



How Xylan® coatings improve bearing applications

Xylan fluoropolymer coatings are wear-resistant, low-friction materials that improve the life of bearings and wear surfaces. By reducing metal-to-metal contact at interface surfaces, the coatings minimize the points of adhesive wear and heat buildup.

These coatings are particularly important when parts are operating on the outer limits of their fluid lubrication, the so-called “boundary” lubrication phenomenon, or during break-in periods. Find out which coatings are best suited to your bearing applications and how you should apply them.

Whitford

Makers of the world's largest, most complete line of fluoropolymer coatings

Why coatings are used on bearings

Low-friction coatings are used for two reasons. The first is as a backup lubricant for circumstances where the primary (fluid) lubricant could fail or is insufficient to prevent surface-to-surface contact. This often occurs when machinery is in a start-up or reversing condition, or when equipment is new and in its “break-in” period. Occasionally, these conditions happen when a conventional hydrodynamic bearing is momentarily overloaded and the hydrodynamic film of oil is partially pressed aside, permitting mixed lubrication or, worse, boundary lubrication.

Adhesive wear occurs when asperities on two surfaces come in contact and move over each other. The pressure of the load and the heat generated by the movement tend to weld the asperities momentarily. As the surfaces move, the welds are broken and small particles are ripped out of the surfaces.

To prevent surface-to-surface contact, designers can specify an application of low-friction coatings to minimize bearing wear under these conditions.

The second reason for using low-friction coatings is as the primary lubricant for a bearing where fluids cannot be used. This most frequently occurs with nonmetallic bearings, such as those made of fiber, plastic, composites, or paper. In these cases, the coating reduces friction in the bearing which, in turn, reduces the heat and wear on the coating.

Where coatings improve bearing performance

Some bearing applications benefit more than others from a coating. For example:

- **Length-to-diameter ratio:** Hydrodynamic lubrication in journal bearings is best supported when the length-to-diameter ratio of the bearing is greater than 1. These types of bearings are found on line shafts, prop shafts, turbine shafts, pumps, machine tools, and some axle bearings. Side leakage from these bearings is not so much that there is a resulting degradation of the oil film. However, in

many applications — notably engine bearings — the l/d ratio of the bearing is 0.5 or less. Thus, side leakage can be great enough so that metal-to-metal contact in the bearing can occur, particularly in moments of high loads.

A coating on the bearing surface can prevent momentary contact between the journal and the shaft. As a starting point in bearing design, we suggest that, when the l/d ratio is less than 0.4, you consider using a coating for fail-safe protection.

- **Slow-turning bearings:** Journal bearings where shafts turn at speeds that are less than 600 rpm are usually built with medium fits. An accepted rule of thumb is to use a diametral clearance that is $0.002 + 0.001 \times \text{diameter}$ inches. Under these circumstances, overloads can result in momentary boundary lubrication conditions, increased friction (and heat), and increased wear. This also applies to bearings that are frequently stopped, started, and reversed. Unless a hydrodynamic lift is provided to keep the journal “floating” during the period when it is not rotating, boundary lubrication conditions can occur.

- **Increasing vibration damping:** Lubrication fluids contribute to the overall vibration-damping properties of a rotating mechanism. The degree to which they do this depends, in part, on the film thickness.

If a low-friction coating is used, additional vibration damping is gained. Again, the degree depends on the thickness of the coating. To date, we know of no studies that determine the magnitude of the damping property of dry-lubricant coatings. It may never be large. However, where smoothness is paramount, the use of a coating can be worthwhile.

- **Infrequent use:** In bearings that operate infrequently, fluid lubricants drain away from the loaded area and the bearings may experience severe wear during start-up. A low-friction coating can prevent the metal-to-metal contact and wear that takes place during start-up.

Selecting coatings for bearings

Reducing friction and supporting bearing loads are the criteria for any coating that is

used in a bearing. To this end, Whitford formulators have developed coatings that are based on tough resins, into which dry lubricants such as polytetrafluoroethylene (PTFE), moly disulfide, and graphite are added.

PTFE is the premier low-friction material. A coating with PTFE may improve the friction encountered. On the negative side, coatings with low-coefficients of friction are those with relatively high quantities of PTFE, which is soft and has little wear resistance. Thus, coatings with very low friction may also be soft and less wear-resistant.

Moly disulfide enables the coating to bear high loads. Even under low-slip velocities, moly can carry extreme loads.

Graphite is perhaps the oldest known dry lubricant, used in coatings where ambient temperatures are high, or where PTFE and moly cannot be used. For example: the Nuclear Regulatory Agency does not permit the use of lubricants that contain PTFE or moly because they break down if irradiated. So Whitford uses graphite as the lubricant in such applications.

Whitford provides coatings that contain PTFE (for low friction), plus moly disulfide (for low friction and load-bearing capacity), or graphite (for high temperatures). These are one-coat materials that can be applied to almost any bearing material (except polyolefin resins). Depending on the formulation, they are continuously stable at temperatures as high as 500°F/ 260°C, or 550°F/288°C for short periods of time.

Applying coatings to bearing surfaces

Almost any solid material that is used for bearings can be coated.

Metals: Suitable substrates include carbon and stainless steel, wrought and cast aluminum, copper and its alloys, titanium. Take special precautions with powder metal parts. Many of these parts are treated with resinous impregnates that are trapped within the porosity of the parts. To coat them successfully, pre-bake the parts at a temperature that is higher

Applications of coatings to bearing-type surfaces

Flat sliding surfaces

- Actuators
- Launch rails
- Lead screws
- Pneumatic cylinders
- Thrust washers
- Valve stems

Journal bearings

- Connecting rod bearings
- Crankshaft main bearings
- Fractional horsepower motor shafts
- Power tools

Rolling element bearings

- High-speed shafts
- Motor shafts
- Needle bearing cages

Bearings for special applications

- Aircraft bearings
- Ball screws
- Blowout preventor pistons
- Hinges
- Servo motors
- Swash plates
- Tension leg adjusters

than the anticipated cure temperature for the coating. Contaminants that bleed to the surface during the bake must be removed. Then the parts are ready for coating.

Die-cast parts are another special case. These components are typically cast with alloys that can be porous. When coated parts are placed in an oven and heated, trapped gases in internal cavities expand and erupt. When cured over 400°F/205°C, these parts may have numerous eruptions on the coated surface. To avoid this, preheat the parts to the cure temperature to produce the eruptions first, then coat them. Otherwise, cure the parts under 400°F/205°C.

Xylan Coatings for Bearings				
Property	1010	1014	1052	1054
Dry lubricant	PTFE	PTFE	PTFE/Moly	Graphite
Temperature limit °F/°C	500°F/260°C	500°F/260°C	500°F/260°C	500°F/260°C
Cure temperature °F	400-600°F	400-600°F	400-600°F	400-600°F
Cure temperature °C	205-316°C	205-316°C	205-315°C	205-315°C
Hardness	2H	4H	4H	4H
Max. thickness/coat* (mil)	1.0	1.0	1.0	1.0
Characteristics	Lowest friction	Corrosion-resistant	Anti-galling	Wet lubrication
* Can be used from 0.2 to 3.0 mils				

Plastics: Most “engineering” plastics can be coated, including nylon, PEEK, PEK, PPS, ABS, polycarbonate, epoxy, polyester, and phenolic. The exceptions are polyolefins and fluoropolymers, which have natural release properties. Also, vinyl materials that contain a high content of plasticizer can cause adhesion problems. Coated plastic parts must be cured at temperatures well below the softening temperature of the substrate to avoid distortion and polymer degradation.

Elastomers: Most elastomeric parts that are not expected to elongate more than 30% in service can be coated.

Surface considerations

Here are ways to improve the wear resistance of a coating in bearing applications.

Which surface to coat: In some cases, a slight improvement in lubricity and wear life is gained by coating both surfaces of mating parts. If only one surface can be coated however, choose the surface with the *greater swept area*.

Different mating materials: In many cases, two dissimilar materials are used in a bearing. In such situations, coat the softer of the two materials because, if boundary lubrication occurs, this is the one that will suffer the greater damage.

Surface roughness: The roughness of a mating surface also has an effect on coating wear. The optimum surface has a roughness of 8-12 µin. rms. Surprisingly, hyper-smooth surfaces (less than 4 µin.) produce higher wear rates than those in the optimum range — even those in the 15-30 µin. range which is typical for machined parts. The reason for this is that the hyper-smooth surface permits less transfer of PTFE to the mating surface and friction increases. Surfaces that are rougher than 30 µin. also result in high wear rates.

Maximum hardness: The temperature at which a coating is cured can influence its hardness. Where substrates permit, we recommend that coatings in bearing applications be cured at or near their upper limit (typically 600 to 750°F/315° to 400°C).

How to contact Whitford:

Whitford manufactures in 7 countries, has employees in 7 more and agents in an additional 25. For more information, please contact your Whitford representative or the nearest Whitford office (see our website: whitfordww.com) or email: sales@whitfordww.com.

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