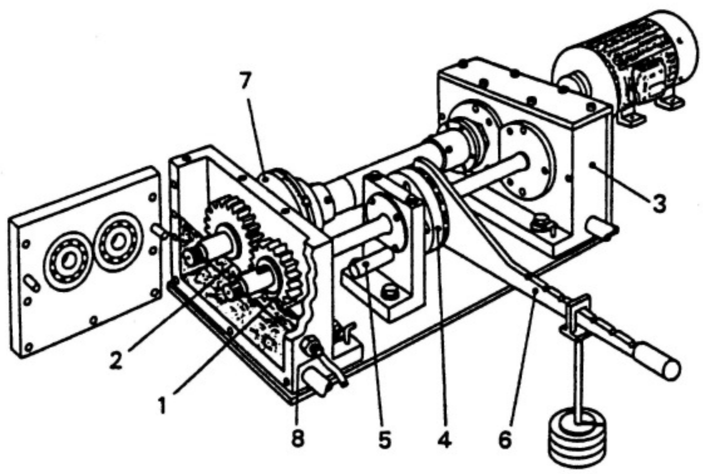
Useful information on scuffing load tests

What are the FZG scuffing load tests all about?

FZG is the Technical Institute for the Study of Gears and Drive Mechanisms (**F**orschungsstelle für **Z**ahnräder und **G**etriebebau) of the Technical University in Munich, where this test rig was developed. The several scuffing load tests performed on the FZG test rig serve for determining the extent to which gear lubricants help to prevent scuffing on the tooth faces at the lubrication gap. Scuffing occurs locally where the gears are in mesh, i.e. where at roughness peaks in contact temperatures rise sharply ('flash temperatures'), depending on the load, peripheral speed and oil sump temperature. At these contact points, the surfaces weld together briefly and are torn apart again as the gears revolve, which leads to partial destruction of the surfaces. The scuffing load capacity of a lubricant depends primarily on the base oils and additives used, and the consequent lubricant film thickness.



1. Test pinion
2. Test wheel
3. Drive gear case
4. Rotating coupling
5. Locking pin
6. Load lever with weights
7. Torque gauge
8. Temperature sensor

Drawing of an FZG four square gear oil tester

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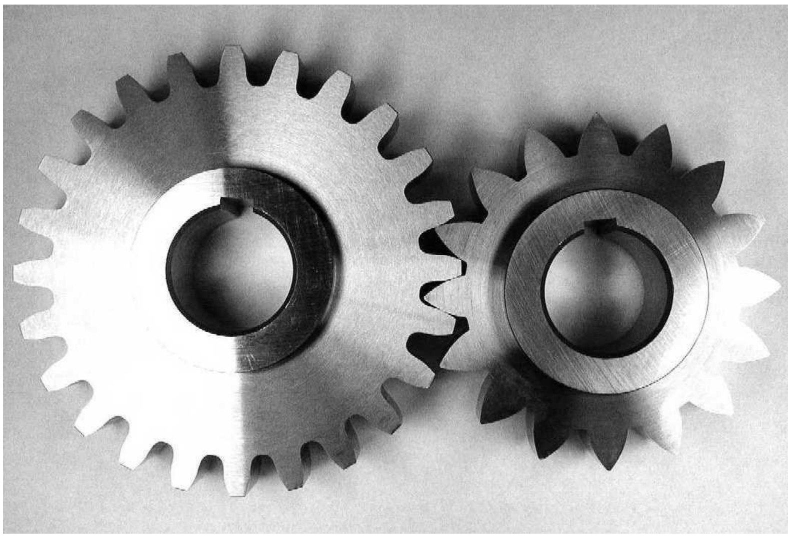

Test gear pair type A for scuffing load tests

The gear pair type A shows a considerable profile offset, which causes the tooth flanks to move at higher speeds relative to each other. This in turn increases the percentage of sliding movement on the flanks, which makes the teeth more susceptible to scuffing.

In the FZG standard scuffing load test, a defined load is applied to a pair of spur wheels, which is increased after a certain run time. After each load stage, the gear wheels are inspected visually and wear is measured. If wear exceeds a certain limit, the test is terminated and the last load stage documented as scuffing load step.

However, there is a variety of different FZG scuffing load tests with different peripheral speeds, oil sump temperatures, gear pairs and senses of rotation. Different tests and consequently different scuffing load steps are listed for the various lubricants. The following list is to help make the different results comparable by taking into account the flash temperatures to be theoretically expected.
Another classification based on scuffing load capacities is provided by API GL4 and GL5 specifications. For these, FZG tests (step or leap tests) generating the same flash temperatures can also be used.

Please note that this list does not indicate if a lubricant is suitable for a particular application, but solely serves for comparing the various scuffing load tests by the different flash temperatures.

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List for comparing the various FZG scuffing load tests:

The various scuffing load tests can be classified according to the occurring flash temperatures, which renders a list as follows.

Scuffing load test	Flash temp. $\Delta\vartheta$ [K]
FZG (A/8.3/90) sls > 11	≈ 370
FZG (A/8.3/90) sls > 12	≈ 420
FZG (A/16.6/90) sls > 11	≈ 460
FZG (A/8.3/90) sls > 13	≈ 500
FZG (A/16.6/90) sls > 12	≈ 520
FZG (A/8.3/90) sls > 14	≈ 570
FZG (A/16.6/90) sls > 13	≈ 610
FZG (A10/16.6R/90) sls > 10 = API GL 4	≈ 620
FZG (S-A10/16.6R/90) ls 8 PASS = API GL 4	≈ 770
FZG (S-A10/16.6R/90) ls 9 PASS = API GL 5	≈ 950

sls = scuffing load step **ls = load step**

In this list, the requirements to be met by the lubricant in order to pass the tests increase from top to bottom.

The scuffing load tests listed refer to the use of gear oils. Scuffing load tests for gear greases, where peripheral speeds and temperatures are lower, have not been considered.

Comments on scuffing load capacity and the individual tests

The indicated flash temperatures (temperature increase over tooth bulk temperature [1]) were determined by means of the integral temperature method DIN 3990

Standard scuffing load test acc. to DIN 51354 FZG (A/8.3/90)

Gear pair type A, peripheral speed 8.3 m/s, oil sump temperature 90 °C, centre distance in test gear 91.5 mm;
At first, the gear pair is run in at low load stages. Then the load stages are increased, which leads to higher flash temperatures occurring in the gears. The running-in smoothens the surfaces.

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Enhanced scuffing load test **FZG (A/16.6/90)**

The peripheral speed is increased ot 16.6 m/s;
In this test, the flash temperature level is higher. Running-in at low load stages is as in the normal scuffing load test.

Step test **FZG (A10/16.6R/90)**

Sense of rotation is reversed (gear wheel driving the pinion), a narrower pinion is used (A10);
This change of operating conditions increases pressure and makes it more difficult for the lubricant to reach the friction points.

Leap test **FZG (S-A10/16.6R/90)**

The load is not increased gradually, but the load of a certain stage is applied without running-in. The result obtained is PASS or FAIL.
There is no running-in, so the surfaces are not smoothened, which leads to higher flash temperatures.
However, it should be noted that a lubricant should normally possess certain running-in characteristics, especially for use in gears. These characteristics will eventually increase the scuffing load capacity of the gear pair.
For this reason it is essential to always bear in mind the conditions under which a particular suffing load test is performed.

We hope this will contribute to a little "enlightenment" regarding the testing of gear lubricants.

References

[1] B.-R. Höhn, P. Oster, K. Michaelis: New test methods for the evaluation of wear, scuffing and pitting capacity of gear lubricants. AGMA Technical Paper 98FTM8 (1998)