

SCHAEFFLER

Triondur



Triondur Coating Systems

For surfaces subjected
to high tribomechanical stresses

Coating systems for surfaces subjected to high tribomechanical stresses

Wear protection and friction reduction by Triondur coating systems

With the continuing increases in energy efficiency not only in modern combustion engines but also in the entire energy chain (from a wind turbine gear to any moving part in a vehicle), there are increasing demands on the tribological load carrying capacity of components.

With the aid of modern PVD and PACVD coating processes as used for the Triondur coatings from Schaeffler, it is possible to achieve significant increases in the performance capability of components subjected to high tribological stresses. This gives potential for increased life, minimized friction and lightweight design. Triondur coating systems thus make an active contribution to conservation of the environment and resources as well as sustainability.

Triondur coating systems are created under vacuum by means of physical gas phase deposition (PVD = Physical Vapor Deposition) and plasma-assisted chemical gas phase deposition (PACVD = Plasma assisted Chemical Vapor Deposition). Through selection of the coating composition and the deposition process, Triondur coating systems can be ideally matched to the specific application. From elastic coating systems for rolling contacts to extremely hard wear protection coatings, as well as chemical resistance through to targeted reactions for lubricant film formation with selected oil additives, there are many possibilities for optimization.

Triondur coating systems are more than just a coating: they are coating systems that, on the basis of individually matched coating processes and components of optimized design, take account of all necessary aspects from manufacture to application.

Coating systems for surfaces subjected to high tribomechanical stresses

Triondur coating systems for rolling bearings

In rolling bearings, the use of coated rolling elements can achieve a significant increase in operating life, especially if the bearing is subjected in the application to slippage and lubricant starvation.

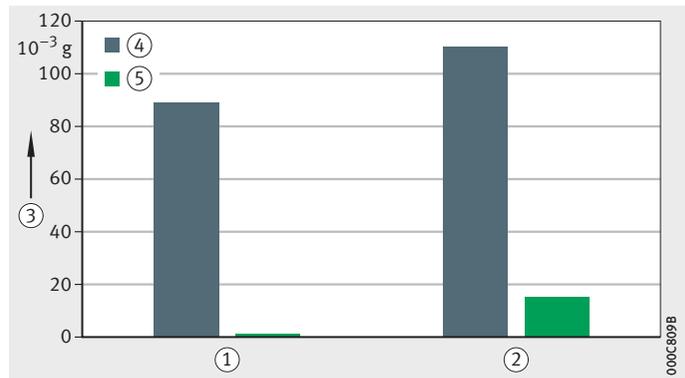
Coated cylindrical rollers that have been tested under extreme lubricant starvation in a test rig run, exhibit significantly improved results in comparison with uncoated reference parts, *Figure 1*. Gravimetric evaluation of the wear shows that the use of Triondur C has almost eliminated wear of the rolling element, *Figure 2*. At the same time, wear of the uncoated axial washers has been significantly reduced.

A further application for Triondur coating systems in rolling bearings is the coating of large end faces of tapered rollers in order to reduce friction and wear in contact with the rib of the inner ring.

Coating of the outer ring of stud type track rollers, *Figure 3*, page 3, increases not only the operating life of the track roller but also that of the running partner, which is often much more costly. As a result, the additional costs incurred by coating can be amortised within a very short space of time.

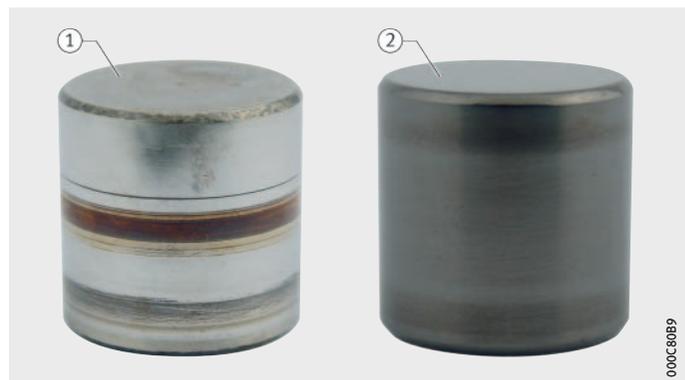
- ① Rolling elements
- ② Axial washers
- ③ Wear
- ④ Uncoated
- ⑤ Coated

Figure 1
Test rig run with extreme lubricant starvation



- ① Uncoated
- ② Triondur C coated

Figure 2
Rolling element after test rig run



- ① DLC (Triondur C) coating, no wear
- ② Without coating, adhesive wear

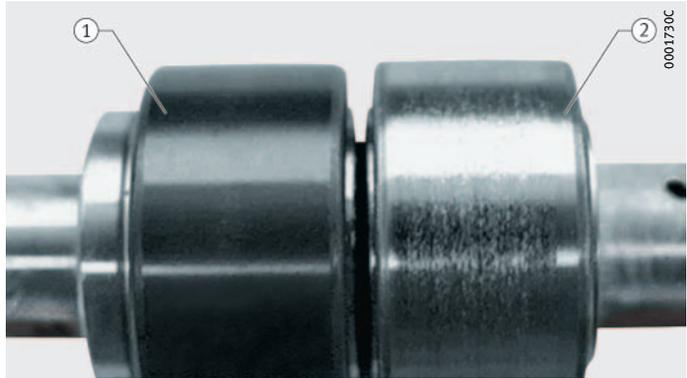


Figure 3
Stud type track rollers, with and without coating

Triondur coating systems for engine components

Through the use of Triondur coating systems, it has been possible to continuously reduce friction at the tappet/cam contact in the valve train, *Figure 4*.

Until about 15 years ago, the use of purely heat treated tappets was the state of the art. Through the use and continuous development of Triondur coating systems, it has been possible to reduce frictional torque using Triondur CH by up to 50%. This corresponds to a reduction in CO₂ emissions of between 1% and 2%.

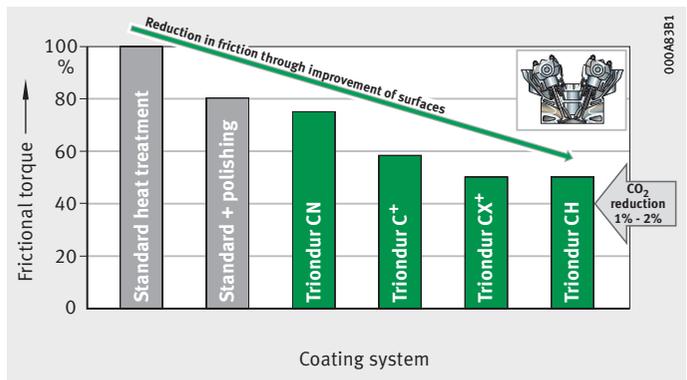
Triondur coating systems are used not only on mechanical tappets but also on other contacts subjected to strong loads.

Examples:

- cam rollers and valve contact surfaces for roller type finger followers
- plain bearing components
- pistons in the high pressure area of fuel pumps.

Example:
engine speed $n = 2000 \text{ min}^{-1}$ and
oil temperature $+80 \text{ }^\circ\text{C}$

Figure 4
Friction reduction in valve train by means of Triondur coating systems



Coating systems for surfaces subjected to high tribomechanical stresses

Triondur C Metal-containing hydrogenated amorphous carbon coating.

Coating process ■ PVD method.

Advantages, benefits ■ High level of protection against abrasive and adhesive wear together with preservation of the friction partner
 ■ Dry friction against steel is reduced by up to 80%
 ■ If only one friction surface is coated, the operating life of the entire tribological system is increased considerably
 ■ Due to its highly ductile coating structure, Triondur C can withstand the high contact pressures that occur in rolling bearing applications.

Common applications ■ Bearing components such as rolling elements, inner rings, outer rings and axial bearing washers
 ■ Yoke and stud type track rollers.

Characteristics

Feature	Coating
Composition	a-C:H:Me (functional layer)
Colour	Anthracite
Layer thickness	0,5 µm – 4 µm
Friction reduction	Up to 80% with DLC/steel in comparison with steel/steel (in dry state)
Hardness	> 1200 HV

Barrel roller with Triondur C coating

Figure 5
Asymmetrical spherical roller bearing for the bearing arrangement of the rotor shaft in a wind turbine

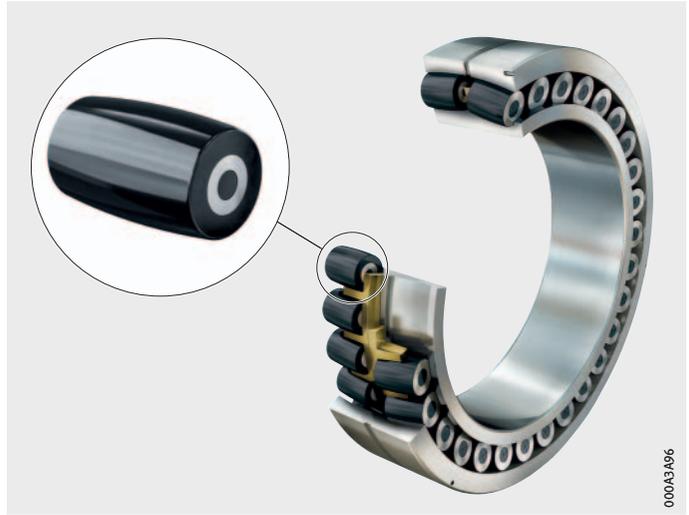


Figure 6
Application example
Spherical roller bearings
in wind turbines



Coating systems for surfaces subjected to high tribomechanical stresses

Triondur C⁺

Hydrogenated amorphous carbon coating.

Coating process

- PVD and PACVD methods.

Advantages, benefits

- Coating systems for very high tribomechanical stresses
- High resistance to abrasive wear and high level of protection against adhesive wear
- Very high mechanical strength
- Highly suitable for components subjected to high tribological stresses with lubricant starvation.

Common applications

- Engine components such as tappets or finger followers
- Injection components such as pump and control pistons, nozzle needles.

Characteristics

Feature	Coating
Composition	a-C:H (functional layer)
Colour	Black
Layer thickness	2 μm – 4 μm
Friction reduction	Up to 85% with DLC/steel in comparison with steel/steel (in dry state)
Hardness	> 2 000 HV



Figure 7
Switching hydraulic tappet

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Triondur CX⁺

Modified hydrogenated amorphous carbon coating. Triondur CX⁺ is a modified and nanostructured coating system.

- Coating process
- PVD and PACVD methods.
- Advantages, benefits
- Very precise adaptation possible to the tribological requirements present
 - Best combination of friction minimization, tribochemical resistance and wear protection of all coating systems.
- Common applications
- Engine components:
- finger followers
 - tappets
 - finger follower lever stud
 - cages in piston drive.

Characteristics

Feature	Coating
Composition	a-C:H:X (functional layer)
Colour	Black
Layer thickness	2 μm – 4 μm
Friction reduction	Up to 85% with DLC/steel in comparison with steel/steel (in dry state)
Hardness	> 2 000 HV

① Sliding surfaces with Triondur CX⁺ coating



Figure 8
Tappet TSTM

① Outer lever with Triondur CX⁺ coating



Figure 9
Switchable finger follower

Coating systems for surfaces subjected to high tribomechanical stresses

Triondur CH

Tetrahedral hydrogen-free amorphous carbon coating.

Coating process

■ PVD method.

Advantages, benefits

- Due to its high hardness, Triondur CH has the highest wear resistance of all Triondur coatings
- In dedicated tribological systems with appropriately matched lubricants, Triondur CH gives the most effective action and provides the maximum reduction in friction as well as maximum protection against wear.

Common applications

■ Tappets.

Characteristics

Feature	Coating
Composition	ta-C (functional layer)
Colour	Greenish
Layer thickness	0,5 μm – 1 μm
Friction reduction	Up to 85% with DLC/steel in comparison with steel/steel (in dry state)
Hardness	> 4 000 HV

① Sliding surfaces with Triondur CH coating

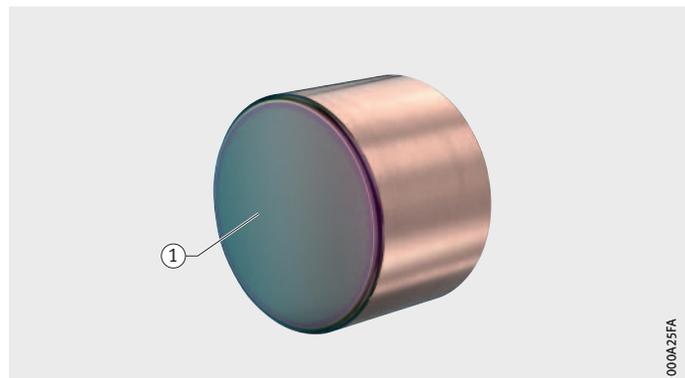


Figure 10
Tappet with Triondur CH coating

Triondur CN

Chromium nitride coating.

Coating process

- PVD method.

Advantages, benefits

- Due to its nanocrystalline structure, the chromium nitride coating has particularly high hardness and ductility
- The adaptive, very smooth surface is maintained even during operation due to its high wear resistance and very good oil wetting behaviour
- Significant reduction in friction between the contact partners
- Triondur CN is the right choice for parts subjected to high stresses with adequate oil provision.

Common applications

- Engine components.

Characteristics

Feature	Coating
Composition	Chromium nitride (functional layer)
Colour	Silver
Layer thickness	1 μm – 4 μm
Friction reduction	Up to 20% with Triondur CN/steel in comparison with steel/steel (in dry state)
Hardness	> 2 200 HV



Figure 11
Tappet with Triondur CN coating

Coating systems for surfaces subjected to high tribomechanical stresses

Triondur TN

Titanium nitride coating.

Coating process

■ PVD method.

Advantages, benefits

■ High protection against abrasive wear
 ■ Wear protection of components in sliding contact.

Common applications

■ Wear protection of ribs in engine bearings, especially due to the cage running in contact with the rib.

Characteristics

Feature	Coating
Composition	TiN (functional layer)
Colour	Gold coloured
Layer thickness	2 μm – 5 μm
Friction reduction	Up to 20% with Triondur TN/steel in comparison with steel/steel (in dry state)
Hardness	> 2 000 HV



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Figure 12
 Contact running surfaces of inner ring with Triondur TN coating



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Figure 13
 Application example
 Aerospace

Triondur MN

Nano-structured molybdenum nitride coating with metal doping.

Coating process

- PVD method.

Advantages, benefits

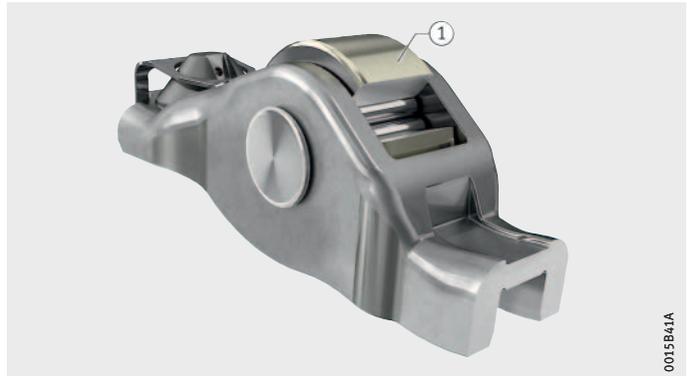
- Wear protection and minimization of friction under challenging lubrication conditions
- High hardness and very low friction coefficient in comparison with other nitridic coatings
- Very high temperature resistance up to +600 °C
- High tribochemical wear resistance.

Common applications

- Rolling bearing components
- Plain bearing components
- Engine components.

Characteristics

Feature	Coating
Composition	CuMoN (functional layer)
Colour	Silver
Layer thickness	1 μm – 4 μm
Friction reduction	Up to 85% with Triondur MN/steel in comparison with steel/steel (in dry state)
Hardness	> 2 200 HV



① Triondur MN coated cam roller

Figure 14
Cam roller in finger follower

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