



## 2018 STLE Annual Meeting & Exhibition

### SHORT TERM HEAVY LOADS; ONE CAUSE FOR PREMATURE BEARING FAILURES AND WHITE ETCHING CRACKS

Rolling Element Bearings II, May 21, 2018 from 2:00 PM to 2:30 PM – ID: 2836516

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Bearings in large industrial gearboxes or drive train applications, such as paper mills, crusher mill gearboxes, lifting gear drives or wind turbine gearboxes are often subjected to a wide variety of operating conditions that may push them, under certain circumstances, beyond their limits.

These conditions may cause bearing damages, such as cracks and spalling. Due to the appearance of the cracks these damages are known as white etching cracks (WEC) or sometimes called white structure flaking (WSF).

The root cause for crack initiation and propagation with subsequent WEC formation can be manifold [1]-[3]. The detrimental effect of local bending of bearing inner rings, where tensile stresses are the driver for failure, has been successfully demonstrated in [4]. In this work, it will be shown that short term heavy loads will lead to a reduced performance as well as WEC generation too. Bearings that ran at the beginning under heavy load conditions for a very short time do show potential for extensive sub-surface initiated crack and WEC development later. The study confirms that pure stresses are sufficient to generate sub-surface crack and WEC networks, without additional influence of lubricants, slip, electrical current or hydrogen.

Table 1: Test conditions

Axial rig, 'short term heavy load' test conditions	Radial rig, test conditions
<ul style="list-style-type: none"> <li>• Lubricant = ISO VG 100 (<b>no</b> WEC critical low ref. oil)               <ul style="list-style-type: none"> <li>• Kappa <math>\approx</math> 3,5</li> <li>• Temperature <math>\approx</math> 35 °C</li> </ul> </li> <li>• Hertzian pressure outer ring <math>\approx</math> 3,4 to 3,8 GPa</li> <li>• Hertzian pressure inner ring <math>\approx</math> 3,5 to 3,9 GPa               <ul style="list-style-type: none"> <li>• Time = 5 to 15 min</li> </ul> </li> <li>• Support outer ring in loose fit as well as press fit bucket</li> </ul>	<ul style="list-style-type: none"> <li>• Lubricant = ISO VG 220 (<b>no</b> WEC critical low ref. oil)               <ul style="list-style-type: none"> <li>• Kappa <math>\approx</math> 1,8</li> </ul> </li> <li>• Hertzian pressure outer ring <math>\approx</math> 1,9 GPa</li> <li>• Hertzian pressure inner ring <math>\approx</math> 2,1 GPa               <ul style="list-style-type: none"> <li>• Suspension time <math>\approx</math> 1000 hours</li> </ul> </li> </ul>

In literature, besides many other parameters, the effect of so-called 'peak loads' potentially caused by heavy dynamic loads and torques has been discussed as one potential root cause for early failures [5][6]. In this work, the wording 'short term heavy loads' has been chosen, because considerably short events in the range of minutes compared to the overall running time of the bearing in the range of >100-1000 hours are meant. The word 'peak load' may eventually associate to the reader effects in the range of seconds or milliseconds, which are not considered here.

To check if short term heavy loads will reduce bearing performance as well as generate WEC the following test has been developed (see table 1 and figure 1). More details can be found in [7].

Spherical roller bearings of type 23024 made of SAE 52100 (100Cr6) steel, martensitic as well as bainitic hardened, have been run in two different rigs. As shown in figure 1, in a first step the test bearings have been axially loaded for a short period. Following, the same bearings have been put into a radial rig (see figure 1 b) to run until failure, or being suspended.

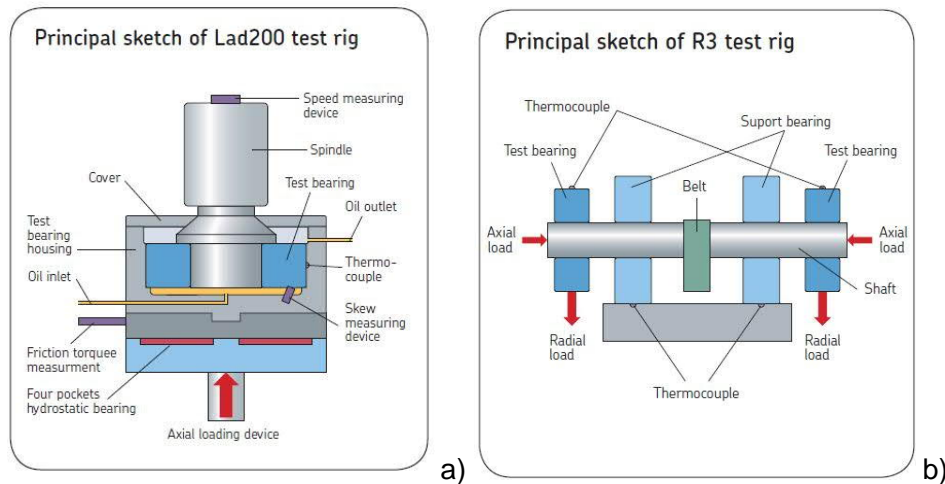


Fig. 1: a) Principle sketch of the LAD rig (axial load) and b) R3 rig (radial load)

It needs to be mentioned that the short term heavy load conditions applied to the 23024 spherical roller bearings (see table 1 left) are outside the recommendation of application engineering.

After the test, the bearings have been visually inspected, followed by ultrasonic immersion tank (US) and metallurgical investigations. Here, as an example, the metallurgical finding inside a bearing outer ring (of bearing #15067) is shown, that has been stopped by sudden death due to the failure of the parallel running bearing #15066. The ultrasonic investigation indicated sub-surface alterations of the material below the raceway of the suspended bearing outer ring (no visual spalling damage).

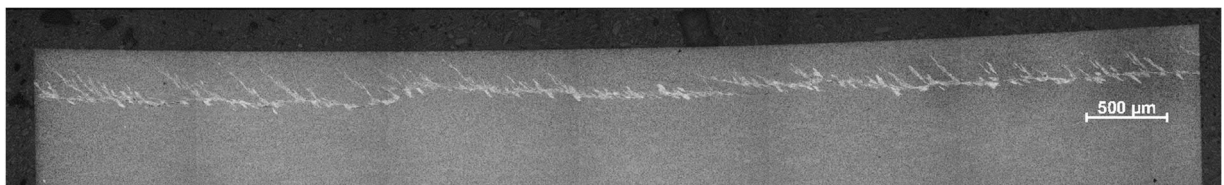


Fig. 2: Extended sub-surface WEC network – circumferential section of the outer ring of bearing #15067 (no visual spalling damage)

The observations shown in figure 2 are only found below the corresponding raceway that has seen the short-term heavy axial load conditions prior the radial load test. Furthermore, the sub-surface WEC have been found in the corresponding radial rig load zone of the outer ring only. The raceway that has not been exposed to any short term heavy loads, has not developed any sub-surface WEC networks. It needs to be mentioned, that in metallurgical investigations of short term heavy loaded bearings only (no radial load test afterwards), neither material transformations such as macro dark etching regions nor butterfly formations have been observed.

The results presented above demonstrate that heavy loads being applied for a comparable short time can reduce bearing life and lead to sub-surface WEC formation. In industry, often a potential interaction between different factors, either structural stress or environmental based (weakening effects caused by corrosion, certain lubricants, hydrogen, stray current etc.) are discussed. However, the tests mentioned above have been carried out without any WEC critical oils, without electrical currents and/or hydrogen. It seems that mechanical stresses such as local tensile stresses [4] as well as short term heavy loads [7] are sufficient to produce WEC networks. More research is needed to fully understand the effect of short term heavy loads (and related limits) with respect to bearing failures and performance reduction. Nevertheless, in certain applications rather low loaded bearings can fail too (e.g. high-speed shaft wind gearbox bearing), therefore the above described effect is one potential root cause only.

## REFERENCES

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## KEYWORDS

Rolling Bearings: Rolling Element Bearings, General, Wear: Fatigue