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Lubricants — Determination of tribological quantities for oils and greases — Tribological test in the translatory oscillation apparatus

Lubrifiants — Détermination de quantités tribologiques d'huiles et de graisses — Essais tribologiques dans l'appareil translation-oscillation

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 28, *Petroleum and related products from synthetic or biological origin*.

Introduction

Liquid lubricants (oils) and consistent lubricants (greases) reduce friction and wear and/or prevent adhesive wear (scuffing, galling). In order to establish the tribological profile of a lubricant adequate tribometric, test methods are required. The test method described in this document can be regarded as an evaluation tool for the determination of the lubricant-related contribution to friction, wear, load carrying capacity and extreme pressure behaviour.

This test method is dedicated to a translatory oscillation apparatus which is fully computer controlled.

This test method harmonizes the following national test methods using the ball-on-disk contact geometry:

a) DIN 51834-2[1] (oil, coefficient of friction and wear);

b) ASTM D6425[2] (oil, coefficient of friction and wear);

ASTM D7421[4] (oil, pass load/O.K. load);

ASTM D5706[6] (grease, pass load/O.K. load);

ASTM D5707[8] (grease, coefficient of friction and wear);

c) SH/T 0721[9] (grease, coefficient of friction and wear);

SH/T 0784[7] (grease, pass load/O.K. load);

NB SH/T 0847[3] (oil, coefficient of friction and wear);

NB/SH/T 0882[5] (oil, pass load/O.K. load).

The harmonization is also related to the use of only one type of cleaning solvent.

Users of this test method should determine whether the results obtained from this method correlate with field performance or other applications.

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

Lubricants — Determination of tribological quantities for oils and greases — Tribological test in the translatory oscillation apparatus

1 Scope

This document describes test methods based on a high-frequency, linear-oscillation test machine to determine tribological quantities like friction, wear, load carrying capacity and extreme pressure behaviour of liquid lubricants (oils) and consistent lubricants (greases) in the ball-on-disk contact geometry.

NOTE This method is technically equivalent to DIN 51834–2/ASTM D6425[1] (NB/SH/T 0847[3]) and ASTM D7421[4] (NB/SH/T 0882[5]) for oils, as well as ASTM D5706[6] (SH/T 0784[7]) and ASTM D5707[8] (SH/T 0721[9]) for greases.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 683-17, *Heat-treated steels, alloy steels and free-cutting steels — Part 17: Ball and roller bearing steels*

IEC 584-1, *Thermocouples — Part 1: Reference tables*

IEC 584-2, *Thermocouples — Part 2: Tolerances*

IEC 751, *Industrial platinum resistance thermometer and platinum temperature sensors*

ASTM D7755, *Standard Practice for Determining the Wear Volume on Standard Test Pieces Used by High-Frequency, Linear-Oscillation (SRV) Test Machine*

DIN 51631:1999-04, *Mineral spirits — Special boiling point spirits — Requirements*

DIN 51834-3, *Testing of lubricants — Tribological test in the translatory oscillation apparatus — Part 3: Determination of tribological behaviour of materials in cooperation with lubricants*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp/

3.1
wear volume
W_V
irreversible loss of volume to the ball or the disk (flat) at the end of test

Note 1 to entry: The determination of the wear volumes of ball and disk are described in DIN 51834–3 or ASTM D7755 or an equivalent National Standard.

3.2
adhesive failure
particularly severe form of damage to the surface in which *seizure* (3.3) or welding together of surface areas occur

Note 1 to entry: Synonyms frequently used are “galling” (US) or “scoring” (UK). It has different meanings and macroscopic morphologies (see Annex A).

Note 2 to entry: The surface damages are usually material transfer, roughening and plastic flow, or all, as well as localized fusion of metal.

3.3
seizure
localized fusion of metal between the rubbing surfaces of the test pieces

Note 1 to entry: Seizure is usually indicated by a sharp increase in coefficient of friction, over steady-state, of delta >0,2 for over 20 s, or by unusual noise and vibration.

Note 2 to entry: In severe cases, a stoppage in the motor will occur.

Note 3 to entry: Under unlubricated oscillation, ball bearing steel 100Cr6 has coefficients of friction above 0,4.

3.4
pass load
O.K. load
last load during the extreme pressure test where no *adhesive failure* (3.2) or adhesive mechanisms were observed

3.5
load carrying capacity
geometric contact pressure at the end of the test

Note 1 to entry: The load carrying capacity of the tribocouple can be additionally calculated according to the following formula:

$$P_{\text{geom}} = \frac{4 \cdot F_{\text{n}}}{\pi \cdot WSD^2}$$

where

F_{n} is the normal force (synonym: test load);

P_{geom} is the geometric contact pressure;

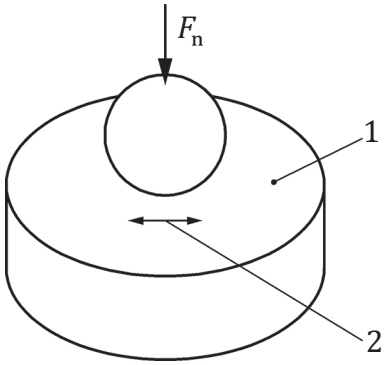
WSD is the mean wear scar diameter of ball.

4 Principle

This test method is performed on a translatory oscillation apparatus using a test ball made in bearing steel mating the top of a flat stationary disk made in bearing oscillating each other, which can be operated under different sets of test parameters (test frequency, stroke length, temperature, load and test time). The general contact situation is shown in Figure 1.

NOTE It has been assumed by the compilers of this test method that anyone using the method will be familiar with the operation manual of the test machine, as well as either be fully trained and familiar with all usual engineering and laboratory practices, or will be under the direct supervision of such a person.

IMPORTANT — Protection against machine noise during testing is recommended.



Key

1 finished test surface

2 Δx, *v*

Figure 1 — Contact situation of the tribosystem

The basic principle of the test system is the exact measurement of the coefficient of friction of a material couple with or without a lubricating interfacial medium. This is done by:

a) pressing the counter upper test specimen onto the base lower test specimen with a defined normal force, F_n;

b) oscillating sliding of the upper specimen on the lower specimen;

c) vibration-compensated measuring of the lateral friction force, F_f, acting on the lower specimen and resulting from the movement of the upper specimen. The coefficient of friction, *f*, is generated from peak-to-peak measurements of each period and calculated according to Formula (1):

$$f = F_f / F_n \quad (1)$$

5 Reagents

5.1 Cleaning solvent, non-chlorinated and non-film forming cleaning fluids of the type of hydrocarbon-based solvents according to DIN 51631:1999, type 2.

NOTE 1 Type 2 in DIN 51631:1999 is termed “special-boiling-point spirits” with distillation characteristics of initial 80 °C and final 110 °C and contains less than 5 % by weight of *n*-hexane and less than 0,2 % by weight of aromatics. The CAS number 64742-49-0[1)] comply with this type of cleaning solvent.

NOTE 2 The synonyms are: naphtha (petroleum), hydrotreated light; Siedegrenzenbenzin (German); petroleum ether or mineral spirits.

1) Seven CAS registration numbers cover this m*ulti-constituent subcategory* composed of predominantly C7 to C9 paraffins with varying compositions of normal paraffins, isoparaffins, and/or cycloparaffins. CAS = Chemical Abstracts Service, http://www.cas.org/.

WARNING — The user of special-boiling-point spirits has to consider the following risk and safety phrases:

— R45: May cause cancer;

— R46: May cause heritable genetic damage;

— R65: Harmful: may cause lung damage, if swallowed;

— S53: Avoid exposure - obtain special instructions before use;

— T: Toxic. The specific toxicity profile for CAS number 678472-49-0 can be downloaded from the OECD website.

6 Apparatus

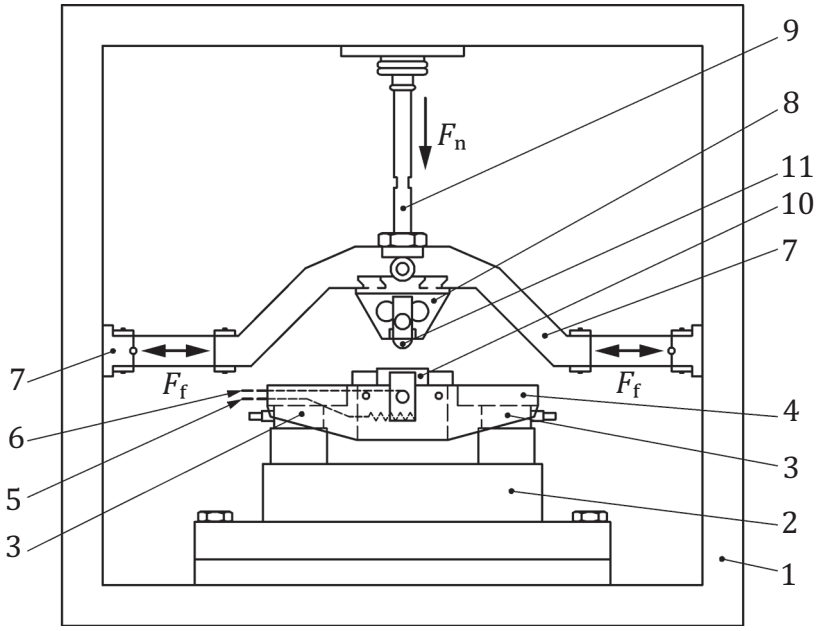
6.1 Translatory oscillation apparatus.

The tribological test system is shown in Figure 2 and includes a test chamber in which an upper and a lower specimen are installed in their respective holders. An electromagnetic linear drive with integrated stroke sensor generates the oscillating movement performed by the upper specimen on the lower specimen. The normal force, F_n, is applied to the specimen pairing by a servomotor and a load rod. To carry out tests below ambient temperature, the block can be provided with an integrated cooling coil. Environmental conditions, like relative humidity, may be measured optionally.

The holder of the lower specimen is equipped with a thermostatically monitored electric resistance heater and a resistance thermometer conforming to IEC 751 for temperatures up to 350 °C or an electric temperature sensor conforming to IEC 584-1 and IEC 584-2 for temperatures up to 1 000 °C.

Operation of the test system is monitored by several electronic control units (for drive, load, temperature, frequency, stroke) and a specific software.

The friction force, F_f, is measured continuously by a piezo-electric device contained in the test block and recorded throughout the test. Wear can be measured during the test by means of a sensor as total linear wear length of the tribosystem. After the test, wear quantities can be determined by an external measuring device (see 9.5).



Key

1	test chamber	9	drive rods of the load unit
2	receiving block	10	disk
3	piezo force measurement elements	11	test ball
4	lower specimen holder	F_n	normal force (test load)
5	electrical resistance heating	F_f	friction force
6	resistance thermometer		
7	oscillation drive rods		
8	upper specimen holder		

Figure 2 — Scheme of a translatory oscillation apparatus

NOTE A suitable apparatus is the SRV®[2)] test machine.

6.2 Torque wrench, adjustable between 0,01 Nm and 5 Nm.

6.3 Measuring microscope, or similar length measuring device, with a scale range of 2 mm or above, and scale intervals of 0,005 mm or less and sufficient magnification to allow for ease of measurement.

7 Test pieces

7.1 General

The tribosystem consists of a ball mated to the top side of the surface of a flat disk (see Figure 1). At the start of the test, a point contact is formed. The contact zone is wetted by the lubricant.

2) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results. SRV is an abbreviation from the German attributes „Schwingung, Reibung, Verschleiß“ and translates into English as “oscillating, friction, wear” or into French « oscillation, frottement, usure ».