Plastic Plain Bearings

Plastic Plain Bearings with compensation gap

Introduction

Plain bearing materials have to meet very stringent demands in terms of sliding capacity, toughness, resistance to wear, compression and heat as well as to lubricants and chemicals. Polyamides, the materials used to manufacture Plastic Plain Bearings, satisfy these requirements to a high degree.
If sufficient quantities are ordered, Star can also supply other thermoplasts on special request.

Properties of polyamide 6.6
as a bearing material

Since the majority of Plastic Plain Bearings are manufactured from polyamide 6.6 and very good test results have been obtained with this material, it seems appropriate to give a brief description of its properties at the outset.

Mechanical properties

The compression strength of polyamide 6.6 lies at around 6,000 N/cm^2. Experience has shown that average contact pressures of up to 2,500 N/cm^2 are permissible when the sliding velocity is not too high.
The elongation after fracture is about 120 - 220%. This is the measure of toughness. Tough plastics stand out for their high wear resistance.
Compared to metallic materials, polyamide 6.6 has a very high deformation capacity. This property is a favorable one in plastic plain bearings, which cannot be sealed absolutely dust-free. Any dirt particles penetrating the bearing will become embedded in the plastic and rendered virtually harmless. Polyamide 6.6 also has a very high internal mechanical damping capacity and can thus effectively absorb shaft vibrations. The damping pro-perties of polyamide 6.6 peak at temperatures between 50 and 80° C, the range in which bearings are most commonly used. This is the reason for the smooth and quiet running characteristics of Plastic Plain Bearings. Compared to metallic materials, polyamides have a low modulus of elasticity. This is an advantage in terms of the maximum load capacity of the bearing material. Since shafts under load tend to press into the bearings, better conformity is achieved along with a reduction in maximum contact pressure and edge pressure.

Thermal properties

Polyamide 6.6 is a thermoplast, i.e. the material softens on heating and eventually melts. The melting point lies around 250-255°C.
Wherever possible, the continuous thermal load of polyamide plain bearings should not be allowed to rise above 80°C. Sustained exposure to higher temperatures renders the material brittle, and the bearings wear out very quickly as a consequence.

Plastic Plain Bearings

Polyamide 6.6 has a linear thermal expansion coefficient six times higher than that of metallic plain bearing materials. Special note should be taken of this fact when designing machinery.
By contrast, the thermal conductivity of polyamide 6.6 is substantially lower than that of metals. This is of crucial importance in Plastic Plain Bearings as their bearing capacity is in part determined by the amount of frictional heat that can be dissipated through the given wall thickness.

Absorption of moisture

The rate of absorption and release of atmospheric moisture is so low that the moisture content of saturated parts will not change significantly in the event of rapid changes in the normal climate.
Any swelling is, however, easily compensated for by the special design of Plastic Plain Bearings.

Properties of Polyamide 6.6		**Unit**	
Density	**DIN 53 479**	**g/cm^3**	**1.12-1.15**
Tensile strength[1)]	DIN 53 455	N/cm^2	5,500-6,000
Elongation after fracture[1)]	DIN 53 455	%	120-220
Modulus of elasticity[1)]		N/cm^2	170,000
Notch impact toughness[1)]	DIN 53 453	Ncm/cm^2	150-200
Cone thrust hardness[1), 4)]		Ncm/cm^2	9,000-10,000
Elongation due to static tensile loading[2)]			
at 20°C and	500 N/cm^2 after 100h	%	0.3
	500 N/cm^2 after 1,000h	%	0.4
	1,000 N/cm^2 after 100h	%	0.7
	1,000 N/cm^2 after 1,000h	%	0.9
	2,000 N/cm^2 after 100h	%	1.8
	2,000 N/cm^2 after 1,000h	%	2.3
Maximum logarithmic damping decrement			
(DIN 53 445) [3)]	in the range 20-50°C	-	0.14
	50-80°C	-	0.44
Permissible continuous	High	°C	80-100
service temperature	Low	°C	-20
Melting point		°C	250-255
Coefficient of linear thermal expansion		1/K	$7 \cdot 10^{-5}$
Thermal conductivity		W/K · m	0.23
Specific electrical resistance[1)]		Ω cm	1012
Maximum absorption of moisture at 20°C and 65% relative humidity		%	3.4-3.8

Table 1

1) After 4 months storage in a normal climate 20/65 DIN 50014
2) After saturation with moisture at 20°C and 65% relative humidity
3) Dry
4) After 10 impressions at 250 N load

Values as supplied by manufacturer.

Plastic Plain Bearings

Chemical resistance of polyamide 6.6

Polyamide 6.6 is resistant to a great number of chemicals. Plastic Plain Bearings are insoluble in common organic solutions and are not attacked by the majority of weak organic and inorganic acids.
Plastic Plain Bearings are resistant to most of the lubricating oils and greases in use today.

Medium	Concentration %	Resistance	Medium	Concentration %	Resistance
Aluminum chloride, aqueous	10	((1)) to +	Sodium chloride	10	+
Formic acid, aqueous	85	O	Sod. hydroxide sol., aqueous	10	+
Formic acid, aqueous	10	-	Petroleum		+2
Ammonia, aqueous	10	+8	Hydrochloric acid, aqueous	2	-
Gasoline		+	Sulfur		+
Butyric acid		+	Sulfuric acid, aqueous	2	-
Calcium chloride, aqueous	10	+9	Soap solution, aqueous		+
Chlorine gas	100	-	Silicone oil		+
Chlorine water		-	Edible fat		+
Diesel oil		+	Edible oil		+
Acetic acid, conc.		-	Tallow		+
Acetic acid, aqueous	5	+7	Water (sea, river, drinking and condensate)		+7.5
Milk		+			
Lactic acid, aqueous	10	+	Water, hot		((1)) to ((2))
Mineral oil		+0	Wine		+

Table 2

\+ = Resistant, no or only slight changes in weight and dimensions
((1)) = Limited resistance; after prolonged exposure, major changes in weight and dimensions, possible discoloration, weakening, possible slight embrittlement
((2)) = Not resistant; may still be usable under certain conditions (e.g. temporary exposure)
\- = Not resistant; strong attack within a very short period
O = Soluble

The figures alongside the symbols indicate the maximum increase in weight and length in %.
Example: + 11/3 = resistant; 11% max. in-crease in weight, 3% elongation.

Friction and Wear

When mated with steel or other polyamides, polyamide 6.6 exhibits very good sliding properties and wear resistance. This is especially true in the case of dry or mixed friction.
These two types of friction are defined in the usual way, i.e.

Dry friction

Lubricants are, if at all, applied once on installation to improve running in conditions.

Mixed friction

Oil lubrication, but with insufficient dynamic lubrication pressure, resulting in tearing of the lubricant film.

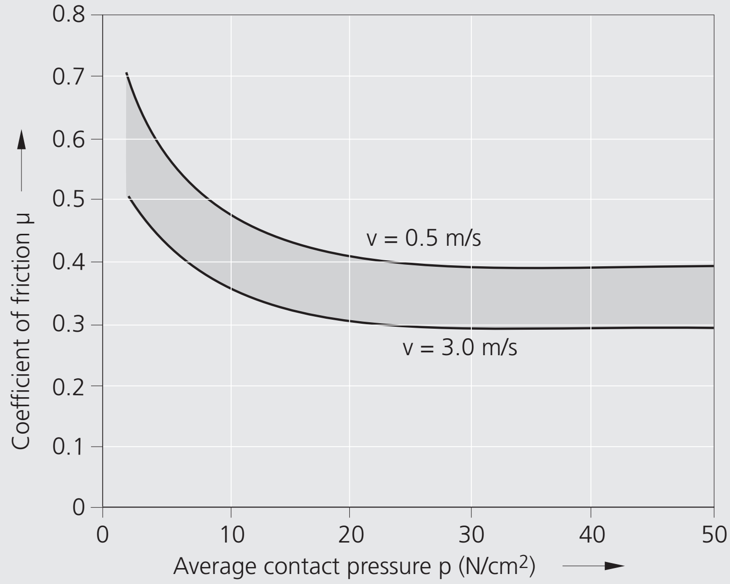
Coefficient of friction

This is influenced by many different factors. The average contact pressure, sliding velocity, temperature, bearing clearance, and running time, as well as the properties of the mating material, the finish of the surfaces sliding relative to each other, the quality and amount of lubricant applied, and the wall thickness of the plastic plain bearings – all of these contribute to the coefficient of friction.

Plastic Plain Bearings

Contact pressure and sliding velocity and their effect on friction

Figure 1 shows that the coefficient of friction declines rapidly with increasing bearing load. It is less dependent on the sliding velocity and decreases at a much slower rate as the sliding velocity rises.

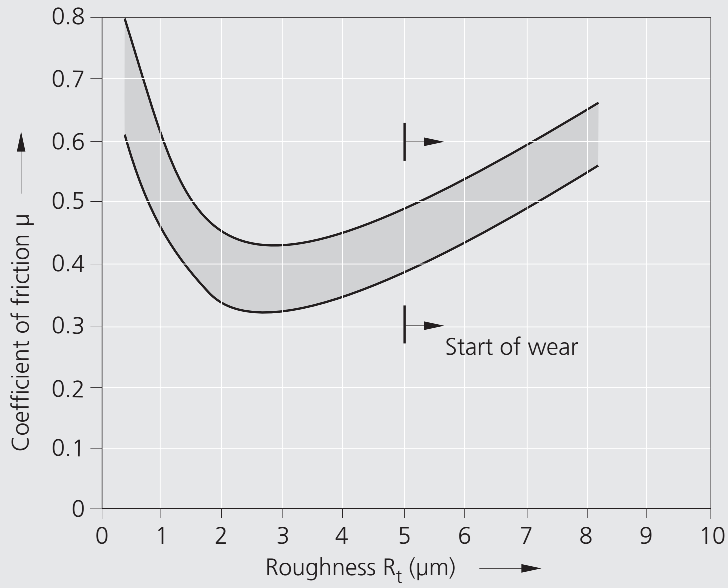


Coefficient of friction as a function of contact pressure. Dry running. Polyamide 6.6 mated with hardened and ground case hardening steel 16MnCr5. Roughness R_t 2.5 µm, sliding velocity v = 0.5-3 m/s, temperature at bearing surface = 20-30°C.

Figure 1

Roughness of the mating material and its effect on friction

Figure 2 shows that the roughness of the shaft surface has a pronounced effect on the coefficient of friction. The curve clearly illustrates that both very smooth and very rough surfaces produce high sliding friction, while the friction reaches a definite low at between 2 and 3 µm roughness.



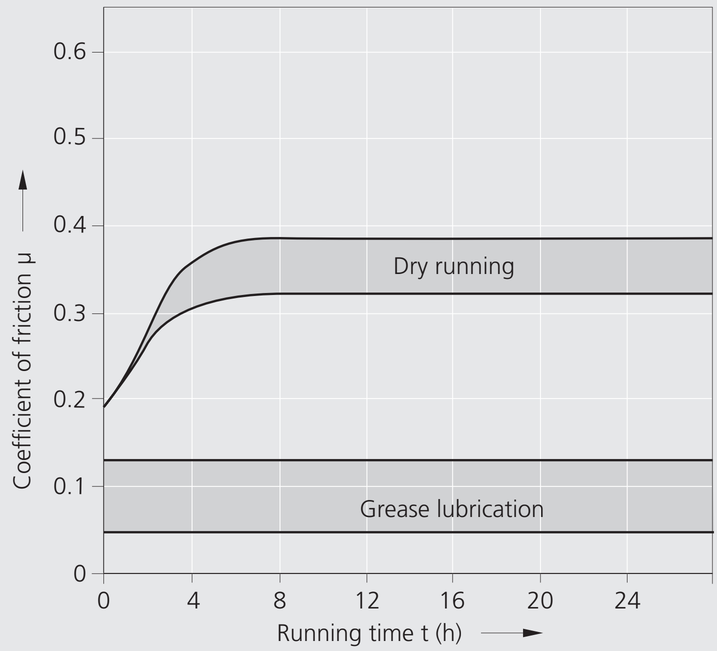
Coefficient of friction as a function of roughness of the steel surface. Dry running. Polyamide 6.6 mated with hardened and ground case hardening steel 16MnCr5. Sliding velocity
v = 1 m/s, temperature at bearing surface = 20-30°C, average contact pressure p = 15 N/cm².

Figure 2

Plastic Plain Bearings

Time and its effect on friction

Figure 3 shows that, for dry running, the steady state value is reached after a running in period of about 5 hours.
No running in period is required when the bearing is grease lubricated.



Coefficient of friction as a function of running time for dry running and grease lubrication. Polyamide 6.6 mated with hardened and ground case hardening steel 16MnCr5. Roughness R_t 2.5 μm, for dry running
p v = 6 N/cm^2 m/s, when greased
p v = 18 N/cm^2 m/s, bearing temperature 60°C.

Figure 3

Coefficient of friction values

The load capacity calculations (see page 11) are based on average conditions. The following values are recommended:

Type of lubrication	Coefficient of friction μ
Dry running	0.35
Non-recurring grease lubrication	0.12
Sustained release grease lubrication	0.09
Oil mist	0.09
Water lubrication (mixed friction)	0.04
Oil lubrication (mixed friction	0.04

Table 3

Wear

Provided the wall thickness has been properly dimensioned, the bearing temperature does not exceed 80°C, and the shaft surface has a roughness of 2 to 4 μm with a surface hardness of 45 Rockwell C, the wear on Plastic Plain Bearings will be virtually undetectable.
Softer shafts, smoother or rougher surfaces (Figure 2) or bearing temperatures above 80°C will cause a higher wear rate. If Plastic Plain Bearings are to run under corrosive conditions, corrosion-resistant steel is a more appropriate choice for the shaft material than brass or bronze, as the latter materials tend to wear too rapidly.

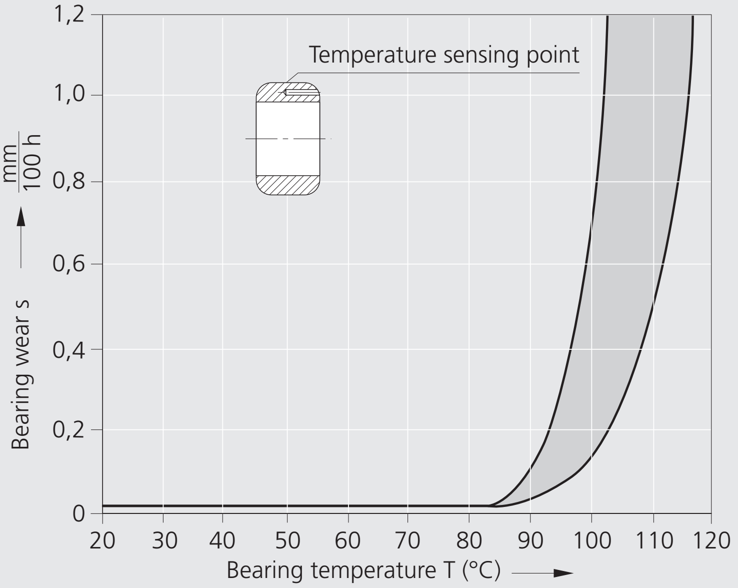
Plastic Plain Bearings

Temperature and its effect on wear

Figure 4 shows that the rate of bearing wear is minimal up to a temperature of 80°C. At temperatures above 80°C, Plastic Plain Bearings wear very quickly as the bearing surface embrittles at these high temperatures and is rapidly abraded.

Wall thickness and its effect on wear

As polyamide 6.6 is a poor thermal conductor, increasing wall thickness would cause heat to build up, with a consequent sharp rise in the bearing surface temperature. This would result in premature wearing of the bearings.



Bearing wear as a function of bearing temperature.
Polyamide 6.6 mated with hardened and ground steel.

Figure 4