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Gears — FZG test procedures —

Part 3: FZG test method A/2,8/50 for relative scuffing load-carrying capacity and wear characteristics of semifluid gear greases

Engrenages — Méthodes d'essai FZG —

Partie 3: Méthode FZG A/2,8/50 pour évaluer la capacité de charge au grippage et les caractéristiques d'usure des graisses d'engrenages semi-fluides

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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14635-3 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 step load test A10/16, 6R/120 for relative scuffing load-carrying capacity of high EP oils*

— *Part 3: FZG test method A/2,8/50 for relative scuffing load-carrying capacity and wear characteristics of semifluid gear greases*

Introduction

The types of gear failure which can be influenced by the lubricant are scuffing, low-speed wear and the gear fatigue phenomena known as micropitting and pitting. In the gear design process, these types of gear damage are taken into consideration by the use of specific lubricant and service-related characteristic values. In order to provide a reasonable estimate of performance in service, adequate lubricant test procedures are required. The FZG test procedures described in ISO 14635-1, ISO 14635-2 and ISO 14635-3 can be regarded as tools for the determination of relative scuffing performance of lubricants. Characteristic values can be introduced into the load-carrying capacity calculation of gears. ISO 14635-1 FZG test method, A/8,3/90 for relative scuffing load-carrying capacity of oils, is useful for the majority of applications in industrial and marine gears. ISO 14635-2, FZG step load test A10/16, 6R/120, is related to the relative scuffing load-carrying capacity of high EP oils as used, e.g. for the lubrication of automotive driveline components such as manual transmissions. ISO 14635-3 FZG test method A/2,8/50 describes a test procedure for the determination of the relative scuffing load-carrying capacity and wear characteristics of semi-fluid greases used for enclosed gear drives. Other FZG test procedures for the determination of low-speed wear, micropitting and pitting load capacity of gears are currently being considered for standardization. They could be added later to ISO 14635 as further parts.

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

When the rig is running, there are long-loaded shafts and highly stressed test gears turning at high speed and precaution must be taken to protect personnel. It is also necessary to provide protection from noise.

Gears — FZG test procedures —

Part 3:
FZG test method A/2,8/50 for relative scuffing load-carrying capacity and wear characteristics of semifluid gear greases

1 Scope

This part of ISO 14635 specifies a test method based on an FZG [1] four-square test machine for determining the relative load-carrying capacity of semi-fluid gear greases defined by the gear surface damage known as scuffing.

This method is useful for evaluating the scuffing load capacity potential of semi-fluid gear greases of NLGI classes 0 to 000, typically used with highly stressed gearing for enclosed gear drives. It can only be applied to greases giving a sufficient lubricant flow in the test gear box of the FZG test machine.

NOTE The test method is technically equivalent to DIN Fachbericht 74.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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*

ISO 14635-1, *Gears — FZG test procedures — Part 1: FZG test method A/8,3/90 for relative scuffing load-carrying capacity of oils*

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

DIN 51818, *Lubricants; consistency classification of lubricating greases; NLGI grades*

1) FZG = Forschungsstelle für Zahnräder und Getriebebau, Technische Universität München (Gear Research Centre, Technical University, Munich).

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
scuffing
particularly severe form of gear tooth surface damage in which seizure or welding together of areas of tooth surface occurs, owing to insufficient or breakdown of lubricant film between the contacting tooth flanks of mating gears, typically caused by a combination of high temperature, high pressure and other factors

NOTE 1 Scuffing is most likely when surface velocities are high. It can 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 2 Care should be taken that scuffing does not occur and is polished away before ending the running time at the higher load stages.

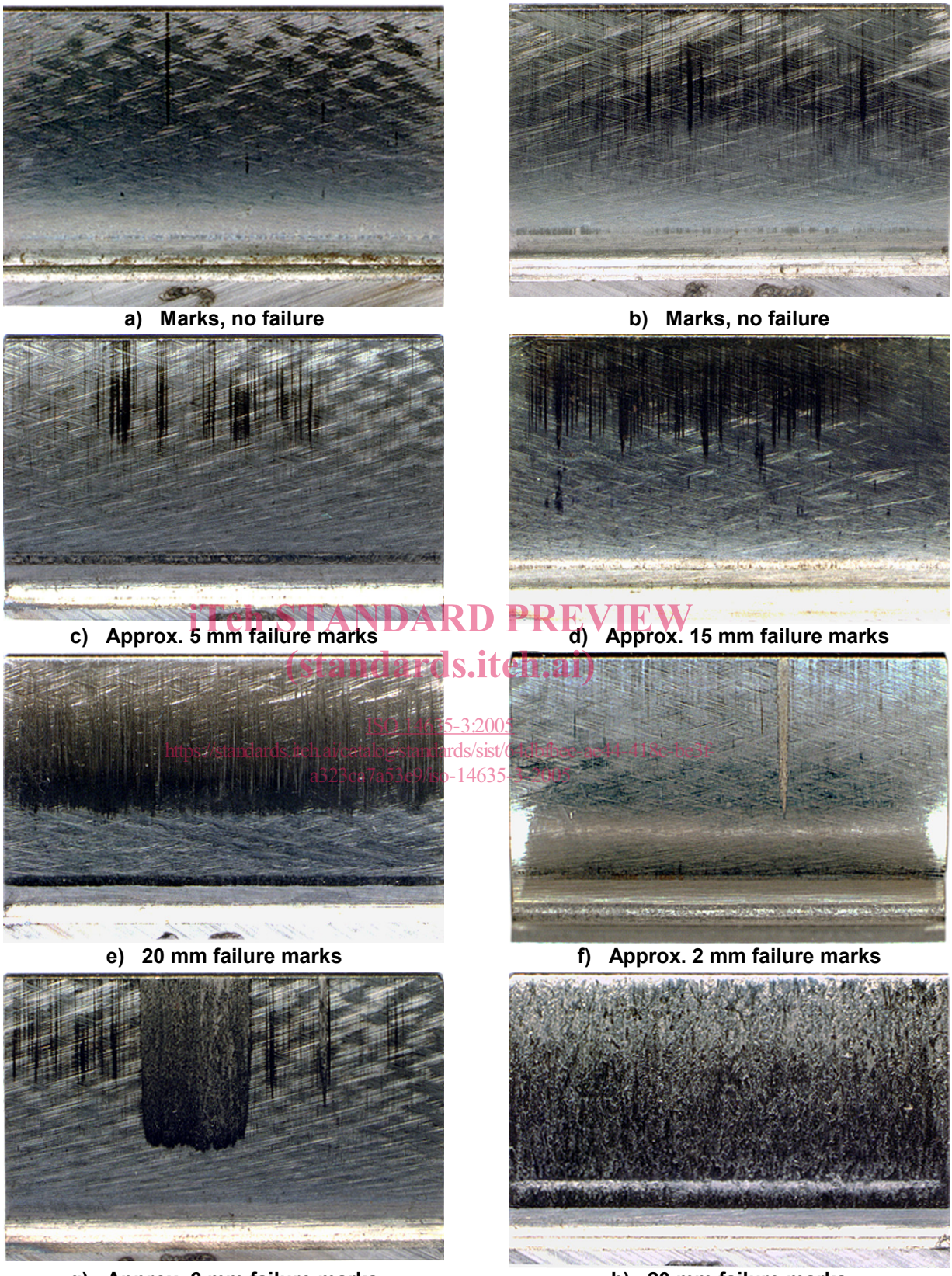
3.2
wear
continuous removal of material occurring when two surfaces roll and slide against one another

3.3
scuffing load-carrying capacity
⟨of a lubricant⟩ maximum load which can be sustained under a defined set of conditions

3.4
FZG test condition A/2,8/50
test condition where A is the particular tooth form of the test gears, according to Table 1, 2.8 is the speed at the pitch circle in metres per second (m/s), and 50 is the initial lubricant temperature in degrees Celsius, from load stage 4 onward in the lubricant sump

3.5
failure load stage
load stage reached when 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 For examples of failure, see Figure 1. Examples of tooth flank changes due to continuous wear are given in Figure 2. Continuous wear is not a failure criteria for the test.



a) Marks, no failure

b) Marks, no failure

c) Approx. 5 mm failure marks

d) Approx. 15 mm failure marks

e) 20 mm failure marks

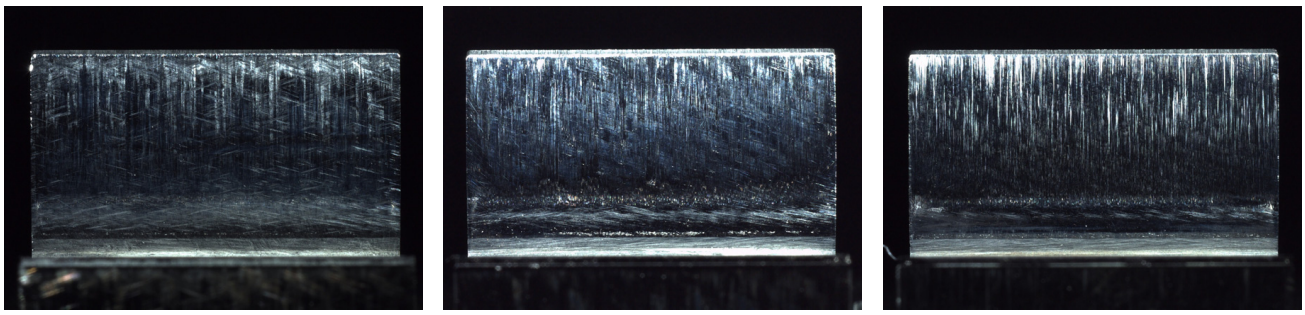
f) Approx. 2 mm failure marks

g) Approx. 6 mm failure marks

h) 20 mm failure marks

NOTE This figure describes the typical pinion tooth flank changes occurring in FZG scuffing type tests. Changes in the original surface condition (criss-cross grinding) can be described by their physical appearance. One and the same type of flank damage can 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.

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



a) Light wear b) Medium wear c) Severe wear

Figure 2 — FZG A-type gear tooth flank changes due to continuous wear

4 Brief description of method

4.1 General

A set of test gears as defined in Clause 5, Tables 1 and 2, weighed to the nearest 0,001 g before the test, is run with the test lubricant at constant speed for a fixed number of revolutions in dip lubrication mode. Loading of the gear teeth is increased in the steps outlined in Table 3. Beginning with load stage 5, the initial lubricant temperature is controlled between (50 ± 3) °C. During the test run of each load stage, the lubricant temperature is allowed to rise freely. After load stage 4, the weight loss of the gear set is determined to the nearest 0,001 g and the pinion tooth flanks are inspected for surface damage. For each subsequent load stage 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. If load stage 12 is reached without meeting the failure criteria, the gear set weight loss is determined to the nearest 0,001 g.

4.2 Precision

Values of repeatability, r, and reproducibility, R, as defined in ISO 5725-2, are not valid for this test procedure. However, experience suggests that similar methods (see ISO 14635-1) are expected to be representative. Values for ISO 14635-1 are indicated below.

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 Table 1 and Table 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 spirits conforming to ASTM D 235 shall be used.

Table 1 — Details of FZG test gears type A

Dimension		Symbol	Numerical value	Unit
Shaft centre distance		a	91,5	mm
Effective face 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 line velocity		v_w	2,8	m/s
Addendum engagement	pinion	e_{a1}	14,7	mm
	wheel	e_{a2}	3,3	mm
Sliding speed at tooth tip	pinion	v_{ga1}	1,85	m/s
	wheel	v_{ga2}	0,42	m/s
Specific sliding at tooth tip	pinion	ξ_{E1}	1,86	
	wheel	ξ_{A2}	0,34	
Specific sliding at tooth root	pinion	ξ_{A1}	–0,52	
	wheel	ξ_{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).