INTERNATIONAL STANDARD

ISO 14635-1

First edition
2000-06-01

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)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

Contents

Page

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

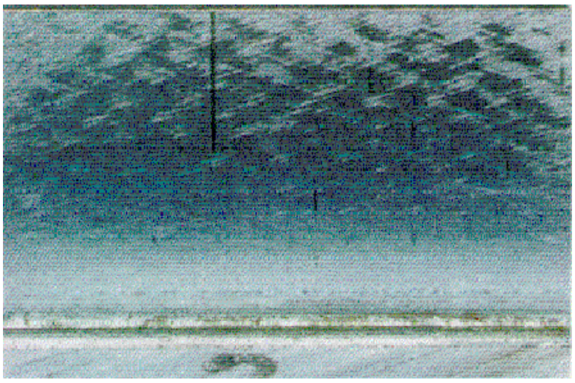
A set of test gears as defined in clause 5, Tables 1 and 2, is run with the test lubricant at constant speed for a fixed number of revolutions using dip-lubrication mode. Loading of the gear teeth is increased in steps outlined in Table 3. Beginning with load stage 5, the initial oil temperature is controlled 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.

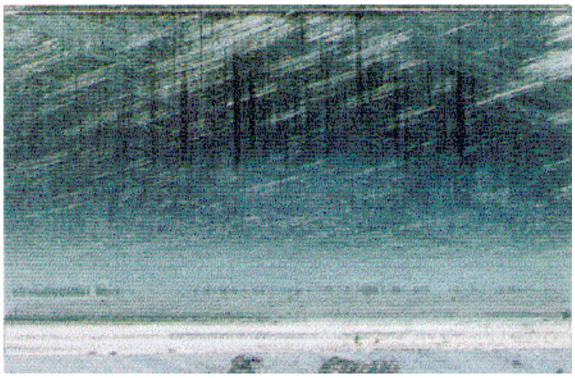
NOTE It has been assumed by the compilers of this test method that anyone using the method will either be fully trained and familiar with all normal engineering and laboratory practice, or will be under the direct supervision of such a person.

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.

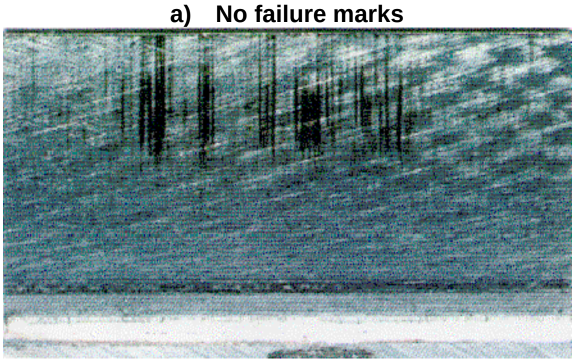
Protection from noise is also highly recommended.



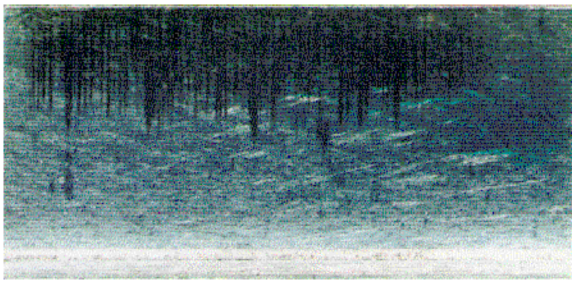
a) No failure marks



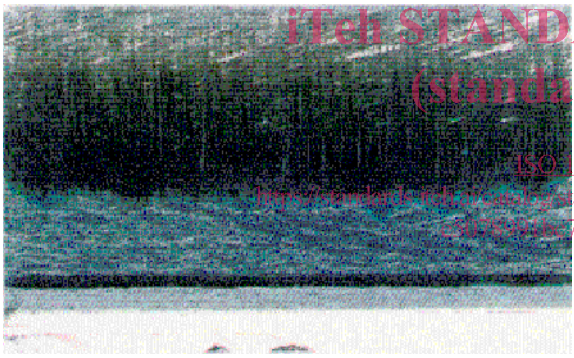
b) No failure marks



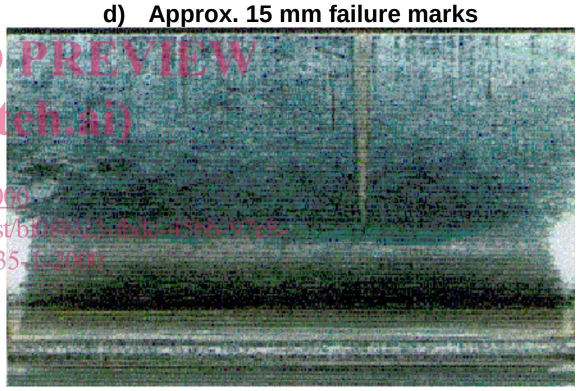
c) Approx. 5 mm failure marks



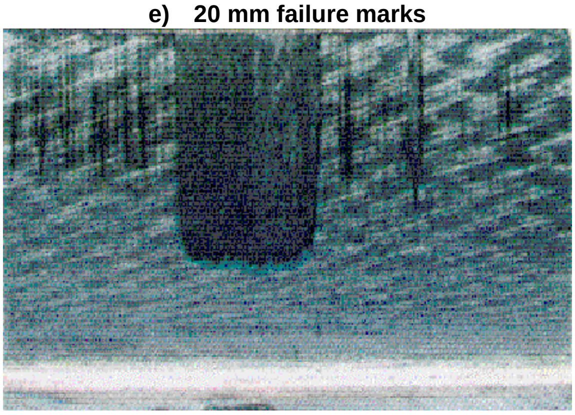
d) Approx. 15 mm failure marks



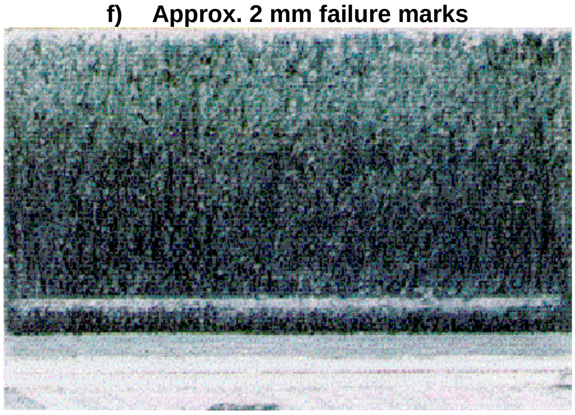
e) 20 mm failure marks



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).