

Development of CreepLess ball bearings

The Bearing Show, Essen

07.09.2022

Dr. Volker Rombach, Application Engineering
NTN Wälzlager (Europa) GmbH
SNR Wälzlager GmbH

- NTN @ a glance
- Increasing challenges in industrial application, general countermeasures
- Ring creeping – description, failure mode and mechanisms
- NTN countermeasures and new development
- Comparison as a conclusion



4,9*

Milliarden €



25.000*

Mitarbeiter

Our brands:

NTN®



BOWER®
HEAVY DUTY BEARINGS by **NTN**



Founded

März 1918

CEO

Eiichi Ukai

Stock market Nikkei

Listed since may 1949

Headquarter:

Osaka (Japan)

Occupation

Development, manufacturing and sales of all products linked to bearings, linear motion, driveshafts for automotive and industry incl. all services

Products

Bearings, sensor bearings, mounted units, linear motion, CVJ, tools and services, products for maintenance



Challenges: (in extracts only)

- Increasing power, loads, speeds
- Downsizing of design elements to save space, weight,....
- Still further demand for friction reduction
- Severe side effects of specific application:
 - Bearings more and more elements in electric circuits
 - Not just mechanical loads (N, kN,...) but also electrical loads (V, A,...)
 - Harsh environments
 - Temperatures
 - Humidity, dust
 - Transient condition, shocks
- ...

General countermeasures after application study to face these challenges:

- Appropriate bearing selection by engineering
- Bearing specification adjustment e.g. (special) materials, heat-treatments, coatings,...
 - → “toolbox” of pre- and suffixes available
 - → case wise still need for further development existing

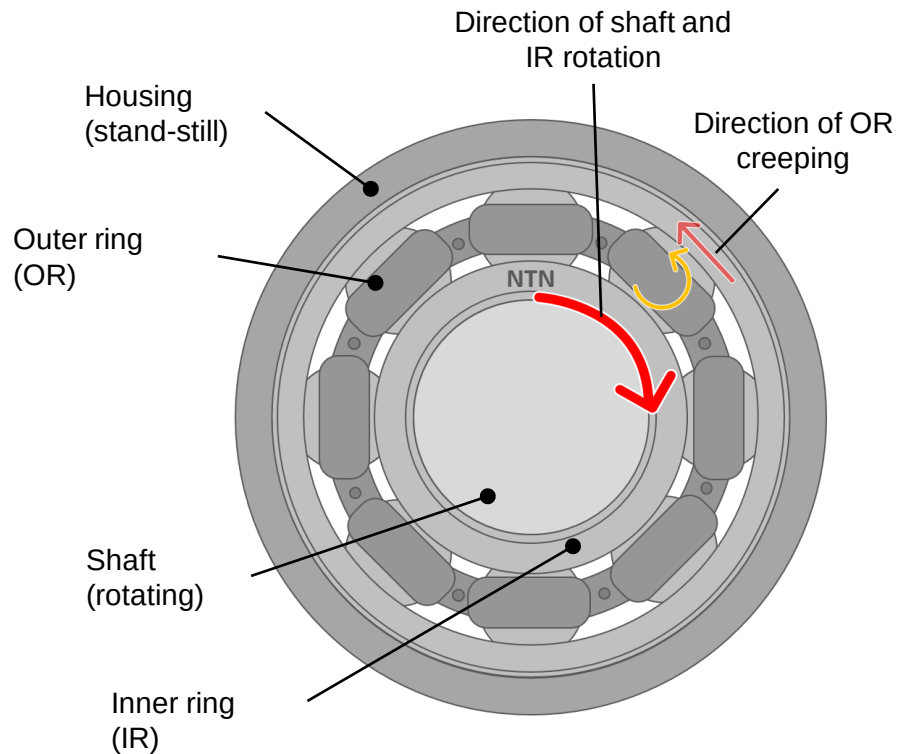
Challenges: (in extracts only)

- Increasing power, loads, speeds
- Downsizing of design elements to save space, weight,....
- Still further demand for friction reduction
- Side effects of specific application:
 - Bearings more and more as elements in electric circuits
 - Not just mechanical loads (N, kN,...) but also electrical loads (V, A,...)
 - Harsh environments
 - Temperatures
 - Humidity, dust
 - Transient condition, shocks
- ...



Result:

- Rising **power density** from the global application down to the local rolling contact of the bearing
- Risk of **ring creeping** and potential bearing failure is rising
- **Ring creeping** still matter of today's R&D activities - NTN internally but also externally



Process

- gradual (slow), basically continuous movement (creeping) of bearing ring in circumferential direction relative to its adjacent part
- direction of moment can be similar or opposite to direction of rotation

Consequences

- wear of bearing seat surfaces
- consequential damages



source: ISO 15243



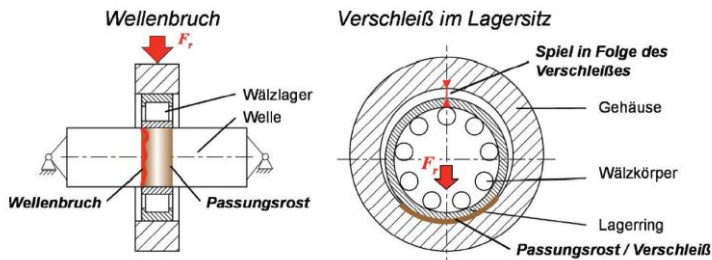
source: NTN catalogue Cat. 3017-2

Fretting corrosion

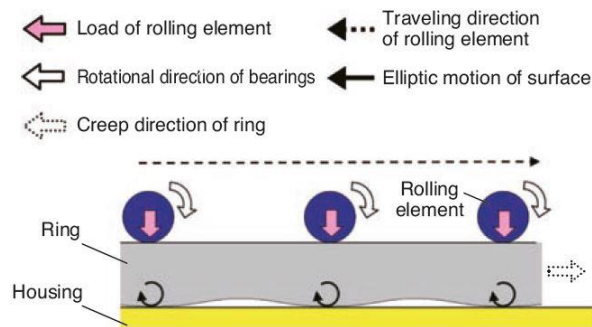
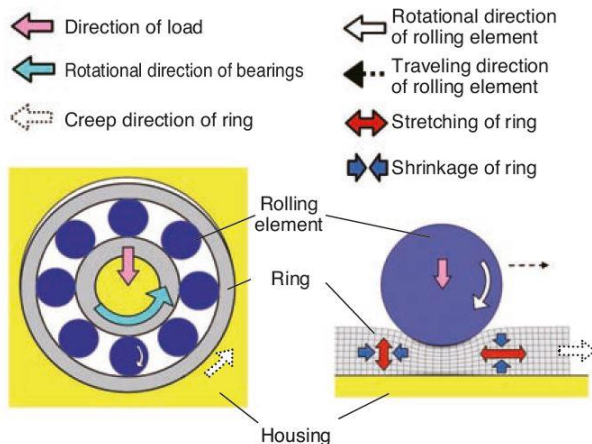
- wear due to relative movement of two surfaces which are in contact to each other
- involves corrosion
- surface asperities oxidize and are rubbed off
- powdery rust develops and surfaces become discoloured blackish red

Possible consequences

- bearing failure or failure of adjacent machine elements due to wear of bearing seat
- shaft displacement caused by radial play in bearing seat due to wear
- shaft fracture due to notch effect caused by fretting corrosion (in case of inner ring creeping)



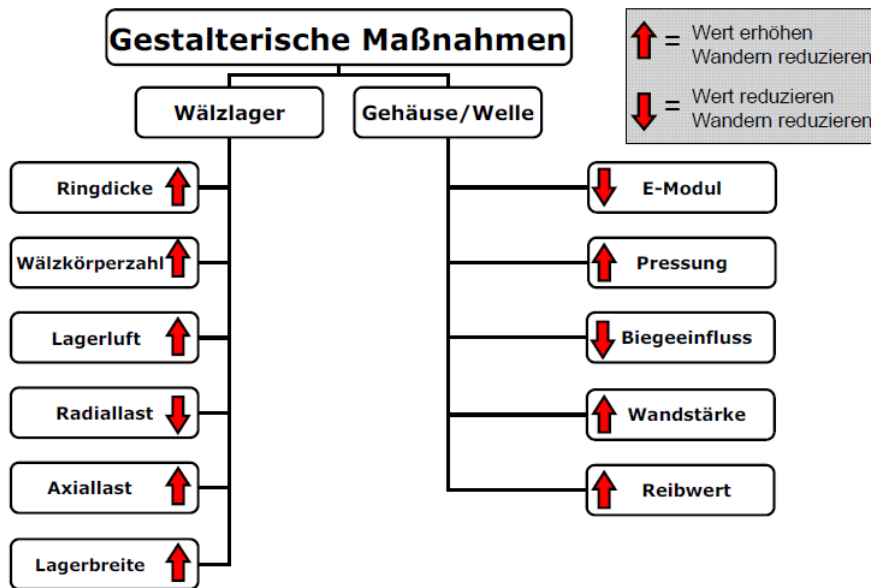
source: FVA research project No. 479-3



source: NTN Technical Review No. 81

Focus of this speech: “progressive wave type creep”

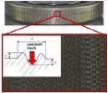
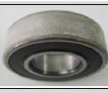
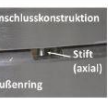
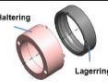
- creeping in direction of rotation
- point load for outer ring application e.g. shaft in transmission
- rolling element load acts on the outer ring
- outer ring material next to rolling contact is displaced
- wave-like deformation of ring up to several micron depended on load
- wave-like deformation travels due to movement of rolling elements (caterpillar-like movement)
- higher tendency for creeping in case of increase of load or decrease of ring thickness
- *Additional type of creep described in NTN Technical Review No. 81*



source: FVA research project No. 479-3

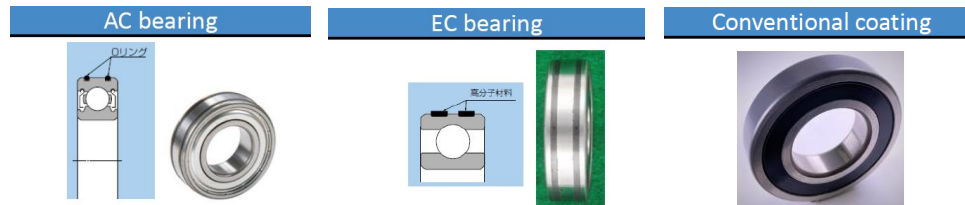
- Overview and evaluation of design measures effective to avoid or reduce creeping
 - refer to FVA 479-2 and -3
- NTN measures for **bearings**
 - Increase to reduce risk:
 - **Ring thickness**
 - **Number of rollers/balls**
 - **Clearance**
 - **Width**
 - Decrease to reduce risk:
 - **Radial load**
- NTN measures for **fits and adjacent parts**
 - Increase to reduce risk:
 - **Fitting overlap**
 - **Thickness**
 - **Friction coefficient**
 - Decrease to reduce risk:
 - **Bending influence**

Creeping – ongoing research work for countermeasure definition, example of FVA project(s)

Wirkprinzip	Maßnahme	Beispiele		Anwendbarkeit (Einschränkungen)	Bemerkung	Fertigungsaufwand / Neukonstruktion	Fertigungsaufwand / Anpassungskonstruktion	Montageaufwand	Modifikation: Wälzlager	Bauraumbedarf	
										axial	radial
Reibwertentziehung	Werkstoffkombination mit Lagerwerkstoff 100Cr6	Werkstoff 1.7225 (42CrMo4) 3.2315 (EN-AW-6082) 1.0503 (C45) 1.7131 (16MnCr5)		am Lageraußenring untersucht	Auftreten von Passungsrost möglich. Zusätzliches Spiel beim Einsatz eines separaten Gehäuses.	gering	hoch	gering	nein	nein	hoch
	Laserstrukturierung			am Lageraußenring untersucht	Passungsrostbildung.	nein	nein	gering	ja	nein	nein
Absorption	Zwischenring	Kunststoff-Gleitlager		am Lageraußenring untersucht, Verwendung begrenzt durch zulässige Flächenpressung	Bei Überschreitung zulässiger Flächenpressung Setzer-schneidungen möglich. Keine Passungsrostbildung.	gering	hoch	gering	nein	nein	mittel
	Beschichtung	GFK-Schicht		bei Zylinderrollenlagern, am Lageraußenring untersucht	Keine Passungsrostbildung.	gering	hoch	gering	ja	nein	gering
Verstellung	Zusatzring	1.7225 (42CrMo4)		am Lageraußenring untersucht	Auftreten von Passungsrost zwischen Zusatzring und Lagering möglich. Kein Passungsrost zwischen Zusatzring und Gehäuse.	mittel	hoch	mittel	nein	nein	mittel
Formschluss	Zylinderstift (radial)	DIN EN ISO 8734	Anschlusskonstruktion  Stift (axial) Außenring	am Lageraußenring untersucht	Formschluss: gegenüber der Lastzone, fester Sitz im Anschlussbauteil.	gering	gering	hoch	ja	nein	gering
	Zylinderstift (axial)	DIN EN ISO 8734		am Lageraußenring untersucht		gering	gering	mittel	ja	gering	nein
	Haltering	3.2315 (EN-AW-6082) / 1.7131 (16MnCr5)	Haltering  Lagering	am Lageraußenring untersucht	Formschluss: gegenüber der Lastzone.	hoch	hoch	mittel	ja	hoch	nein
Stoffschluss	Klebeverbindung	Klebstoff für Welle-Nabe-Verbindungen		anwendbar ausschließlich bei Punktlast	Herstellangaben beachten: Temperatur, chemische Beständigkeit, Montage.	gering	gering	hoch	nein	nein	nein

- design catalogue of countermeasure to prevent or reduce creeping (refer to FVA 479-4)
- several countermeasures:
 - increase friction
 - absorption
 - stiffness
 - form fit
 - adhesive bond
- for some cases it is additional efforts for design, manufacturing, assembly
- for some cases it is required to have additional installation space
- ongoing

Existing



New development published



Still internal work ongoing

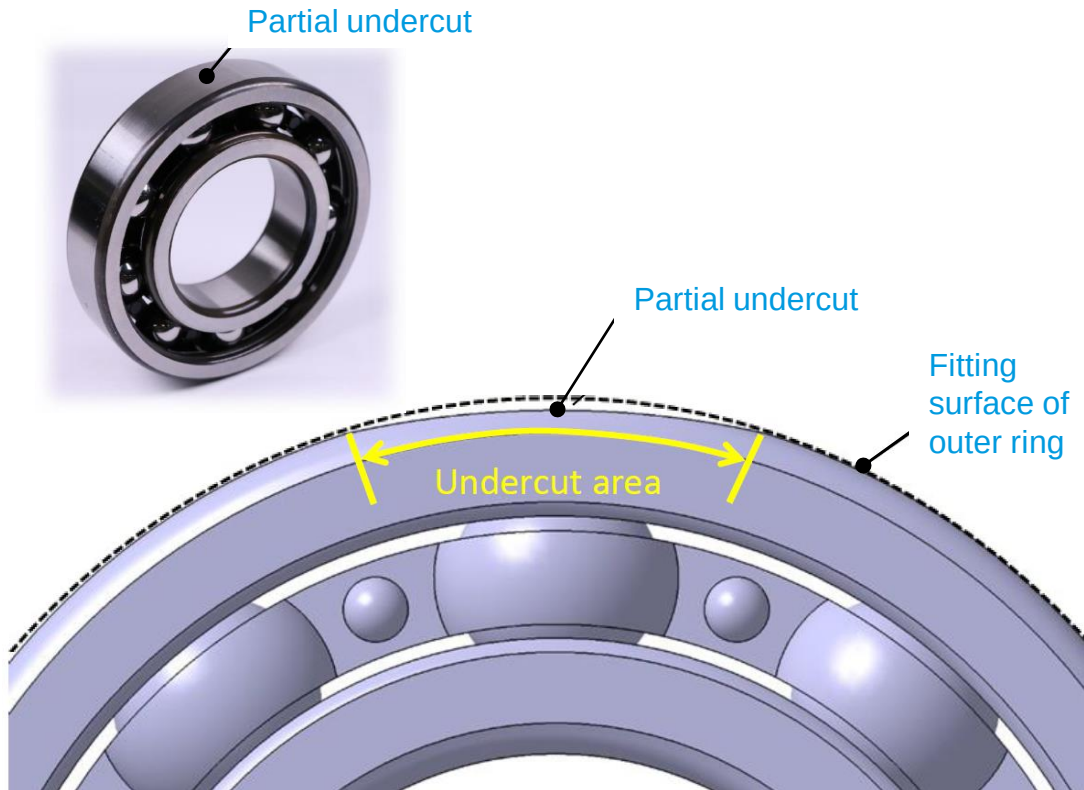
- Not published yet

Existing product range

- AC bearings
- EC bearings
- coatings for outer ring (conventional coatings, usually applied for automotive applications)
 - All three: finally friction increase to avoid turning of OR

New products

- CreepLess Bearings
- focus: stop progressive creep type

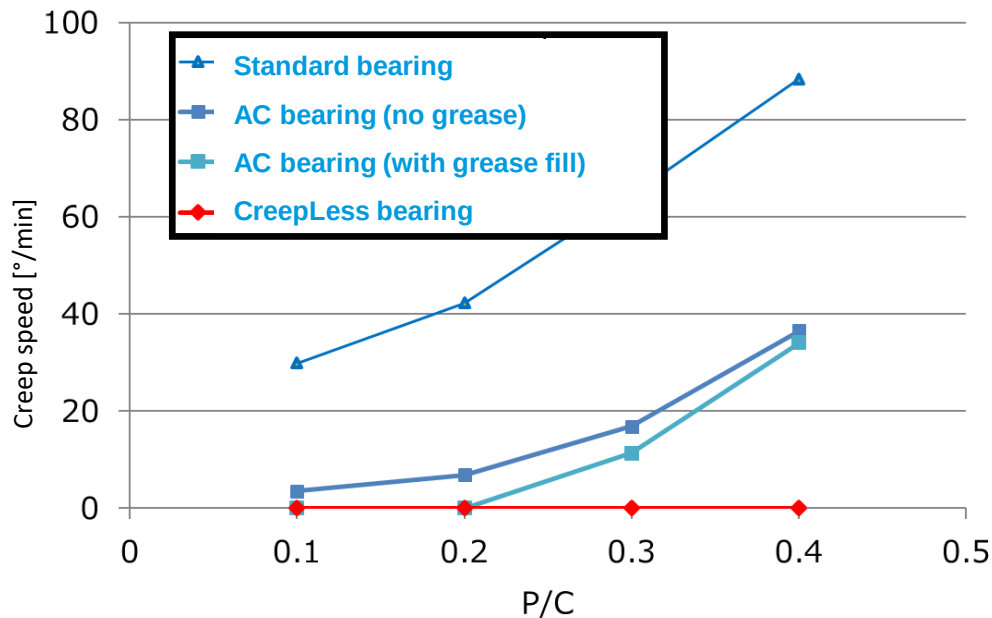


Partial undercut on outer ring fitting surface:

- across full bearing width
- prevents creeping
- sufficient strength and durability

Ease of assembly:

- dimensions similar to standard bearings
- requirements for adjacent parts similar to standard bearings
- → interchangeable
- no orientation required during assembly



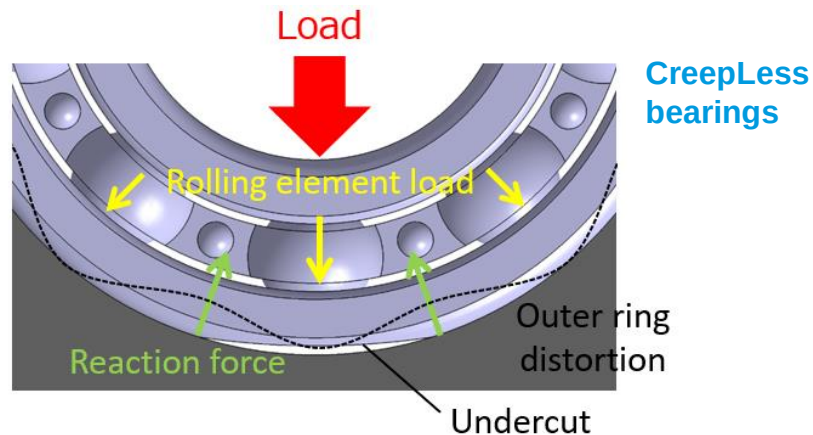
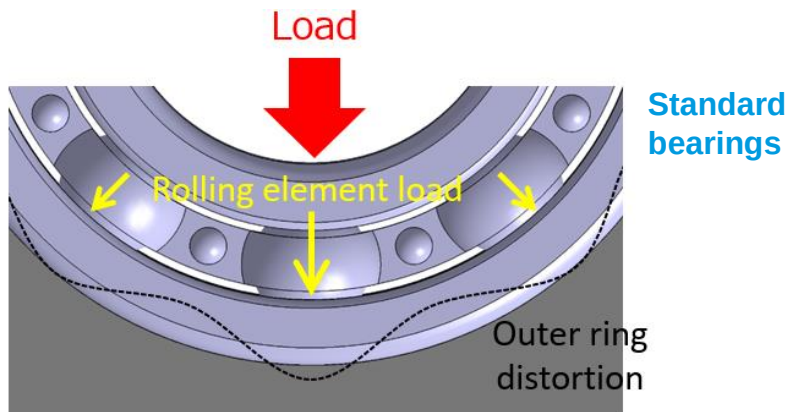
NTN creep speed test

- Test condition

- 6208
- ratio P/C 0.1 to 0.4
- inner ring speed 6000 rpm
- OR temperature 50°C

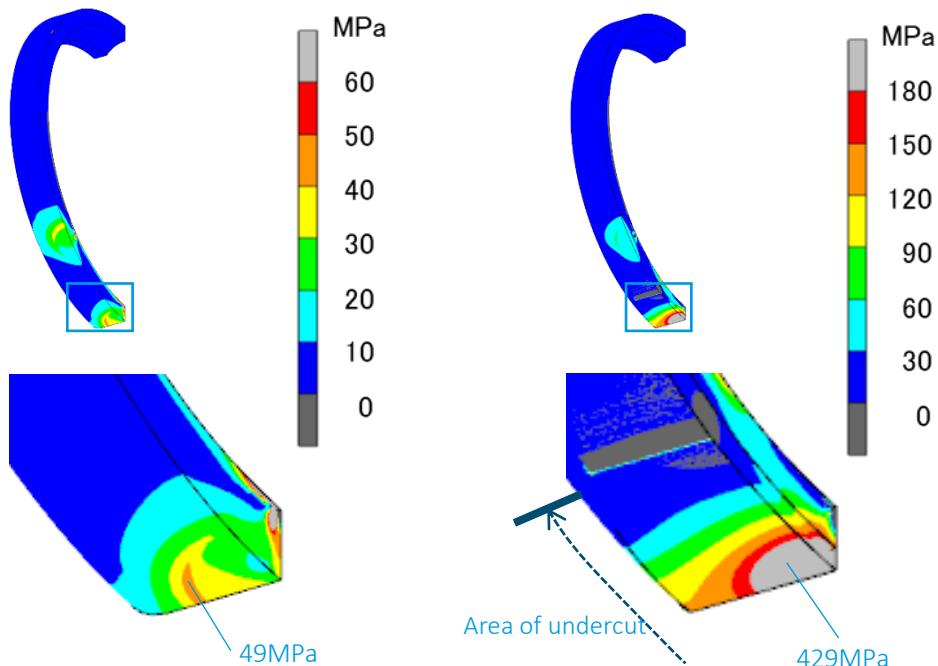
CreepLess bearing prevents creeping

- creeping will be stopped after one revolution of outer ring latest in case undercut is not positioned in the load zone
- no creeping even under high loads
- applicable only in case of point load for outer ring



Mechanism to prevent creeping:

- the undercut prevents partial contact with the housing bore
- caterpillar-like movement is interrupted
- Ring movement (creeping) stops



Standard bearing

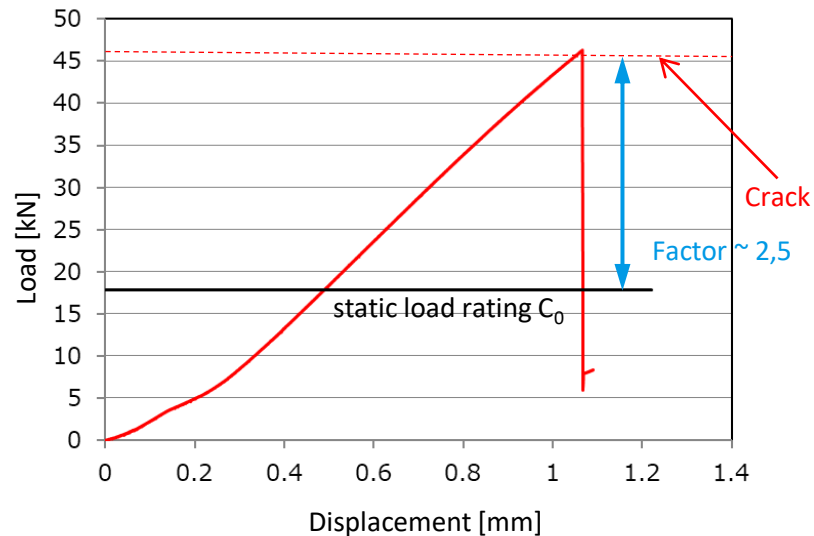
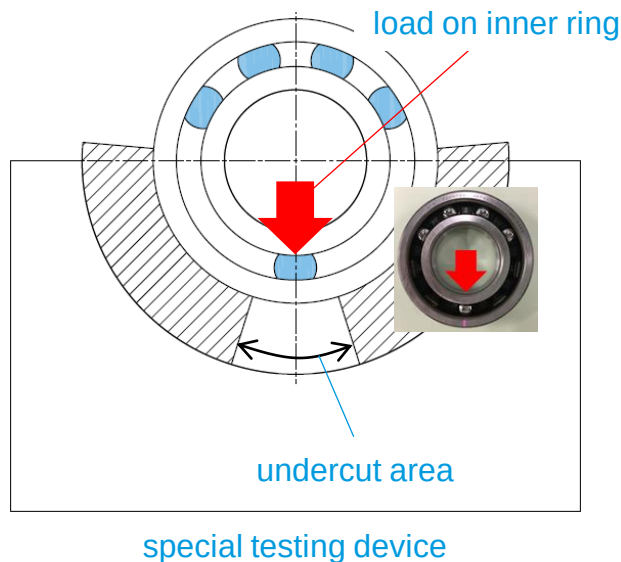
CreepLess bearing

FEM Simulation:

- 6208
- ratio P/C 0.4
- IR and OR elastic
- Rolling elements rigid
- CreepLess bearing: undercut direct below loading point

Result of stress analysis:

- tensile stress approx. 9 times of standard bearing, but within allowable values for bearing steel
- Sufficient strength und durability approved

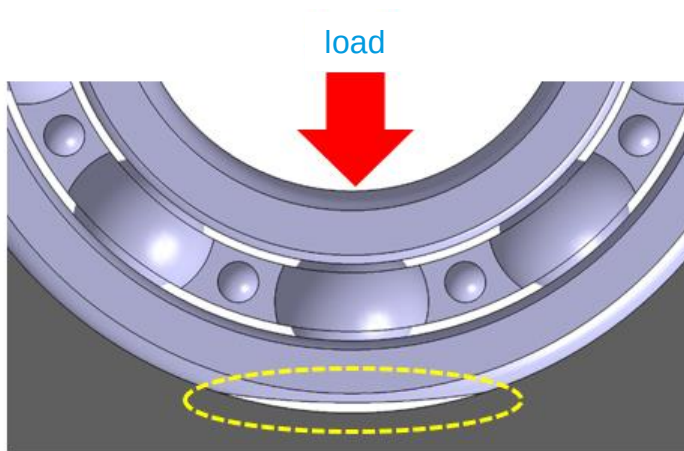


Testing:

- load supported by only 1 rolling element
- continuous increase of load until fracture occurs

Result:

- fracture load exceeds min. 2 times of basic static load rating C_0
- sufficient strength



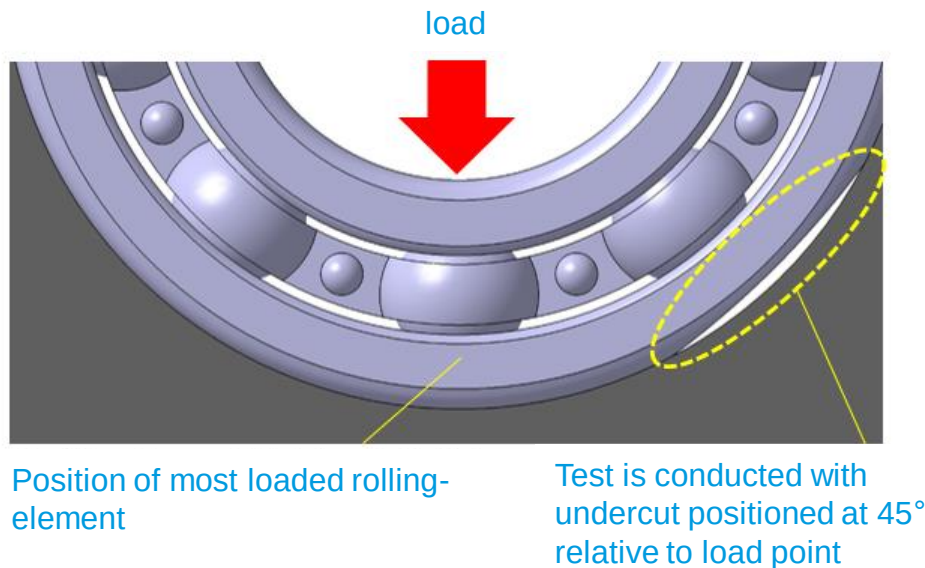
test with undercut direct below load point

Dynamic fracture test conditions:

- 6208
- ratio P/C 1.2
- inner ring speed 2500 rpm
- undercut direct below load point

Result:

- test suspended after 10 mio. load cycles (equivalent to three times of calculated fatigue life)
- sufficient fatigue strength



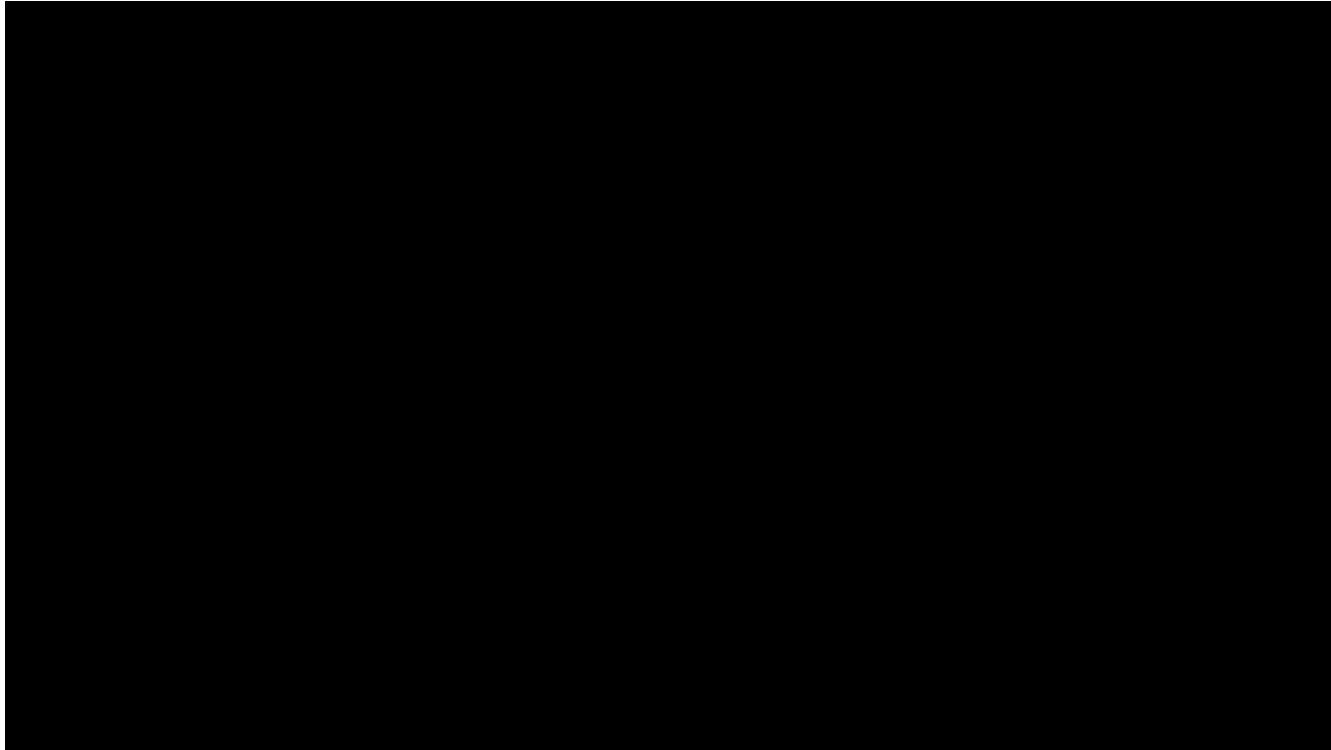
Fatigue life test conditions:

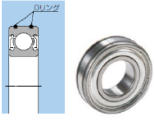
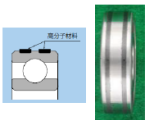
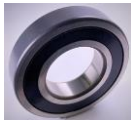
- 6208
- ratio of P/C 0.6
- inner ring speed 3000 rpm
- temperature rise due to operation
- undercut positioned at 45° relative to load point

Result:

- test stopped without failure after more than 10 times of calculated fatigue life
- sufficient strength of bearing approved

NTN CreepLess Lager



		Conventional bearings			Developed bearing
		AC bearing	EC bearing	Conventional coating	CreepLess bearing
Appearance, Structure					
Principle of countermeasures		High-viscosity oil between two O-rings reduces μ factor at outer ring fitting surface, and O-Rings' friction suppresses creeping.	Polymer material suppresses creeping by keeping stable interference under wide temperature range.	Coating on outer ring fitting surface reduces creep wear and suppresses creeping.	Undercut on outer ring fitting surface blocks progressive wave of outer ring distortion
Effect		Creep suppression and Wear reduction	Creep suppression	Creep suppression and Wear reduction	Stop creeping
Assembly		Press fit	Press fit	Press fit not required	Press fit not required
Subject creep type as counter-measures	Same direction as rotation (One direction load)	★ ★ ★	★ ★ ★	★ ★ ★	★ ★ ★
	Opposite direction of rotation (Rotational load)	★ ★ ★	★ ★ ★	★ ★ ★	-
	Spin (Bearing torque)	★ ★ ★	★ ★ ★	★ ★ ★	-
Function	Anti-Creep (Creep speed)	★ ★	★ ★	★ ★ ★	★ ★ ★ ★
	Heavy load creep resistance	★ ★	★ ★	★ ★ ★	★ ★ ★ ★
	Assembly	★	★	★ ★ ★	★ ★ ★
Price (Individual bearing)		★ ★ ★	★ ★	★	★ ★ ★

★ ↔ ★★★★★
bad --- excellent



Thank you for your attention!