

USING A TRANSLATORY OSCILLATION TRIBOMETER (SRV®) TO SCREEN GEAR OILS

TRACK OR CATEGORY

Tribotesting

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Introduction

To create an impression of how well gear oils are suited for practical use, they are put into categories according to their seizure load capacity using the FZG rig. The higher the classification, the better the properties of a given oil. This test is conducted with different loads and the classification correlates with the highest load that the oil can withstand without showing seizure.

The SRV® model test environment sees use in many different applications, e. g. in component testing [2] or oil testing [3,4]. An important measuring feature offered is the execution of screening tests, to preselect promising candidates from a batch of new formulations. [5]

Experimental Procedure

The screening procedure as presented in this paper is the result of a continuous revision process, to recreate the results of FZG rig tests.

A suitable gear lubricant will show high EP load-carrying capacity and minimal friction and wear behaviour in the mixed friction range, which reflects typical load situations and damage patterns in gearboxes. It can be improved by optimising the following characteristics: Seizure in the range of sliding friction (EP properties), micro pitting near the pitch point (reduction of friction), low-speed wear (friction and wear behaviour in the mixed friction range). [6]

Therefore, a step load test (EP) based on ASTM D7421 [4] as well as a test to examine the anti-wear (AW) characteristics of the lubricant at its maximum load range are conducted [7]. The tests are carried out on an SRV® test system of the fifth generation.

Step load tests

The loads used in this test are in accordance with [1], as is the temperature, to create comparable results. The step time is 217 s, which is a result of prior investigations [8], where it was compared to shorter runs and reflects two conflicting physical phenomena: Too high step times will lead to too much wear and thereby change the applied pressure, as the system is load controlled; too short times will not let the tribo-system establish itself properly and, therefore, do not allow for distinction between the tested oils. The conditions for the step test are as follows:

Temperature: 90 °C

Frequency: 50 Hz

Stroke: 4 mm

Step time: 217 s

load: depending on step (see Table 1)

Table 1: Pressures and according normal forces used to achieve FZG load steps (excerpt)

FZG load step	1	2	4	6	8	10	12	14	16	18
Hertzian surface pressure [N/mm ²]	146	295	621	929	1223	1539	1841	2170	2465	2777
SRV® normal force [N]	7	28	126	282	489	774	1107	1538	1985	2520

Tests for evaluating the AW behaviour

The AW tests are based on DIN 51834-4 [7]. They are conducted at 90°C surface temperature and instead of a running-in period at a load of 50 N, they begin with increasing load steps until the test load is reached. The test load is equal to the ok load from the step test. Seizure events in the course of the 2h test duration will result in repeating the test at the next lower load stage. If necessary, this is repeated until no seizure occurs. The stroke is 2 mm, the frequency is 50 Hz. The lower stroke width compared to the step load test is owed to the longer testing time.

Test pieces and oils used

For both test types, the lower test specimen is a disk Ø 24 x 7.9 mm, in accordance with [7]. It is made of hardened rolling bearing steel AISI 52100 / 100Cr6. The upper test specimen is a cylinder Ø 6 x 8 mm. The cylinder is crowned so that the contact length at the beginning of the test is 4 mm. The surface is polished. It is aligned at 10° to the direction of movement along its longitudinal axis (cf. Figure 1). The lubricants tested are commercially available gear oils, with known FZG seizure load stages.

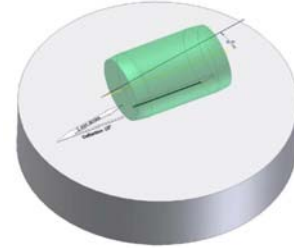


Figure 1: Schematic showing the angling of the cylinder on the disc

Results

The aim of the presented method is to continuously and repeatedly reproduce the load stage of the FZG test rig for the tested oils, with as small a deviation as possible. To evaluate this, the results of the above described tests are presented here.

Table 2 shows the results of the step tests and AW-tests, exemplary for oil 2.14, which has a FZG load stage of 14. It is the oil with the most data available from all the tests and thus most reliable to evaluate. For the step test the ok-load is reported (highest load without seizure), for the AW-test the maximum load, that repeatedly (three times) showed no seizure during the test. The results very clearly suggest, that the oil's seizure load stage, as estimated by the presented screening method, is 14, with five and six occurrences of this value, respectively. The step tests show a single deviation from this value, at 15 and the AW- tests show no deviation. Both tests' results show no deviation greater than one load step. The AW-test having only "correct" results, meaning there was no deviation from the FZG test at all.

Table 2: Results of step and AW-tests on oil 2.14

Seizure load step	1 – 13	14	15	16 – 18
Step test	none	5	1	none
AW-test	none	6	0	none

Discussion

To label a test run as a success, it is necessary to predict the FZG load step within a reasonable margin. It is supposed to select a small enough number of oils, that show promise, without eliminating hopeful candidates. Using one load step deviation, creates the smallest possible corridor for samples, to be reported as positive and go on to the more complex and expensive tests.

When looking at the results of both test types combined, it can be concluded, that in all of the twelve tests shown here, the FZG seizure load category of the oils could be gauged to within a margin of +/- 1; eleven of them are exactly on target.

When looking at a wider range of results, with different oils and parameters, the scatter becomes more distinct, as is to be expected. All tests presented here have been conducted using an identical parameter set. It has shown good correlation and shall therefore be recommended to be used for estimations of seizure load capacities, using the SRV®, pending further investigations.

The large range of parameters and oils tested, to arrive at this conclusion, results in a large variety of testing conditions. As a result of this circumstance the shown oil 2.14 is the only one, that fulfills the set condition of repeated successful AW tests. There have not been enough test repetitions for the other oils at the given parameters, to allow for the same statements. The single test results however show promise in regards of adequately predicting the seizure load stage. Therefore, creating a more solid and rigorous data base for all oils involved is necessary, to further validate this method.

Summary and Outlook

In this paper a screening method was presented, that reduces the number of tests on the FZG rig and thus saves the operators time and effort. This is done by identifying formulations, that would perform badly, up front.

The method combines two different standards for the SRV® testing environment. An EP and an AW test method are used to approximate the seizure load capacity category on the FZG.

Through thorough testing, that was only partially shown in this paper, a solid and reliable set of parameters was found. A large quantity of SRV® test results presented here show a discrepancy from the FZG rig results of two load steps or lower. The presented test concept therefore shows, that the test environment of the SRV® is well-suited to characterize and clearly distinguish gear oils with regard to EP and AW properties in an acceptable timeframe. The test results can provide first indications on the behaviour of the lubricant in practical applications and facilitate the pre-selection for further bench and field tests.

Looking forward, it will be necessary to increase the number of tests with the parameters used to generate the presented results, for further validation. The number of oils, especially with lower FZG load categories shall be increased as well.

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KEYWORDS

Wear: Bench Wear Tests, Friction: Friction Test Methods, Lubricants: Gear Lubricants.
SRV®, gear oils, seizure load capacity, test concept, translatory oscillation tribometer