# Notes on the life cycle of Rolling Bearings

## General

The life cycle of rolling bearings is the way that AWT GmbH provides technical advice on the bearings offered and applies them at every stage in the life cycle of a machine (general customer application) so that our customers can work more successfully, more sustainably and more profitably.

At AWT GmbH, the consideration of the life cycle includes the following conditions:

- Customer specification or standard requirements
- Design and development together with the suppliers
- Manufacturing, production and storage for the customer
- If necessary, operation and monitoring
- Repair
- Disposal instructions after the end of the life cycle

Regardless of whether linear or rotary motion or a combination of both, AWT GmbH supports customers in every phase of the machine's life cycle to improve performance. This approach is not limited to individual components such as bearings or seals. It relates to the overall application and the interaction of the individual components.

## Service life calculation under changing operating conditions

There are a large number of bearings, for example those of industrial gears, in which the load over time is variable both in size and in the direction, the speed, the operating temperature and the lubrication conditions. In cases with changing operating conditions, the individual operating phases must therefore be reduced to a limited number of simplified load cases. With continuously changing loads, different load levels can be formed. The load spectrum can then be reduced to a histogram with intervals of constant operating conditions. Each interval represents a certain amount of time in the company. It should be noted that high and medium loads “consume” significantly more bearing life than light loads. It is therefore important to take sufficient account of shock and peak loads in the histogram, even if they occur only relatively rarely and are limited to just a few revolutions.

Within each interval, constant mean values are set for the bearing load and the other operating conditions. The number of operating hours or revolutions of each interval characterize their share in the overall life cycle of the storage.

The service life calculation requires more precise knowledge of the operating processes and the respective operating conditions. Otherwise, generally known and typical operating states must be used for a certain storage.

The AWT GmbH accompanies the customers over the entire life cycle of our products, e.g. from the first idea to the optimization of a bearing point to the repair of rolling bearings.

For this purpose, AWT GmbH compiles all services that aim to ensure that the customer-specific application provides the most technically and economically optimal service, e.g.:

- Construction of new individual solutions for the individual bearing points and their connecting parts
- Selection of the correct bearing designs for the operating conditions and the associated lubrication concept
- Optimization of existing warehouse designs

**Dimensioning of rolling bearings**

The required size of a rolling bearing depends on the following requirements:

- lifespan
- load capacity
- operational safety

**Dynamic load capacity and lifespan**

The dynamic load capacities are the measure of the dynamic load capacity. The dynamic load ratings are based on ISO 281.

The fatigue behaviour of the material determines the dynamic load capacity of the rolling bearing.

The dynamic load capacity is described by the dynamic load rating and the nominal service life.

The fatigue life depends on:

- the burden
- the operating speed
- the statistical randomness of the first occurrence of damage.

However, modern bearings of high quality can significantly exceed the calculated values of the nominal service life under favourable operating conditions.

**Through hardening roller bearing steels**

The most common hardening steel used for rolling bearings is chrome steel with approximately 1% carbon and 1.5% chromium content according to EN ISO 683-17. Today, this steel can be regarded as the oldest and best researched structural steel - since it had to meet the constantly increasing demands on the component strength of rolling bearings. Its chemical composition ideally combines material properties and

operational reliability. Two types of heat treatment - martensite or bainite hardening - are typically used to achieve the required hardness of 58 to 65 HRC.

The further development of metallurgical processes in recent years has resulted in steels with higher purity, homogeneity and quality. The properties of the rolling bearing steels used could be significantly improved by reducing the oxygen content and the proportion of harmful, non-metallic inclusions.

**Induction hardening roller bearing steels**

Induction hardening roller bearing steels offer the possibility of selectively hardening only the raceways without changing the material structure of the other bearing ring areas through the heat treatment. Since the partial induction surface hardening only slightly changes the properties of the steel and the component as a whole, certain functional properties can be specifically combined in one component.

The wheel bearing units, the so-called HBU units, with a flange on the inner and / or outer ring are a good example of such a combination. The uncured flange is designed for the required fatigue strength, whereas the raceway areas have the hardness required for resilience and fatigue strength.

**Case hardening rolling bearing steels**

The use hardening bearing steels are mostly chromium nickel alloyed steels and manganese chromium alloyed with about 0.15% carbon content corresponding EN ISO 683-17, used for rolling bearings.

Bearings with rings and / or rolling elements made of case hardening steel are recommended for installation cases where high tensile stresses occur due to very tight fits and / or shock loads.

**Stainless rolling bearing steels**

The stainless steel X65Cr14 according to EN ISO 683-17 or X105CrMo17 according to EN 10088-1 are mainly used for the bearing rings and rolling elements made of stainless steel.

In some cases, bearings with anti-corrosive coatings can be an alternative to stainless steel bearings.

**Hot-hard rolling bearing steels**

Depending on the type of bearing, some standard rolling bearings made of hardening steel or case hardening steel can be exposed to temperatures of 120 to 200°C during

operation. The maximum permissible operating temperature essentially depends on the heat treatment of the bearings during manufacture.

Bearings that have to withstand operating temperatures up to 250°C can be subjected to a special heat treatment with corresponding dimensional stabilization during production. In this case, however, a reduction in the bearing capacity of the bearings must be accepted.

For bearings that are to be operated over a longer period of time at temperatures of more than 250°C, high-alloy steels, such as steel 80MoCrV42-16 according to EN ISO 683-17, must be used, which, even under these temperatures, are still suitable for Performance of the bearings maintain high hardness.

**Ceramic materials**

Ceramic bearing rings and rolling elements are primarily made from silicon nitride, which is probably the best material for rolling bearings due to its mechanical and physical properties. The starting material is a beta silicon nitride, which consists of fine, elongated crystal grains and is shaped into the desired shape by hot pressing. This ceramic material ideally combines the favourable properties for rolling bearings, such as high hardness, low density, low thermal expansion, high dielectric strength, low dielectric constant and insensitivity to magnetic fields in one material.

**Materials for cages**

**Sheet steel cages**

Hot-rolled, low-carbon steel sheets in accordance with DIN EN 10111 are predominantly used for the pressed steel sheet cages. The cages are characterized by comparatively high strength and low weight and can be surface-treated to reduce friction and wear.

The stainless steel bearings are normally equipped with a steel cage X5CrNi18-10 according to EN 10088-1.

**Solid steel cages**

Solid cages are usually made of unalloyed structural steel S355GT (St52), which complies with EN 10025. To improve the sliding and wear properties, some of these cages can also be surface-treated. The solid steel cages are suitable for operating temperatures up to 300°C. They are not attacked by the usual mineral or synthetic lubricants or by the organic solvents used for cleaning.

Solid steel cages are primarily intended for large bearings, but are also used in bearings that are directly exposed to aggressive media, such as ammonia vapours in refrigeration machines, and there is a risk of stress corrosion cracking in cages made of other materials.

### Sheet brass cages

Pressed brass cages are used in small and medium-sized bearings. They are made from brass sheet L, which complies with EN 1652. In the presence of ammonia vapours (e.g. in chillers) stress corrosion cracking can occur in brass cages. Therefore, solid cages made of brass or steel must be used in such cases.

### Solid brass cages

Solid brass cages are mostly made of the material CuZn39Pb2 (CW612N), which corresponds to EN 1652. The starting products are usually cast pipes or rings. The cages are not attacked by the usual mineral or synthetic lubricants or by the organic solvents used for cleaning. Brass cages can no longer be used at operating temperatures above 250°C.

## Plastic cages

### Polyamide 66

Polyamide 66 is used for the majority of the cages that are injection moulded. This material, with or without glass fibre reinforcement, is characterized by a favourable combination of strength and elasticity. The mechanical properties of the polymer materials mainly depend on the temperatures that occur during operation and are subject to aging, which they change gradually. The most important factors influencing the aging of the polymer material are, in addition to the temperature, the time and the medium, e.g. the lubricant to which it is exposed.

Therefore, whether polyamide cages are suitable for special applications depends on the operating conditions and the requirements for service life.

A typical example is storage cases with ammonia or freon as a coolant. In such cases, bearings with cages made of polyamide 66 may only be used up to 70°C.

The possible application of polyamide cages in the lower temperature range is also limited because its elasticity then decreases sharply, which can lead to damage. Cages made of polyamide 66 should therefore no longer be used at operating temperatures below –40°C.

A specially modified polyamide 66 is available for cases in which there are special requirements for mechanical strength, such as the bearings for railway wheel bearings.

### Polyamide 46

Glass fibre reinforced polyamide 46 has roughly the same material properties as polyamide 66, but allows operating temperatures up to 15°C higher. Cages made of this material are used as standard for some small and medium-sized roller bearings.

### Polyether ether ketone (PEEK)

The high-tech material polyether ether ketone is often used when special demands are placed on the turning capacity, the chemical and thermal resistance of the cages. The outstanding properties of PEEK lie in the special combination of strength and elasticity, high temperature and chemical resistance, high wear resistance and good processability. These properties have meanwhile made PEEK the standard material for the cages of entire rows of ball and cylindrical roller bearings, such as the hybrid ball bearings or the high-precision cylindrical roller bearings. Cages made of this material show no signs of aging at temperatures up to 200°C, not even in the presence of lubricant additives. For storage in the high-speed range, the maximum permissible operating temperatures are limited to +150°C, as from this temperature PEEK becomes soft.

### Phenolic resin

Phenolic resin with a fabric insert is suitable for lightweight cages that have to withstand high centrifugal and acceleration forces, but are not exposed to high temperatures. Cages made of phenolic resin are mainly used in high-precision angular contact ball bearings.

### Other materials

In addition to the materials described, bearings for special installation cases can also be equipped with cages made from other polymer materials, from light metals or from special cast iron materials.

### Materials for seals

The seals integrated in the bearings are primarily made from elastomer materials. Depending on the row and size of the bearing, but also the operating conditions, the following materials are used.

### Acrylonitrile butadiene rubber

Acrylonitrile butadiene rubber (NBR) is the universal material for seals. The polymer made of acrylonitrile and butadiene shows good resistance to

- most mineral oils and greases based on mineral oils,
- regular gasoline, diesel fuels and light heating oil,
- animal and vegetable oils and fats as well
- hot water

This rubber also allows the sealing lip to run dry temporarily. The temperature application range is between - 40 and + 100°C, for a short time temperatures up to + 120°C are permissible. The material hardens at higher temperatures.

## Hydrogenated acrylonitrile butadiene rubber

Hydrogenated acrylonitrile-butadiene rubber (HNBR) has a considerably higher wear resistance than acrylonitrile-butadiene rubber and thus enables seals with a longer service life. HNBR is more resistant to heat, aging and hardening in hot oil or ozone.

Oil-air mixtures can, however, have harmful effects. The maximum permissible operating temperature is + 150°C and is therefore considerably higher than that permitted for simple nitrile rubber.

## Fluoride rubber

The special properties of fluor rubber (FKM) are its high thermal and chemical resistance. The aging and ozone resistance is also very good and the gas permeability is very low. Fluorocarbon rubber seals have exceptional wear properties, even under extreme environmental conditions and can withstand temperatures up to + 200°C. Temporary dry running of the sealing lip is permitted.

Fluor rubber is resistant to oils and hydraulic fluids, fuels or lubricants, mineral acids and aliphatic and aromatic hydrocarbons, which would lead to the failure of the seals with the other sealing materials. It is not possible to use seals made of fluorine rubber in conjunction with esters, ketones, ether compounds, certain amines and hot, non-aqueous hydrogen fluoride.

At temperatures above 300°C, fluorine rubber releases harmful gases and vapours. The following safety instructions must always be observed because handling fluor rubber seals is dangerous.

## Safety instructions for fluorine rubber

Under normal operating conditions and at temperatures below +200°C, fluorine rubber is very stable and harmless. However, if it is exposed to temperatures above +300°C, for example by fire or the flame of a cutting torch, dangerous gases and vapours are released. These vapours are harmful to health if they are inhaled or get into the eyes. Even after cooling, handling seals that have been heated to such temperatures is dangerous. Skin contact must be avoided. When dealing with sealed bearings that have been exposed to high temperatures, such as when removing the bearing, the following safety regulations must be observed:

- Always wear safety goggles and protective gloves, if necessary also appropriate respiratory protection.
- Place the remains of the seals in a tightly closing plastic container, which is marked with the symbol for "caustic material".
- Observe the corresponding safety regulations in the safety data sheet.

If you accidentally come into contact with such seals, wash your hands with soap and rinse with plenty of water, rinse your eyes with plenty of water, and see a doctor. If vapours are inhaled due to overheating of the seals, consult a doctor immediately.

The user is responsible for safe handling during the period of use up to scrapping and the environmentally friendly disposal of the seals. The AWT GmbH is not responsible for the improper handling resulting from seals of fluor rubber possible consequential damage to.

**Polyurethane**

Polyurethane (AU) is a wear-resistant material with good elastic properties and can be used at operating temperatures from - 20 to + 80°C. It is resistant to water, water-oil mixtures or mineral oils without or with small amounts of additives. Polyurethane is not resistant to acids, alkalis and polar solvents.

**Coatings**

Coating is a proven method to improve materials and provide bearings with additional properties for special applications. Two developed coating processes are available and have already proven themselves in many applications.

In the process, the rolling elements or the rolling elements and the inner ring raceways of the bearings receive a low-friction ceramic coating, which makes the bearing resistant, e.g. for continuous operation under insufficient lubrication conditions.

The coating, which can be applied to both the outer surfaces of the outer ring and the inner ring, protects the bearing against the passage of current and the resulting damage.

Other coatings, such as chromate zinc, offer themselves as an alternative to bearings made of stainless steel in a corrosive environment, especially with ready-to-install bearing units.

**Disassembly or disposal**

As a rule, the AWT roller bearings are installed in machines and systems. In the technical operating instructions of our customers, the corresponding work for disassembly or disposal is described.

Usually, the dismantling of machines and systems may only be carried out by specially trained specialist personnel.

- Work on the electrical system may only be carried out by qualified electricians.
- Before disassembling, switch the tank, container or pipes, etc. to be liquid-free.

There is a risk to life if you come into contact with live components. Switched-on electrical components can make uncontrolled movements and cause serious injuries.

That's why:

- Before starting disassembly, switch off the electrical supply and disconnect it permanently.

Before starting disassembly:

- Switch off the machine and secure it against being switched on again.
- Physically disconnect the entire power supply from the machine, discharge stored residual energy.
- Remove operating and auxiliary materials as well as remaining processing materials and dispose of them in an environmentally friendly manner. Then clean assemblies and components professionally and disassemble taking into account the applicable local occupational safety and environmental protection regulations.

If no take-back or disposal agreement has been made, recycle the dismantled components:

- Scrap metals.
- Give plastic elements for recycling.
- Dispose of other components sorted according to material properties.

Electronic waste, electronic components, lubricants and other auxiliary materials are subject to special waste treatment and may only be disposed of by approved specialist companies!

The local municipal authority or special waste disposal companies provide information on environmentally friendly disposal.

**Old parts and replaced equipment**

Disposal of the old parts and exchanged equipment during maintenance and repair must be carried out properly in accordance with the applicable environmental protection regulations.

The local municipal authority or special waste disposal companies provide information on environmentally friendly disposal.

**Summary**

The user is responsible for safe handling during the period of use up to scrapping and environmentally friendly disposal of the bearings. Disposal should be in accordance with the material groups mentioned above. The AWT GmbH is not responsible for the arising from improper disposal of possible damages.