASINT 4011</th>
<th>TECASINT 4111</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toluene</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

### Contact plate

TECASINT 5051: Thermal resistance up to 100 °C. High strength. Good electrical insulation.

### Test socket

TECASINT 5051: Low thermal expansion. Thermal resistance up to 300 °C. Wear resistant.
FAQs
What benefits does TECASINT offer when producing bushings and slide bearings?
TECASINT offers an unusual characteristic profile permitting applications for components exposed to extreme levels of stress which cannot be achieved using other materials such as ceramics, metal or conventional plastics. Bushings and slide rings made of TECASINT remain 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.

How do slide bearings made of TECASINT compare 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:

<table>
<thead>
<tr>
<th>Pressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-finished part geometries close to finished measurement</td>
</tr>
<tr>
<td>Extreme economy due to material savings</td>
</tr>
<tr>
<td>Low tendency to warp due to almost isotropic characteristics</td>
</tr>
<tr>
<td>Consequently also easier to machine</td>
</tr>
<tr>
<td>Discontinuous production process</td>
</tr>
<tr>
<td>High semi-finished product costs</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Extrusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous production process</td>
</tr>
<tr>
<td>Lower semi-finished product costs</td>
</tr>
<tr>
<td>High tension levels due to orientations during production</td>
</tr>
<tr>
<td>More difficult to machine</td>
</tr>
</tbody>
</table>

How do TECASINT sliding bearings behave in comparison 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.

How do the wear properties compare 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 un lubricated 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.

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 angle for aluminium machining has proven the most successful for machining these materials. To avoid machining errors, it is important to recognize and replace worn out cutting tools in good time, and to follow 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.

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

Turning
For all machining steps, the use of carbide tools, of the type customary for machining aluminium, offers the best solution. The tip of the cutting tool should have a radius of between 0.2 and 0.4 mm. As a result of wet machining, the cutting pressure at the work-piece 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.

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. PAI 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.

Do you have any other questions?
Please do not hesitate to contact our technical service:
Markus Edelbauer: m.edelbauer@de.ensinger-online.com
or Ben Sin (Asia): s.ben@ensinger.com.sg
Milling
Milling is performed exclusively using the downcut milling. For all machining steps, the use of carbide tools with the same cutting geometry as that customarily used for aluminium is the best solution. Individual grinding of tools 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:
\[ V = 90 - 100 \text{ m/min.} \]
\[ f = 0.04 - 0.08 \text{ mm/tooth} \]

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

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.

Standard shapes dimensions
TECASINT semi-finished products are available as plates, rods and short tubes:
- Rods from Ø 6 mm to max. Ø 100 mm, max. length 1,000 mm
- Plates from 5 mm to max. 100 mm thickness
- Maximum plate formats up to 300 x 1,000 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 plate formats for high cutting efficiency

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

Preferred dimensions can be found online at: www.goo.gl/upydKH
TECASINT is the Ensinger portfolio of non-melting high-temperature polyimides. Sintered TECASINT parts and shapes are used in numerous demanding industries.

ensingerplastics.com