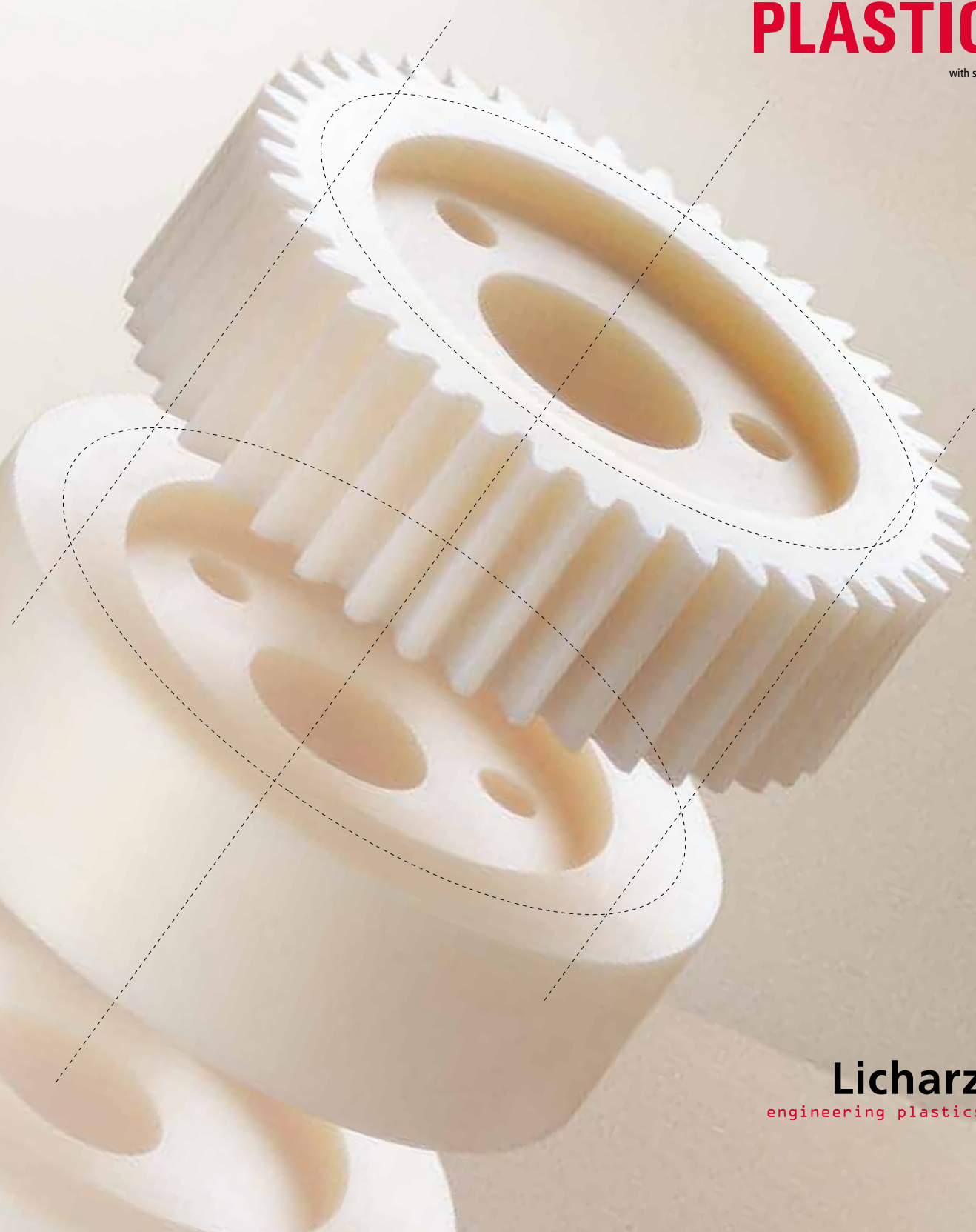


DESIGNING WITH ENGINEERING

PLASTICS

with survey tables





LICHARZ
LiNOTAM

The competitive edge through engineered components made of plastic

Cast polyamides

Cast polyamide is a partially crystalline thermoplastic which is produced by means of anionic polymerisation of the raw material Caprolactam. In a pressureless casting process the liquid monomer is polymerised via a controlled chemical reaction directly to a semi-finished product or mould.

LINNOTAM is the new brand name of the exceptionally effective cast polyamides from LICHARZ.

Polyamides from the **LINNOTAM** brand produced by means of this process

- are mostly free of internal stresses
- display a high degree of crystallinity
- can be manufactured as semi-finished shape or near net shape component
- can be machined to almost any form
- can be manufactured in almost unlimited weights and dimensions

By means of additives, e.g. oil, solid lubricants or heat stabilisers, and modifications to the polymer matrix, the typical properties of cast polyamide can be aligned and adjusted for specific applications. Thus a tailor-made range of material can be offered for a wide scope of applications.

LINNOTAM is available in four other versions:

LINNOTAM*GLIDE*: Optimum anti-friction characteristics over the entire service lifetime.

LINNOTAM*HiPERFORMANCE*: The high-performance triple: dimensionally stable, fatigue-resistant, with excellent damping. Versions designed for special requirements include, for example, low water absorption, good resistance to hydrolysis and high impact strength.

LINNOTAM*DRIVE*: Ideally suited for the transmission of power and torque.

LINNOTAM*CUSTOM*: Your requirements are unique and individual. Ask us. We have the technical capabilities, the experience and the capacity to develop the perfect solution.

Further special settings can be made and delivered on request.

LINNOTAM

Standard quality for high wear demands on parts in machine and plant engineering.
Colours: natural, black, blue

Due to its balanced mechanical properties and its excellent mechanical features this standard quality manufactured in a monomer casting process is the ideal construction material for a wide range of applications.

LINNOTAM offers compelling advantages compared to extruded polyamide 6 due to

- better mechanical strength
- lower moisture absorption
- better creep resistance
- better dimensional stability
- higher wear resistance

Very good friction characteristics

make **LINNOTAM** a classic friction bearing material for highly loaded machine parts. These include bushings, slide and guide plates as well as gears and sprockets. Generally, an initial lubrication during assembly is sufficient due to the low coefficient of friction. In many cases lubrication can be dispensed with altogether.

High abrasion and wear resistance

at low to medium speeds, in particular under demanding conditions (e.g. dust or sand in the bearing), complete the scope of **LINNOTAM** as a friction bearing material. Under demanding conditions a significantly longer service life can be achieved compared to conventional bearing materials such as cast iron, steel or bronze.

Good damping properties

for the reduction of vibration and noise is of particular interest when using ropes and sheaves. **LINNOTAM** reduces the vibrations that are transferred from metallic rollers via the roller to the bearing, bearing to the shaft and from there to the machine frame. Friction bearings made of **LINNOTAM** reduce the vibrations affecting the machine frame. This results in the prolongation of the service life of the machine and machine components. Furthermore, measures to reduce the operating noise level of the machine are supported and enhanced.

Low specific weight

Component weight is less compared to metallic materials. This is of particular interest when centrifugal forces result from rotating components. These centrifugal forces are considerably reduced due to the lower component weight, resulting in fewer imbalances and accompanying vibrations. Often the significant weight reduction also lessens the required drive power and the handling and assembly of large parts is made much easier.

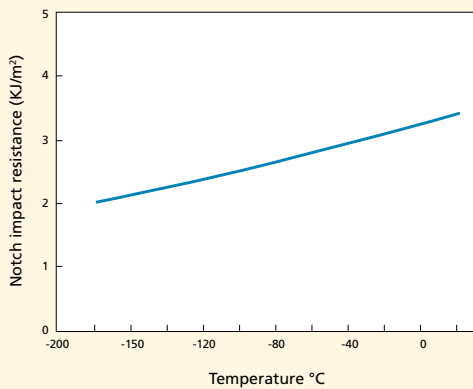
Good machinability, dimensional stability and low residual stress

enable the manufacture of complex components and the use in all areas of design. Machining can be performed with standard tools and conventional machines for working wood and metal. High feed rates and cutting speeds facilitate cost-effective production.

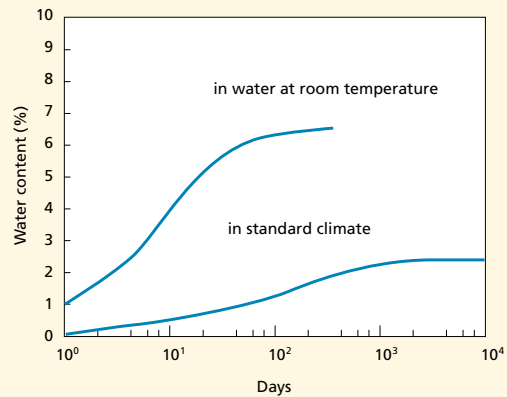
Changes in material properties

due to temperature, environmental conditions and moisture content must be taken into account. An increase in temperature coupled with high moisture content makes the material elastic. Tensile and compressive strength as well as the modulus of elasticity and hardness decrease. Simultaneously, the impact strength and elongation increases. The material assumes a strong, tough, elastic character. The change in length at elevated temperature or increased water content must also be considered. The following charts illustrate the relationship.

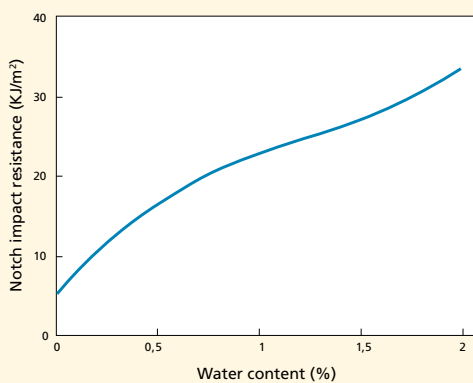
Notch impact resistance of LINNOTAM at low temperatures



Water absorption of LINNOTAM in water at room temperature and standard climate (Test piece: standard small rod)



Notch impact resistance of LINNOTAM with different water contents



LINNOTAM HS

Primarily comparable to the standard quality but with the heat aging stabiliser it is better protected against thermal-oxidative degradation.

Colour: black.

LINNOTAM MoS

Primarily comparable to the standard quality, however the molybdenum disulphide gives increased crystallinity.

Colour: black, anthracite.



LICHARZ

LINNOTAMGLIDE

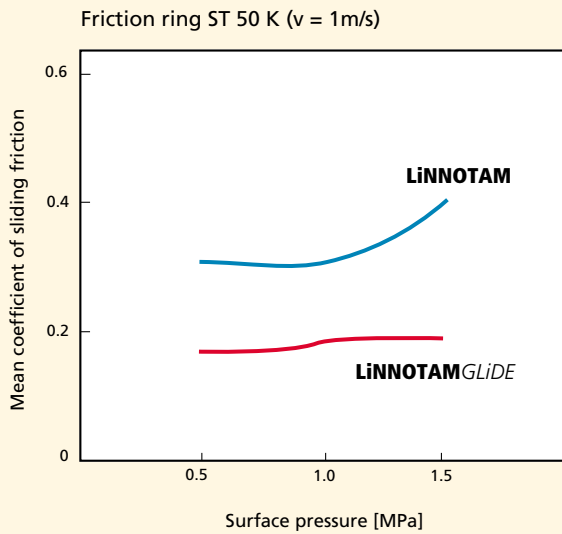
The competitive edge through engineered components made of plastic

LINNOTAMGLiDE is a high crystalline modification of **LINNOTAM**, manufactured in the monomer casting process which, through the addition of oil and active lubricating additives, is specially designed for sliding applications. Contrary to the standard quality **LINNOTAM**, **LINNOTAMGLiDE** features a unique combination of properties.

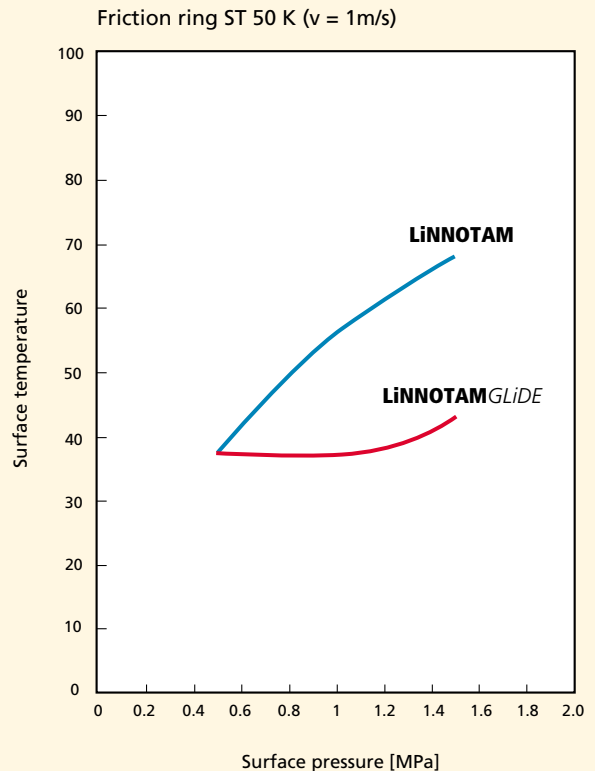
Excellent sliding properties

make **LINNOTAMGLiDE** a special friction bearing material for highly loaded slide and wear parts in machines and equipment. Due to the lubrication and additives in the material, a sustainable lubricating effect is achieved for the whole life cycle. A 50% reduction in friction is achieved in comparison to the standard quality, thus producing less frictional heat and considerably higher peak load capacity. Also the undesirable stick-slip tendency is reduced.

Coefficient of sliding friction of **LINNOTAM** and **LINNOTAMGLiDE**



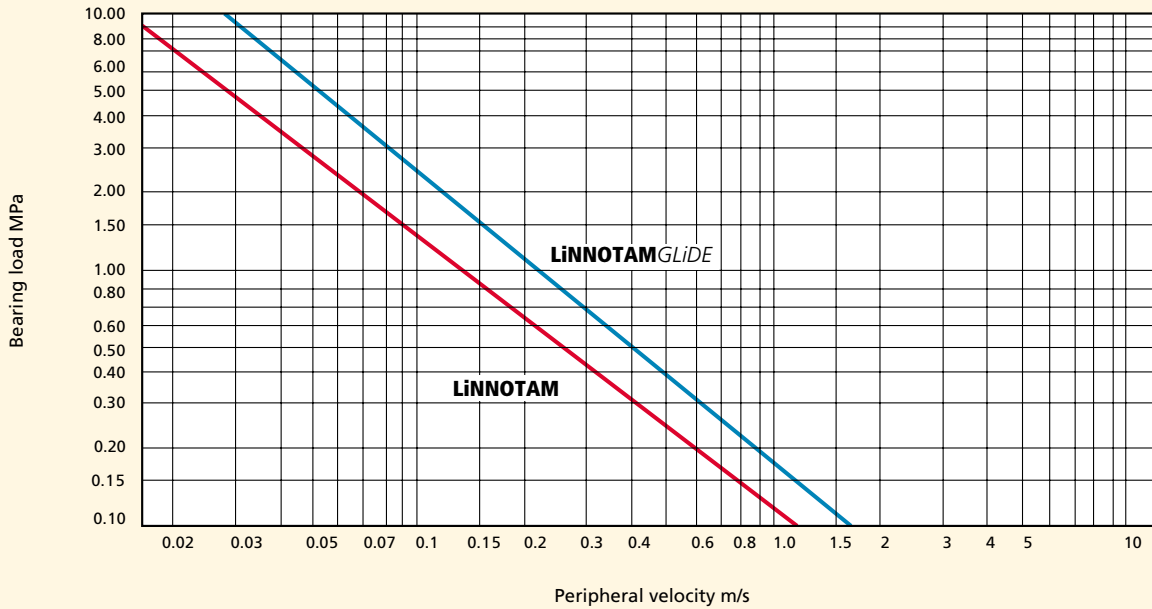
Surface temperature after 1 hour Sliding friction of **LINNOTAM** and **LINNOTAMGLiDE**



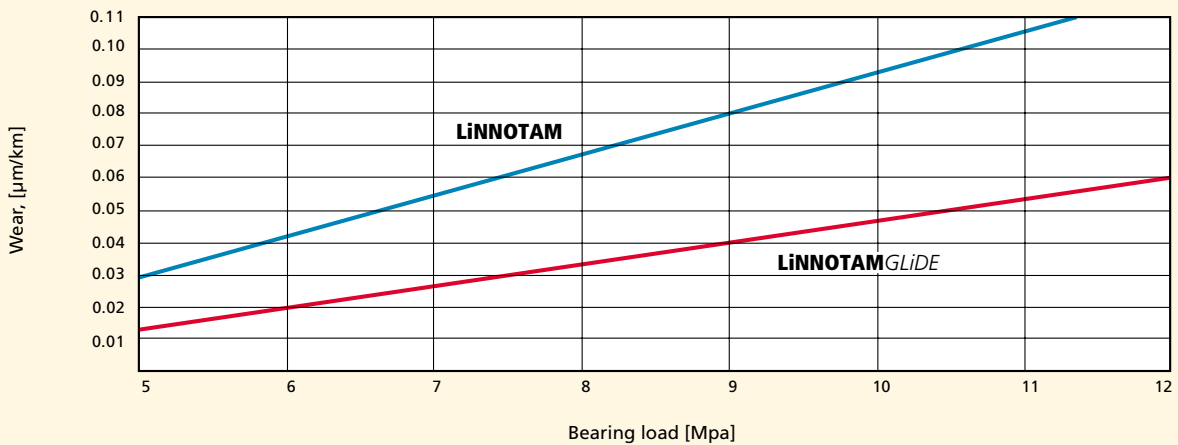
Extraordinary wear resistance

is achieved by the fine crystal microstructure of **LINNOTAMGLiDE**. Compared with standard quality, the reduced frictional heat as well as the reduced friction coefficient makes application possible at higher speeds and surface pressures. This applies not only for dry running and lack of lubrication but also for running under emergency conditions.

LINNOTAMGLiDE/LINNOTAM load limit



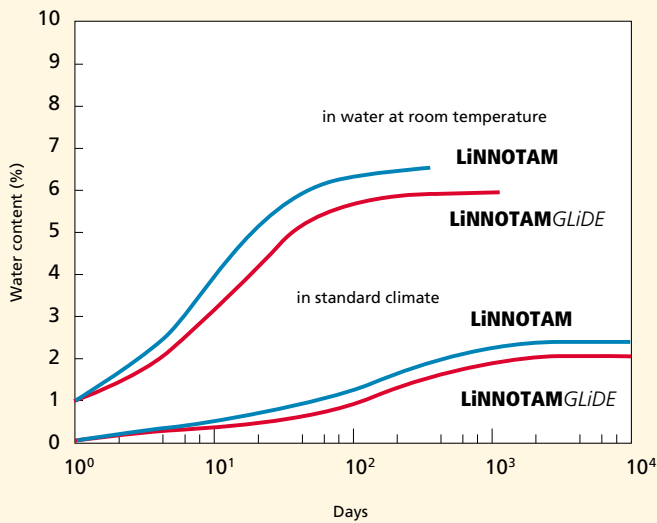
LINNOTAMGLiDE/LINNOTAM wear rate



Reduced moisture absorption and dimensional stability

are achieved with **LINNOTAMGLiDE** due to its highly crystalline molecular structure and specific additives. In comparison to standard quality materials the low moisture absorption results in improved dimensional stability and lower moisture related deterioration of mechanical values.

LINNOTAMDRiVE/LINNOTAM water absorption



Applications and examples

The key applications of **LINNOTAMGLiDE** are in conveyor and transport technology as well as in machine engineering, equipment design and the automotive industry. **LINNOTAMGLiDE** components are of particular advantage in the area of filling, labelling and packaging machines.

LINNOTAMGLiDE meets the requirements of Regulation (EU) No 10/2011 and the requirements of 21 CFR § 177.1500 of the FDA and may be used for the manufacture of consumer goods that come into direct contact with foodstuffs.

Typical applications are:

- Bearings
- Guide rails
- Sprockets and chain guides
- Slide rails
- Feeder wheels
- Actuators
- Curve guides
- Gears

LINNOTAMGLiDE

LINNOTAM with built-in oil lubrication, self-lubricating effect, improved wear resistance.

Colours: black, yellow, natural.



LICHARZ

LINNOTAMGLIDE PRO T

The competitive edge through engineered components made of plastic

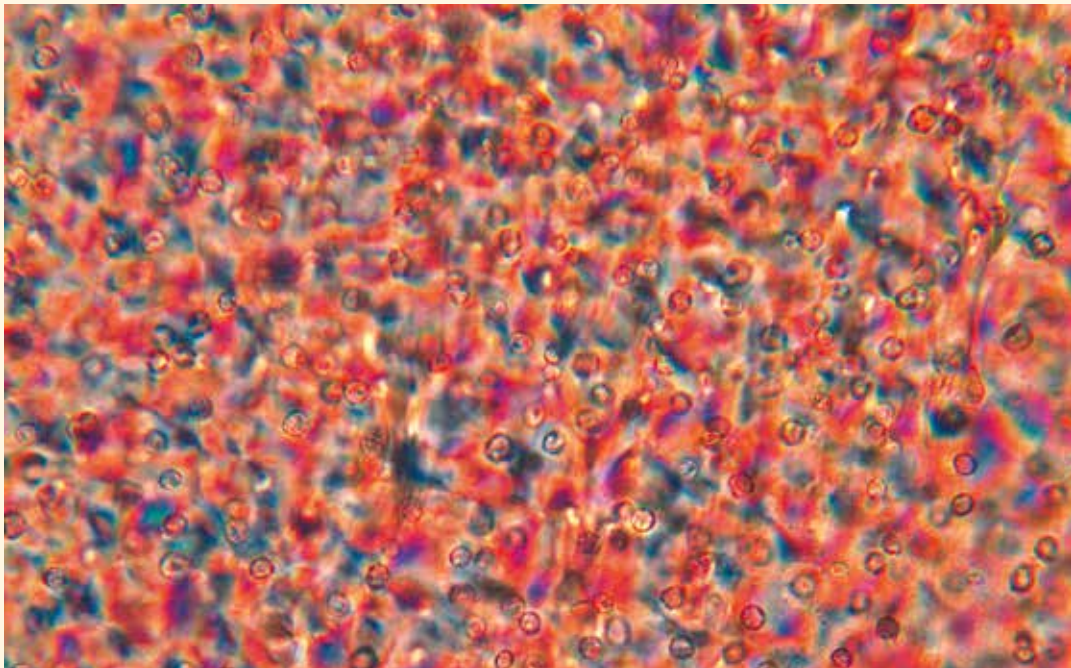
LINNOTAMGLIDE PRO T is a polyamide manufactured in the monomer casting process based on **LINNOTAM**, and with the addition of solid lubricants and special additives is particularly suitable for sliding applications. It complements the bearing materials product line and has maximum wear resistance and long life.

Exceptionally low sliding friction coefficient

The integrated lubricants in **LINNOTAMGLIDE PRO T** are carefully selected with a focus on the sliding properties. The balanced composition of the material formula allows for a friction coefficient of 0.15 μ which is extraordinarily low. Furthermore, the tendency for stick-slip is reliably reduced to a minimum.

Homogeneous structure

The microtome of **LINNOTAMGLIDE PRO T** in polarized light magnified 250x illustrates the uniform microstructure.

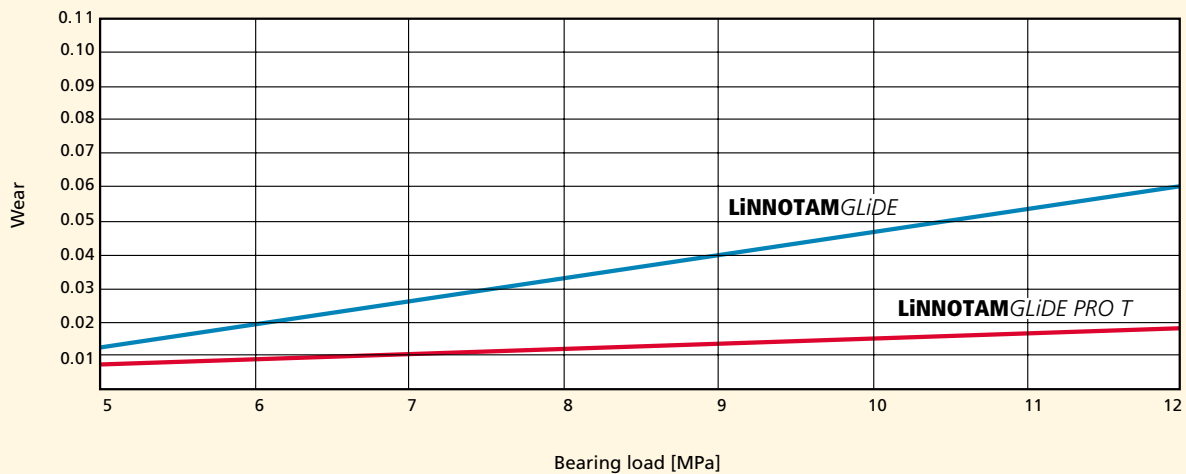


LINNOTAMGLIDE PRO T

Material characteristics

In addition to high strength the fundamental characteristics and performance of this material are of particular importance: the self-lubricating effect and the sliding characteristics remain permanently and uniformly stable throughout the lifetime. Considerably better friction and wear values are realized compared with the unfilled **LINNOTAM** and the oil-filled variant **LINNOTAMGLIDE**. The combination of the properties of **LINNOTAMGLIDE PRO T** make this material the first choice for highly loaded sliding and wear parts when lubrication of components is difficult, impossible or undesirable.

LINNOTAMGLIDE PRO T/LINNOTAMGLIDE wear rate



Application areas

for **LINNOTAMGLIDE PRO T** are in particular machine engineering and equipment design as well as drive and conveyor technology. Due to the carefully chosen raw materials **LINNOTAMGLIDE PRO T** is available in FDA compliant quality and fulfils the requirements of Regulation (EU) No 10/2011 and the requirements of 21 CFR § 177.1500 of the FDA in almost all applications.

Typical applications:

- Bearing bushes
- Curve guides
- Slide and guide plates
- Castors
- Gears and sprockets

LINNOTAMGLIDE PRO T

The finely dispersed solid lubricant contained in the material ensures self-lubricating properties.

Excellent wear resistance is achieved at very low coefficient of friction.

Colours: grey, green, red.



LICHARZ

LiNOTAM HiPERFORMANCE

The competitive edge through engineered components made of plastic

LiNOTAM*HiPERFORMANCE* 612 (PA 6/12 G) is a co-polyamide mix manufactured by static casting from the raw materials caprolactam and laurilactam. Compared to pure **LiNOTAM** it has a higher shock and impact resistance as well as lower tendency to absorb moisture, but retains the same gliding and wear properties. In addition, the material is characterised by improved creep resistance and higher elasticity. **LiNOTAM*HiPERFORMANCE* 612** because of its tough and hard material characteristics is the ideal material for applications where increased shock and vibration load is expected or there are increased demands on fatigue strength or elasticity.

Typical applications are:

- Gears wheels
- Racks
- Pinions
- Rollers with long idle times
- Crane support pads

LiNOTAM*HiPERFORMANCE* 1200 (PA 12 G) is manufactured from the raw material laurilactam based on the anionic reaction in the unpressurized gravity casting process. The process produces a material with high molecular weight that is highly crystalline and largely stress-free, which gives **LiNOTAM*HiPERFORMANCE* 1200** outstanding properties compared to other polyamides.

The main advantages are:

- extremely low water absorption (max. 0.9% in standard climate conditions 25/50)
- excellent dimensional stability and stable mechanical characteristics
- excellent damping of mechanical vibrations
- high toughness at temperatures as low as -50 °C
- very good wear resistance
- very good friction and dry running properties
- low specific weight
- good chemical and hydrolysis resistance
- resistant to stress cracking

These properties make **LiNOTAM*HiPERFORMANCE* 1200** the ideal partner for applications in conveyor and drive engineering.

Material characteristics

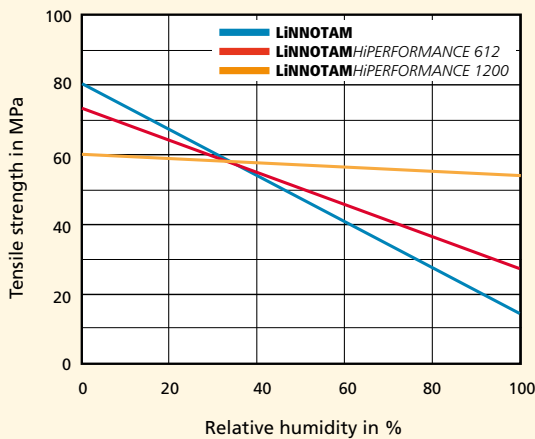
Due to the highly crystalline molecular structure, material properties are created which are far superior to those of conventional polyamides in many ways. The properties typical for polyamides and appreciated by users are thus mostly retained, e.g. wear resistance/ abrasion resistance and the good sliding properties, and are further supported by the special molecular structure.

The main difference to the conventional polyamides is considered to be the tough material characteristics. The **LiNOTAM*HiPERFORMANCE*** materials exhibit a hardness which is essential for many technical applications, without becoming brittle and breakable. At the same time a high degree of toughness is assured.

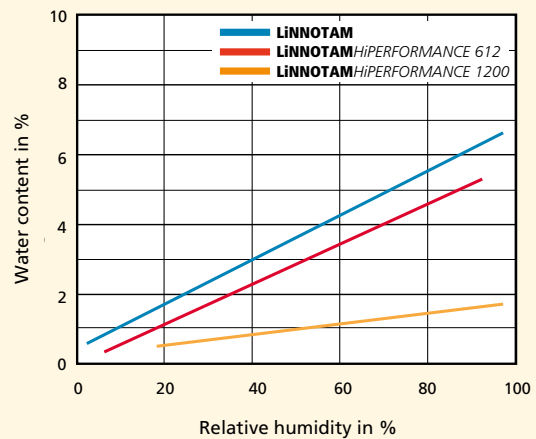
A further important feature is the low moisture absorption from ambient air. Swelling, which is common to polyamides due to moisture from the environment, is minimised, and the dimensional stability of engineered parts is considerably improved. Where **LiNNOTAM*Hi*PERFORMANCE 1200** is used, dimensional changes due to moisture absorption can even be ignored, since in normal climate conditions 23/50 it absorbs a maximum of 0.9% moisture and only 1.5% to saturation in water. It is also used in many technical applications where hardness is a priority without becoming brittle and prone to breakage. At the same time a high toughness is assured. Furthermore the loss of rigidity due to moisture absorption is insignificant. Thus **LiNNOTAM*Hi*PERFORMANCE 1200** is extremely suitable for engineered components for which the special properties of polyamide are essential and long term stability is required.

Both materials also feature improved creep resistance, higher elasticity and very good wear resistance. Furthermore their excellent mechanical damping qualities and high degree of toughness even at low temperatures are impressive.

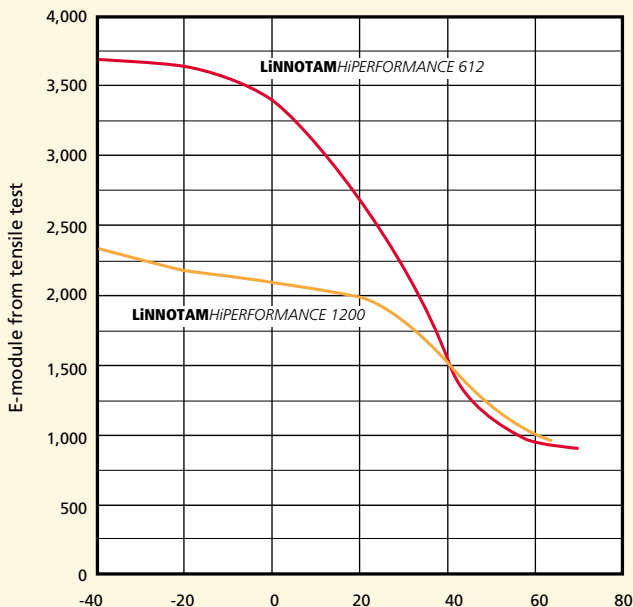
Loss of rigidity due to water absorption



Water absorption when stored in air



E-module at different temperatures



LiNNOTAM*Hi*PERFORMANCE 612

Co-polyamide on the basis of PA 6/12 G with greater impact resistance, less water absorption and improved creep resistance compared to pure **LiNNOTAM**.

Colour: natural, black.

LiNNOTAM*Hi*PERFORMANCE 1200

Cast polyamide from raw material Laurinlactam. Very good impact resistance, toughness, excellent dimensional stability, lowest water absorption, very good creep resistance, hydrolysis resistance, good chemical resistance.

Colour: natural, black.

Drive elements often transmit high torque, and to generate this high power, loads must be transmitted to the elements via the shaft-hub connection. In principle engineering plastics are suitable for these purposes. However, pure plastic designs often reach their limits in such cases. The allowable surface pressure in the keyway is often exceeded or the hubs become distorted under the high load. Furthermore, plastics are susceptible to notching, so that in extreme situations there is a danger that the groove in the side under load will give way. Further problems often arise when tolerances are required which are not possible with plastic designs.

This is where the material varieties of **LINNOTAMDRIVE**, which have been developed for just these applications, come into use. The combination of **LINNOTAMDRIVE** materials with a metal core combines the advantages and specific properties of both materials in an unusual design material. The knurled metal core is completely covered with a low viscosity melt generated in the monomer casting process. After casting, the polymer cools down and shrinks onto the metal core. A powerful bond exists between the core and the mantle, which assures optimal and dependable transmission of power.

Due to the surface structure of the metal core, a safeguard against radial and lateral slip is assured. The mantle consists of **LINNOTAMHiPERFORMANCE 612** or **LINNOTAMHiPERFORMANCE 1200**.

Typical applications of **LINNOTAMDRIVE** construction materials are:

- Gears:
 - spur gears
 - worm gears
 - bevel gears
- Sprockets
- Castors, guide rollers and sheaves
- Cams
- Agitator blades
- Pump impellers

In addition to the advantages over **LINNOTAMHiPERFORMANCE**, these composites are also impressive due to:

- plastic/metal compound
- optimal power and torque transmission
- reliable transmission of high axle power and torque
- calculation and manufacture of the shaft/hub connection with traditional processes and tolerances for metal
- lower momentum mass compared to purely steel constructions
- high level of running accuracy

Practice has shown that with this surface characteristic, power and torque transmission with plastic is successful and sufficiently high power/torque values can be transmitted. Practical results are also supported by the compression and torsion tests shown in fig. 1 and 2.

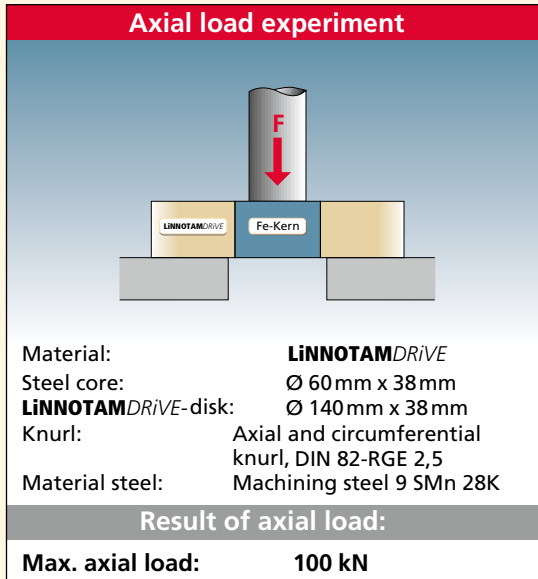


Fig. 1 Axial load test

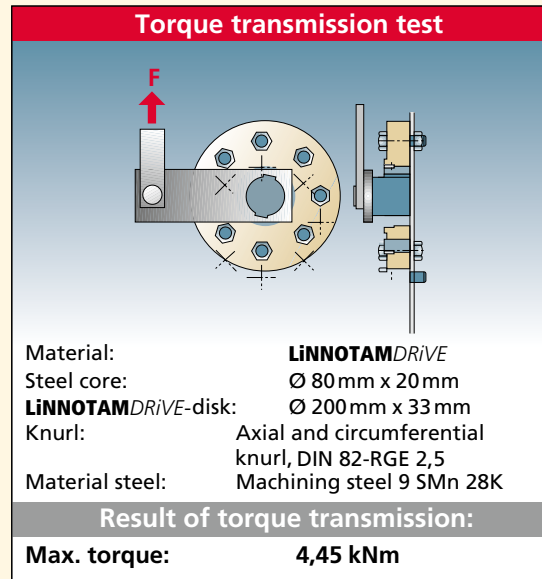


Fig. 2 Torque transmission test

LINNOTAMDRiVE Fe is equipped as standard with a machining steel 9 SMn 28 K as core material.

Other core materials possible are:

- Stainless steel
 - V2A (1.4305)
 - V4A (1.4571)
- Aluminium
- Brass

Other core materials are possible on request.



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- we recommend the material and the process
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