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Gears — FZG test procedures —

Part 1: **FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils**

Engrenages — Méthodes d'essai FZG —

Partie 1: Méthode FZG A/8,3/90 pour évaluer la capacité de charge au grippage des huiles

Reference number
ISO 14635-1:2000(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 14635 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14635-1 was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 2, *Gear capacity calculation*.

ISO 14635 consists of the following parts, under the general title *Gears — FZG test procedures*:

— *Part 1: FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils*

— *Part 2: FZG test method A10/16,6R/90 for relative scuffing load-carrying capacity of lubricants with high EP performance*[1)]

Annexes A and B of this part of ISO 14635 are for information only.

1) Currently a new work item proposal avaiting approval.

Introduction

The types of gear failures which may be influenced by the lubricant in use are scuffing, low-speed wear and the gear-surface fatigue phenomena known as micropitting and pitting. In the gear design process, these gear damages are taken into consideration by the use of specific lubricant and service-related characteristic values. For an accurate, field-related selection of these values, adequate lubricant test procedures are required. The FZG test procedures described in this and other parts of ISO 14635 can be regarded as tools for the determination of the lubricant-related characteristic values to be introduced into the load-carrying capacity calculation of gears.

FZG test method A/8,3/90 for the relative scuffing load-carrying capacity of oils described in this part of ISO 14635 is typical for the majority of applications in industrial and marine gears. ISO 14635-2 will be related to the relative scuffing load-carrying capacity of oils of very high EP properties, as used for the lubrication of automotive driveline components. Other FZG test procedures for the determination of low-speed wear, micropitting and pitting load-carrying capacity of gears are already in a late state of development. They may be added later to ISO 14635 as further parts.

Gears — FZG test procedures —

Part 1:
FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils

1 Scope

This part of ISO 14635 specifies a test method based on an FZG[2)] four-square test machine to determine the relative load-carrying capacity of lubricating oils defined by the gear-surface damage known as scuffing. High surface temperatures due to high surface pressures and sliding velocities can initiate the breakdown of the lubricant films. This test method can be used to assess such lubricant breakdown under defined conditions of temperature, high sliding velocity and stepwise increased load.

NOTE This method is technically equivalent to ASTM D 5182-97, DIN 51354-1 and DIN 51354-2, IP 334/90 and CEC L-07-A-95.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14635. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14635 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1328-1, *Cylindrical gears — ISO system of accuracy — Part 1: Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth*.

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*.

ISO 4964, *Steel — Hardness conversions*.

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*.

ASTM D 235, *Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent).*

2) FZG = Forschungsstelle für Zahnräder und Getriebebau, Technische Universität München (Gear Research Centre, Technical University, Munich), Boltzmannstraße 15, D-85748 Garching, Germany.

3 Terms and definitions

For the purposes of this part of ISO 14635, the following terms and definitions apply.

3.1
scuffing load-carrying capacity
⟨of a lubricant⟩ maximum load which can be sustained under a defined set of conditions

NOTE 1 For examples of failure see Figure 1.

NOTE 2 Scuffing is a particularly severe form of damage to the gear-tooth surface in which seizure or welding together of areas of tooth surface occur, due to absence or breakdown of a lubricant film between the contacting tooth flanks of mating gears, typically caused by high temperature and high pressure. Scuffing is most likely when surface velocities are high. Scuffing may also occur at relatively low sliding velocities when tooth-surface pressures are high enough either generally or, because of uneven surface geometry and loading, in discrete areas.

NOTE 3 Risk of scuffing damage varies with the properties of gear materials, the lubricant used, the surface roughness of tooth flanks, the sliding velocities and the load. Consequences of scuffing of high-speed gears include a tendency to high levels of dynamic loading due to increase of vibrations, which usually leads to further damage by scuffing, pitting or tooth breakage.

3.2
FZG test condition A/8,3/90
test condition where A is the particular tooth form of the test gears, according to Table 1; 8,3 is the speed at the pitch circle, in metres per second, and 90 is the initial oil temperature, in degrees Celsius, from load stage 5 and onward in the oil sump

NOTE The direction of the rotation of the gears is shown in Figure 3.

3.3
failure load stage
load stage in which the summed total width of scuffing damage on the active flank area of the 16 pinion teeth exceeds one gear-tooth width, i.e. 20 mm

NOTE Examples of flank damages for the purpose of the test method are shown in Figure 1.

4 Brief description of method

4.1 General principle

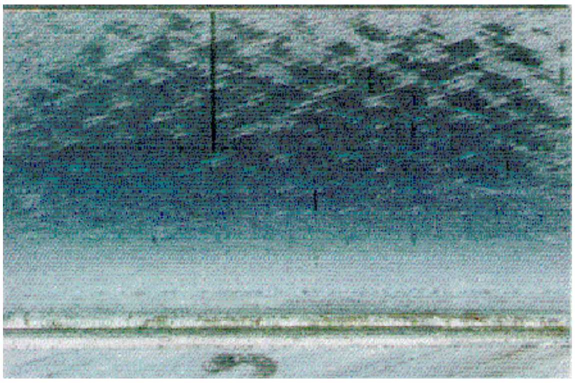
A set of test gears as defined in clause 5, Tables 1 and 2, is run with the test lubricant at constant speed for a fixed number of revolutions using dip-lubrication mode. Loading of the gear teeth is increased in steps outlined in Table 3. Beginning with load stage 5, the initial oil temperature is controlled between (90 ± 3) °C. During the test run of each load stage, the oil temperature is allowed to rise freely. After load stage 4, the pinion tooth flanks are inspected for surface damage at the end of each load stage and any changes in appearance are noted. A test is considered complete when either the failure criteria has been met or when load stage 12 is run without meeting the failure criteria.

It is the responsibility of the operator to ensure that all local legislative and statutory requirements are met.

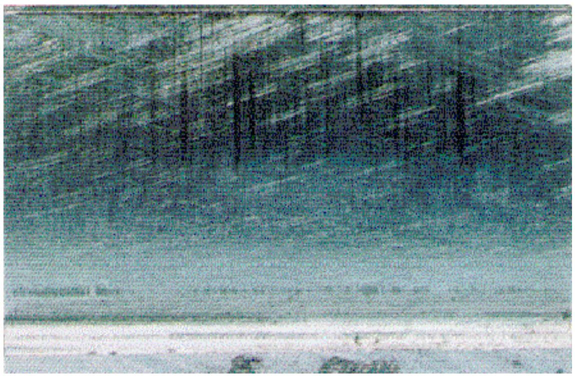
NOTE It has been assumed by the compilers of this test method that anyone using the method will either be fully trained and familiar with all normal engineering and laboratory practice, or will be under the direct supervision of such a person.

WARNING — When the rig is running, there are long loaded shafts and highly stressed test gears turning at high speed and precautions shall be taken to protect personnel.

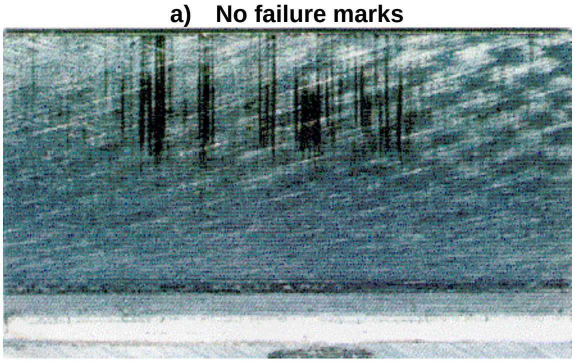
Protection from noise is also highly recommended.



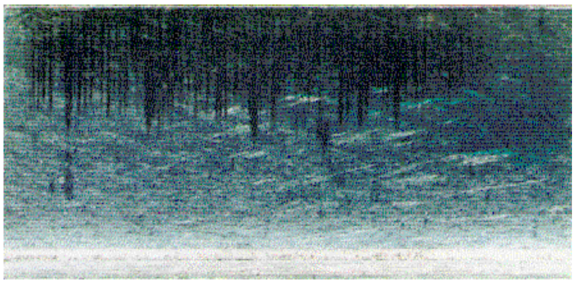
a) **No failure marks**



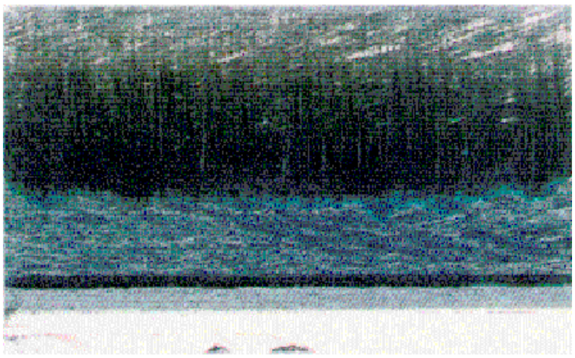
b) **No failure marks**



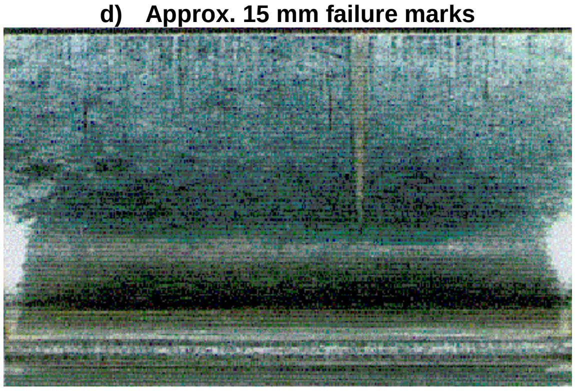
c) **Approx. 5 mm failure marks**



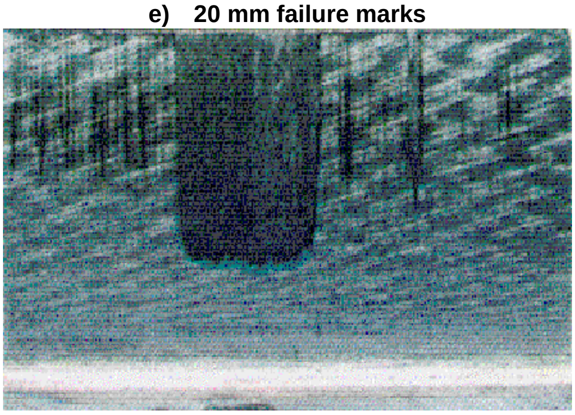
d) **Approx. 15 mm failure marks**



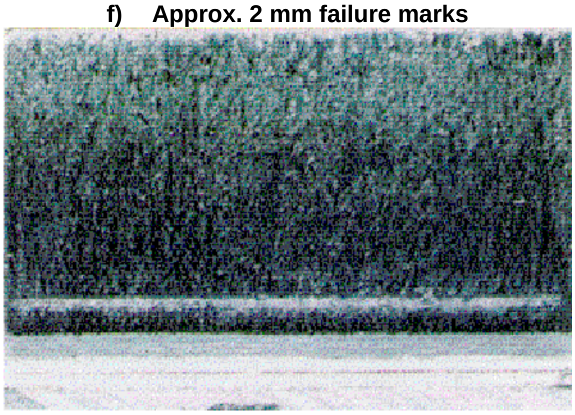
e) **20 mm failure marks**



f) **Approx. 2 mm failure marks**



g) **Approx. 6 mm failure marks**



h) **20 mm failure marks**

NOTE This figure describes the typical pinion tooth flank changes occurring in FZG tests. Changes in the original surface condition (criss-cross grinding) may be described by their physical appearance. One and the same type of flank damage may be described in different places in the world by using different terminology (e.g. "scuffing", "scoring" and "severe wear"). In order to avoid misinterpretation of the pinion tooth flank changes occurring during the test, typical examples of non-failure and failure are given.

PRODUCTION NOTE The colours represented in the electronic file of this part of ISO 14635 can be neither viewed nor printed as true representations. Only copies of this part of ISO 14635 printed by ISO can be guaranteed to represent the true colours.

Figure 1 — FZG A-type gear-tooth face changes (flank damages)

4.2 Precision

The precision of the method has been evaluated according to ISO 5725-2 with three oils (two reference oils and one oil from the market). The failure load stage of these oils covered the range 5 to 12 inclusive.

Values of repeatability (r) and reproducibility (R), as defined in ISO 5725-2, for this test procedure are:

r = 1 load stage

R = 2 load stages

NOTE The above precision results apply to the range of failure load stages 5 to 12.

5 Test materials

5.1 Test gears

A pair of type “A” gears with a specification according to Tables 1 and 2 shall be used for testing. Each pair of test gears may be used twice for testing, utilizing both tooth flanks as load-carrying flanks.

5.2 Cleaning fluid

Petroleum spirit conforming to ASTM D 235.

Table 1 — Details of FZG test gears type A

Dimension		Symbol	Numerical value	Unit
Shaft centre distance		a	91,5	mm
Effective tooth width		b	20	mm
Working pitch diameter	pinion	d_{w1}	73,2	mm
	wheel	d_{w2}	109,8	mm
Tip diameter	pinion	d_{a1}	88,77	mm
	wheel	d_{a2}	112,5	mm
Module		m	4,5	mm
Number of teeth	pinion	z_1	16	
	wheel	z_2	24	
Profile-shift coefficient	pinion	x_1	0,853 2	
	wheel	x_2	– 0,50	
Pressure angle		α	20	Degrees
Working pressure angle		α_w	22,5	Degrees
Pitch-diameter circumferential speed		v_w	8,3	m/s
Addendum engagement	pinion	e_{a1}	14,7	mm
	wheel	e_{a2}	3,3	mm
Sliding speed at tooth tip	pinion	v_{ga1}	5,56	m/s
	wheel	v_{ga2}	1,25	m/s
Specific sliding at tooth tip	pinion	ζ_{E1}	0,86	
	wheel	ζ_{A2}	0,34	
Specific sliding at tooth root	pinion	ζ_{A1}	– 0,52	
	wheel	ζ_{E2}	– 5,96	
Hertzian contact pressure		p_c	$14{,}7\sqrt{F_{nt}}$ [a]	N/mm^2

[a] F_{nt} = normal tooth load in newtons (see Table 3).

Table 2 — Manufacturing details of FZG test gears type A

Material	Case-hardening steel with restricted hardenability to 2/3 of the lower scatter band. Material composition: C = 0,13 % to 0,20 % Mo = max. 0,12 % Si = max. 0,40 % Ni = max. 0,30 % Mn = 1,00 % to 1,30 % Al = 0,02% to 0,05 % P = max. 0,025 % B = 0,001% to 0,003 % S = 0,020 % to 0,035 % Cu = max. 0,30 % Cr = 0,80 % to 1,30 %
Heat treatment	The test gears are carburized and case hardened. The case depth at a hardness of 550 HV10 shall be 0,6 mm to 0,9 mm. The surface hardness after tempering: 60 HRC to 62 HRC, core strength in tooth root centre: 1 000 N/mm^2 to 1 250 N/mm^2 (determined in accordance with ISO 4964 based on Brinell hardness). Retained austenite should be nominally 20 %.
Gear accuracy grade	Q5 according to ISO 1328-1

Arithmetic roughness of flanks Ra	Ra is separately determined for left and right flanks, measured each at three flanks per gear across the centre of the tooth parallel to the pitch line; measuring parameters according to ISO 4287:
	measured length l_t = 4,8 mm, cut-off length λ_c = 0,8 mm;
	velocity = 0,5 mm/s;
	using a skid.

	Average roughness (relating to manufacture batches of a minimum of a 100 gear sets) Pinion: Ra = 0,35 µm ± 0,1 µm Gear: Ra = 0,30 µm ± 0,1 µm
	Maximum roughness (average of three measurements according to the described method and valid for 95 of 100 tested gears). Pinion and gear: Ra = 0,5 µm
Grinding	Maag criss-cross grinding (15° method), 154 r/min of generating stroke drive
Flank modification	None

6 Apparatus

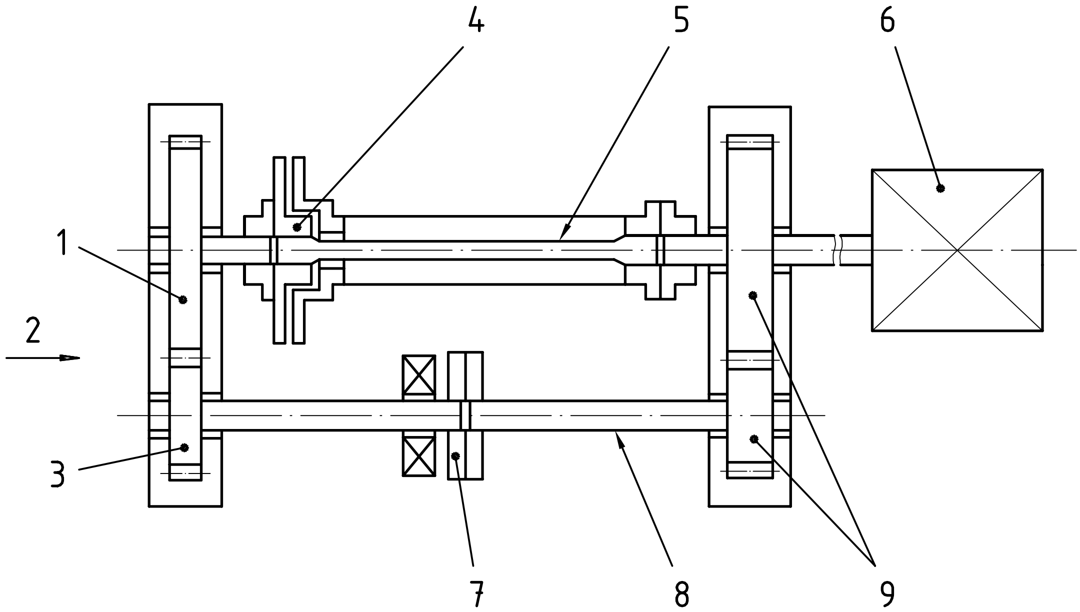
6.1 FZG spur-gear test rig

6.1.1 The FZG spur-gear test machine utilizes a recirculating power loop principle, also known as a four-square configuration, to provide a fixed torque (load) to a pair of precision test gears. A schematic view of the test rig is shown in Figures 2 and 3. The slave gearbox and the test gearbox are connected through two torsional shafts. Shaft 1 contains a load coupling used to apply the torque through the use of known weights defined in Table 3 hung on the loading arm.

6.1.2 The test gearbox contains heating elements to maintain and control the minimum temperature of the oil. A temperature sensor located in the side of the test gearbox is used to control the heating system as required by the test operating conditions.

6.1.3 The test machine is powered by an electric motor of minimum 5,5 kW at a speed of approximately 1 450 r/min.

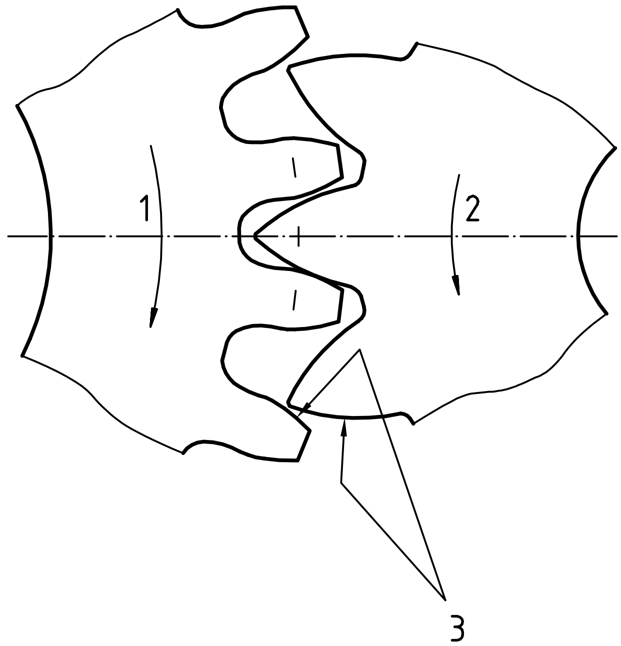
6.1.4 A check list for maintenance of the FZG gear test rig is given for information in annex B.



Key

1 Wheel
2 View A
3 Pinion
4 Torque measuring coupling
5 Shaft 2
6 Drive motor
7 Load coupling
8 Shaft 1
9 Slave gears

Figure 2 — Schematic section of the FZG gear test machine



Key

1 Wheel
2 Pinion
3 Action tooth flank

Figure 3 — Mounting of the FZG test gears of type A (view A)

6.2 Heating device

A suitable oven or heating device is required to warm the test gears to 60 °C to 80 °C for assembling on the shafts.

6.3 Revolution counter

A suitable counter shall be used to control the number of revolutions during each load stage of the test. The counter should be capable of shutting down the test machine at the appropriate number of revolutions.

7 Preparation of apparatus

7.1 Flush the test gear case twice with petroleum spirit, ensuring that the bearings are cleared of any previous oil, and air dry with a water-free air line.

7.2 Clean the test gears in petroleum spirit and air dry, using finger stalls or gloves.

7.3 With the unaided eye, inspect the gears for corrosion, rust or any other damage. Reject the gears if so damaged.

7.4 Heat both the gears to between 60 °C and max. 80 °C, with an appropriate heating device.

7.5 Assemble the test gear box (except the top cover) with the pinion on shaft 1 (right-hand side) and the gear on shaft 2 (left-hand side) as shown in Figure 2. Ensure that the pinion and wheel are correctly aligned, i.e. no offset.

7.6 Check that the switch drain cock is in the CLOSED position.

7.7 Fill the test gear box with nominal 1,25 litre test oil.

7.8 Plug in the heater.

7.9 Fit and secure the top cover to the test gear box.

7.10 Apply load stage 12 using the 0,5 m radius position (see Table 3) for 2 min to 3 min without running the motor, in order to bring the test gears and the clearances in the system into the correct working position.

8 Test procedure

8.1 Apply the first load stage (see Table 3). Using the conditions given in Table 4, start the motor, switch on the heater and run for 21 700 revolutions of the motor (approximately 15 minutes) according to Table 4.

8.2 Stop the motor and apply the load for stage 2. Restart and run according to Table 4 for 21 700 revolutions of the motor. Repeat for load stages 3 and 4.

8.3 At the end of load stage 4, inspect the pinion for damage, without removing the test gears. Record the tooth condition, using the examples in Figure 1 as a guide.

8.4 At the beginning of load stage 5, ensure that the oil temperature in the test gear box is (90 ± 3) °C as stated in Table 4.

8.5 Before starting the next higher load stage, ensure that the oil temperature in the test gearbox is (90 ± 3) °C. This can be accomplished by using of cooling water. When the temperature falls to (90 ± 3) °C, turn off the cooling water and continue the test. The cooling water shall be turned off during the test.

8.6 Continue the test with stepwise increased load stages (Table 3), inspecting all the pinion teeth after each stage, and cooling to (90 ± 3) °C as in 8.5 before applying the next higher load stage.

8.7 The test procedure is continued until the failure load stage according to 3.3 is reached, but if insufficient failure occurs the test is terminated at the end of load stage 12.

8.8 The failure load stage is determined by the summed flank damages on all the pinion gear teeth.

8.8.1 If the failure load stage is not reached, the test is continued.

8.8.2 If, at the next stage above that discussed, there is no increase in the damaged areas, the test is continued until the conditions defined in 3.3 are reached.

8.8.3 If the machine is shut down at the end of a load stage for any reason during a test, for a period of time before the test is completed and the test oil temperature drops below 87 °C, carry out the following before resuming the test:

a) Apply load stage 1, start the motor, switch on the heater and run until the oil temperature reaches (90 ± 3) °C.

b) Stop the motor, switch off the heater and apply the next load stage on, from when the machine was shutdown.

c) Continue the test according to 8.5 and 8.6 respectively.

9 Reporting of results

Report the load stage and the corresponding pinion torque at which the failure occurred, as defined in 3.3. State the test conditions as A/8,3/90. If the test was completed without failure, report "Failure load stage greater than 12". If the test was terminated due to scuffing before the load stage 5 was reached, report "Failure load stage less than 5".

A typical test report sheet is given for information in annex A.

Table 3 — FZG load stages

Load stage No.	**Pinion torque** N·m	**Normal tooth load** N	**Hertzian stess at pitch point** N/mm²	**Total work transmitted by the test gears up to the end of load stage** kW·h	**Load coupling loaded with:**
1	3,3	99	146	0,19	H_1
2	13,7	407	295	0,97	H_2
3	35,3	1 044	474	2,96	H_2 + K
4	60,8	1 799	621	6,43	$H_2 + K + W_1$
5	94,1	2 786	773	11,8	$H_2 + K + W_1 + W_2$
6	135,5	4 007	929	19,5	$H_2 + K + W_1 + W_2 + W_3$
7	183,4	5 435	1 080	29,9	$H_2 + K + W_1 + W_2 + W_3 + W_4$
8	239,3	7 080	1 223	43,5	$H_2 + K + W_1 + W_2 + W_3 + W_4 + W_5$
9	302,0	8 949	1 386	60,8	$H_2 + K + W_1 + W_2 + W_3 + W_4 + W_5 + W_6$
10	372,6	11 029	1 539	82,0	$H_2 + K + W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7$
11	450,1	13 342	1 691	107,0	$H_2 + K + W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7 + W_8$
12	534,5	15 826	1 841	138,1	$H_2 + K + W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7 + W_8 + W_9$

Weight hangers shall be applied to the 0,5 m radius position.

H_1 = load lever H_1 (light)

H_2 = load lever H_2 (heavy, 0,5 m notch)

K = weight support rod

W_1 to W_9 = weights for weight loading

Table 4 — Test conditions

Duration of each load stage:	21 700 revolutions of the motor (approx. 15 min)
Motor speed:	1 455 r/min ± 3 % [a]
Oil temperature at start of load stage 1:	Ambient
Initial oil temperature at start of load stage 5 and each subsequent load stage:	(90 ± 3) °C (shall be preset on temperature-controller)

[a] The direction of the rotation of the gears is shown in Figure 3.

Annex A
(informative)

Typical FZG test report sheet

Company Name *Company Logo*

ISO 14635-1

Gears — FZG test procedures

Part 1: FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils

TEST REPORT

Lubricant: ....

Origin: ....

FZG Test No.: ....

FZG Test Gear Set No.: ....

TEST RESULT:

Failure Load Stage: ....

Pinion Torque T_1 at Failure Load Stage: ....N·m

Remarks:

....

....

Date: Signature:

Annex B
(informative)

Checklist for maintenance of FZG gear test rig

B.1 How to recognize malfunction

B.1.1 Distribution of scuffing marks

Frequently, an indication of maintenance of the machine being required is given by the distribution of scuffing marks across the face width of every tooth and around the circumference after every gear-oil test.

Uneven distribution of scuffing marks across the face width indicates uneven load distribution and, because of elastic deformations, this is more likely at low load stages than it is at high load stages. Figure B.1 shows the distribution scuffing marks for perfect running operation, as well as for misalignment and tumbling error indicating the malfunction.

B.1.2 Tooth contact pattern

From time to time (e.g. after every twentieth test) or after indication of load maldistribution, the contact pattern should be checked either by using soot or Prussian blue. Under no-load conditions, the tooth contact pattern should be uniformly distributed and should cover 70 % or more of the active flank area.

B.1.3 Tests with reference oil

From time to time (e.g. after every fortieth test), a duplicated scuffing test with a minimum of one of the two reference oils for the test is recommended. Deviations from the typical scuffing load stage of the reference oil, high scattering between the two tests and regular increase or decrease of scuffing load stage as compared to former reference-oil tests can indicate a malfunction.

Organizations such as CEC have defined reference oils for comparison testing.

B.1.4 Other indications

Noise and vibrations, temperatures, bearing play, wear, etc. should be checked.

B.2 Parts that need maintenance

B.2.1 Test-gear box

B.2.1.1 Shafts

Bearings shall have a light shrink fit on the shafts. Bearings shall not slide on or off the shaft at the same (ambient) temperature of bearing and shaft. Indication of a slack fit are circumferential wear or even scoring marks on the shaft and the inner diameter of the bearing when the inner race of the bearing slides on the shaft during operation.

Gears shall have a slight shrink fit on the shafts. They shall not easily slide on or off the shaft at same temperature of gear and shaft. Possible slight fretting corrosion on the shafts is not harmful and can be polished off the shaft using, for example, a chrome polish. Tangible wear marks on the shaft cannot be tolerated.

Hard-chrome shafts tend to show spalling in the vicinity of the keys. Spalling up to approx. 5 mm width all along the key can be tolerated.

A tangible wear groove under the shaft seal leads to leakage even when seals are replaced.

B.2.1.2 Bearings

Bearings shall have an adequate small amount of play. Bearing life is normally not limited by pitting but by excess wear.

Bearings shall have a slight shrink fit on the shaft (see also B.2.1.1) and a sliding fit with small clearance in the bore (see B.2.1.5).

B.2.1.3 Keys

Keys shall not be worn or show any plastic deformation. They should fit into the shaft with a small clearance, tilting of the key in the shaft is not allowed.

B.2.1.4 Spacer rings

The spacers between bearings and gears should be hardened and plane-parallel ground. These faces shall not show fretting or scoring marks, grooves or burrs.

Due to the bearing configuration, hubs or spacers that are too wide can cause a compressive force in the bearings.

Check if shafts of unloaded machine are easily turnable, check inner races of bearings for axial thrust. Check temperature in the oil sump after every load stage of standard test A/8,3/90; normally 90 °C is not exceeded in the first six load stages.

B.2.1.5 Gear box and front cover

The outer race of the bearing in the gear box and front cover shall have a sliding fit with no detectable radial clearance.

The sealing surface (front and top, gear box and cover) shall be flat without burrs or scratches. It is essential not to trap dirt particles during mounting.

All threads in the gear box shall be in good condition.

B.2.1.6 Seals

In case of leakage, check seals and seal race on the shafts (see B.2.1.1). Seals shall not slide on the shaft with the key groove unprotected; otherwise the sealing lip might be destroyed.

B.2.2 Connecting shafts and flanges

B.2.2.1 Load coupling

The two halves of the load coupling shall be easily twistable against each other. If this is not possible, check the centring pin in the shafts, the faces of the load coupling and the T-slot guidance of the bolts. Remove fretting corrosion and lubricate parts if necessary.

Tighten bolts using a torque-indicating wrench set to $T = 100$ Nm. Replace broken bolts immediately. Do not operate the rig with missing bolts.

B.2.2.2 Torque-measuring device

Easy twisting with low friction shall be possible. Check the bearing in the measuring coupling.

Roller bearings shall not show deep rippling marks. Journal bearings shall slide easily, therefore check lubrication.

B.2.2.3 Load coupling support bearing

Control for frictionless motion and proper lubrication. Change is only very seldom necessary.

B.2.2.4 Torsion shaft

Replacement is only necessary when plastic deformation has occurred.

After tooth breakage or any other possible overloading, check the torsion shaft for alignment of key slots.

Check the screws of the tube that is over the torsion shaft for a tight fit.

B.2.2.5 Flanges

All flanges should have a slight shrink fit on their shafts. Minor fretting corrosion is tolerable.

B.2.3 Slave-gear box

For shafts, seals, keys, etc. see B.2.1.

B.2.3.1 Slave gears

Check slave gears for pitting, scuffing or wear. Replace or turn slave gears when pitting or scuffing is visible or when tangible wear marks occur.

B.2.3.2 Lubrication

Check the oil level and fill up to approximately the centre of shafts if necessary.

Use a gear oil of industrial quality with extreme-pressure (EP) ingredients of type CKC or CKD as defined in ISO 6743-6, meeting the requirements specified in ISO 12925-1. ISO viscosity grade 220 is recommended.

API GL 4 quality lubricants of SAE J 306 grade 90 may also be used.

Change the oil depending on operating hours, at least once a year.

B.2.4 Other parts

B.2.4.1 Heating

Check that the heating elements function properly. Check "heater on" and "heater off" functions of the temperature-measuring device.

B.2.4.2 Flexible coupling blocks

Check if the flexible-coupling plastic blocks are in good working order.

B.2.4.3 Motor

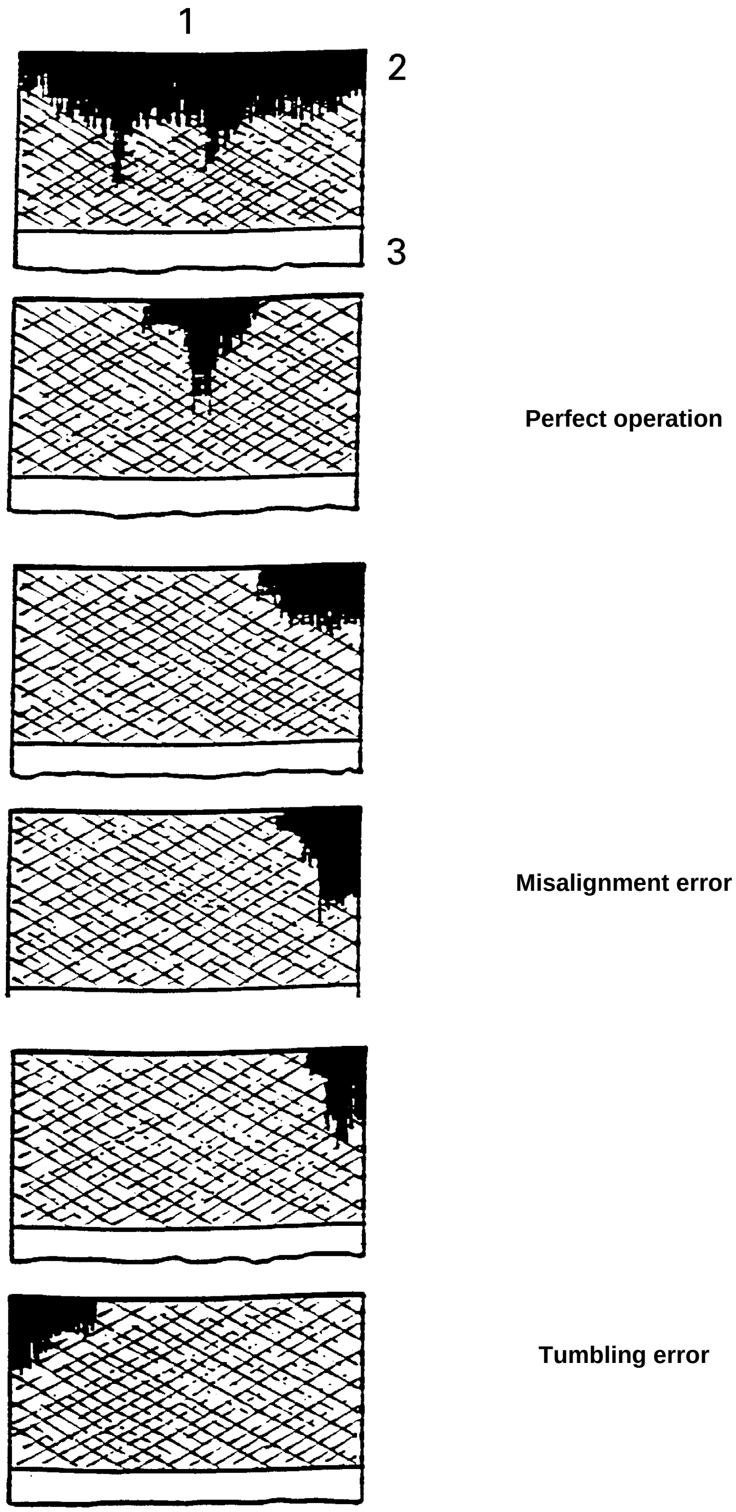
Check any increase in motor noise. Lubricate or replace bearings if necessary.

B.3 Approximate time intervals

Assuming 60 to 80 test runs per year, the following approximate times for change are typical:

Shafts:		2 years
Bearings:	running oil tests:	1 to 2 years
	running grease tests:	2 months
Seals:		Viton / 1 year
Gear box:		5 to 10 years

Deviations from these figures are possible in a fairly wide range, depending on the operating and lubricant conditions.



Key

1 Pinion tooth

2 Tip

3 Root

Figure B.1 — Scuffing marks indicate machine errors

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