INTERNATIONAL STANDARD

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Fourth edition
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Diesel fuel — Assessment of lubricity using the high-frequency reciprocating rig (HFRR) —

Part 1: Test method

Carburant diesel — Évaluation du pouvoir lubrifiant au banc alternatif à haute fréquence (HFRR) —
Partie 1: Méthode d'essai

Reference number
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, 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

This document was prepared by ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain, and powertrain fluids*, in collaboration with Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This fourth edition of ISO 12156-1 cancels and replaces the third edition (ISO 12156-1:2016), which has been technically revised after a user feedback survey. This revision includes the following changes:

— lessening of the requirements on reagents and correction of the ambient test conditions (Figure 2) to reflect the actual conditions met by participants in the inter-laboratory test program;

— the Annex containing details of the major changes (adding the camera and deletion of the humidity correction factor) between the second and third edition of this document has been removed; and

— Annex A has been populated with updated photographs of typical wear scars.

A list of all parts in the ISO 12156 series can be found on the ISO website.

Introduction

All diesel fuel injection equipment has some reliance on diesel fuel as a lubricant. Wear due to excessive friction resulting in shortened life of engine components, such as diesel fuel injection pumps and injectors, has sometimes been ascribed to lack of lubricity in the fuel.

The relationship of test results to diesel injection equipment component distress due to wear has been demonstrated for some fuel/hardware combinations where boundary lubrication is a factor in the operation of the component[1)].

Test results from fuels tested to this procedure have been found to correlate with many fuel/hardware combinations and provide an adequate prediction of the lubricating quality of the fuel. The correlation of biodiesel blends has been validated through 15 years of field experience and anecdotal data.

This document includes content and data, with permission of ASTM International, from ASTM Research Report RR:D02-1718[3] that is cited in ASTM D6079[1] and ASTM D7688[2].

1) NIKANJAM. Manuch, Teri CROSBY, Paul HENDERSON, Chris GRAY, Klaus MEYER, and Nick DAVENPORT, "ISO Diesel Fuel Round Robin Program," SAE Technical Paper No. 952372, 1995, ISSN 0148- 7191, doi: 10.4271/952372

Diesel fuel — Assessment of lubricity using the high-frequency reciprocating rig (HFRR) —

Part 1: Test method

WARNING — Application of this document may involve the use of hazardous materials, operations, and equipment. This document does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices, and to determine the applicability of any other restrictions for this purpose.

1 Scope

This document specifies a test method using the high-frequency reciprocating rig (HFRR), for assessing the lubricating property of diesel fuels, including those fuels which could contain a lubricity-enhancing additive. It defines two methods for measurement of the wear scar; Method "A" — Digital camera, and Method "B" — Visual observation.

This test method applies to fuels used in diesel engines.

NOTE It is not known if this test method will predict the performance of all additive/fuel combinations, including paraffinic fuels for which no additional correlation testing has been performed. Nevertheless, no data has been presented to suggest that such fuels are not within scope.

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*

ISO 3170, *Petroleum liquids — Manual sampling*

ISO 3171, *Petroleum liquids — Automatic pipeline sampling*

ISO 3290-1, *Rolling bearings — Balls — Part 1: Steel balls*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 5272, *Toluene for industrial use — Specifications*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ASTM D4306, *Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination*

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 https://www.iso.org/obp

3.1
boundary lubrication
condition in which the friction and wear between two surfaces in relative motion are determined by the properties of the surfaces and the properties of the contacting fluid, other than bulk viscosity

Note 1 to entry: Metal to metal contact occurs and the chemistry of the system is involved. Physically adsorbed or chemically reacted soft films (usually very thin) support contact loads. As a result, some wear is inevitable.

3.2
lubricity
qualitative term describing the ability of a fluid to affect friction between, and wear to, surfaces in relative motion under load

Note 1 to entry: In this test method, the lubricity of a fluid is evaluated by the wear scar, measured in micrometres, produced on an oscillating ball from contact with a stationary disk immersed in the fluid operating under closely controlled conditions.

3.3
wear scar diameter
WSD
mean diameter of the wear scar produced on the test ball

4 Principle

A sample of the fluid under test is placed in a test reservoir which is maintained at the specified test temperature. A fixed steel ball is held in a vertically mounted chuck and forced against a horizontally mounted stationary steel plate with an applied load. The test ball is oscillated at a fixed frequency and stroke length while the interface with the plate is fully immersed in the fluid. The metallurgies of the ball and plate, test fluid temperature, load, frequency, stroke length, and the ambient air conditions of temperature and humidity during the test are specified. The wear scar generated on the test ball is taken as a measure of the fluid lubricity.

5 Reagents and materials

5.1 Compressed air, if required for drying the equipment (8.1.1 and 8.1.2), supplied at a pressure of 140 kPa to 210 kPa and containing less than 0,1 ml/m^3 hydrocarbons and less than 50 ml/m^3 water.

WARNING — Use with extreme caution in the presence of combustible material.

5.2 Acetone, analytical reagent grade.

WARNING — Extremely flammable. Vapours may cause flash fire.

5.3 Reference fluids[2].

WARNING — Flammable.

2) Reference fluids A and B are available from ASTM Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15026-4489 USA. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the products named. Equivalent products may be used if they can be shown to lead to the same results.

Two reference fluids, Fluid "A" – High (Good) lubricity reference and Fluid "B" – Low (Poor) lubricity reference, shall be used for verifying the performance of the test apparatus. They shall be clearly marked with the HFRR value (WSD) and its expanded uncertainty, expressed in micrometres. Store reference fluids in clean, borosilicate glass with an aluminium foil-lined insert cap or fully epoxy-lined metal container. Store in a dark location.

5.4 Gloves, appropriate for the reagents used.

5.5 Heptane, reagent grade.

WARNING — Extremely flammable. Vapours may cause flash fire.

5.6 Isooctane, reagent grade.

WARNING — Extremely flammable. Vapours may cause flash fire.

5.7 2-propanol, reagent grade.

WARNING — Extremely flammable. Vapours may cause flash fire.

5.8 Wiper, wiping tissue, light-duty, lint-free, hydrocarbon-free, disposable.

5.9 Toluene, in accordance with ISO 5272.

WARNING — Extremely flammable. Vapours may cause flash fire. May be fatal if swallowed and enters airways. May cause drowsiness or dizziness. Suspected of damaging the unborn child. May cause damage to organs through prolonged or repeated exposure.

6 Apparatus

6.1 Test apparatus[3], (see Figure 1), capable of engaging a steel ball loaded against a stationary steel plate with an applied load and oscillating at a fixed frequency and stroke length while the contact interface is fully immersed in a fluid according to the test conditions given in Table 1.

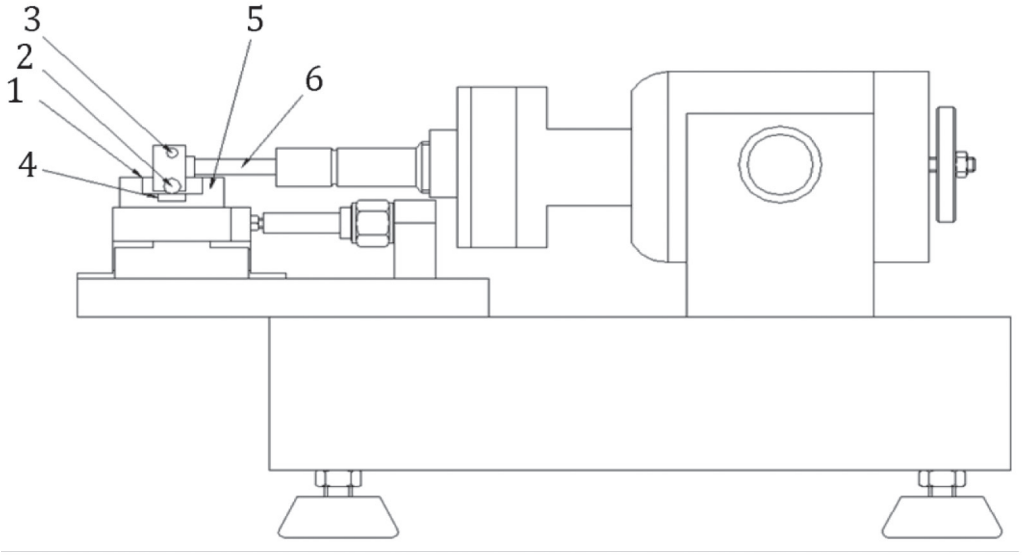
Table 1 — Test conditions

Parameter	Value
Fluid volume, ml	2 ± 0,2
Stroke length, mm	1 ± 0,02
Frequency, Hz	50 ± 1
Laboratory air[a]	See Figure 2
Fluid temperature, °C	60 ± 2
Test mass[b], g	200 ± 1
Test duration, min	75 ± 0,1
Reservoir surface area, mm^2	600 ± 100

[a] Laboratory air conditions as measured between 0,1 m and 0,25 m of the fluid reservoir shall be controlled to the acceptable range of conditions as shown in Figure 2.

[b] Total mass including fixing elements.

3) HFRR units of PCS Instruments, 78 Stanley Gardens, London W3 7SZ, U.K., have been found satisfactory. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products. Equivalent products may be used if they can be shown to lead to the same results.



Key

1	fluid reservoir	4	test plate
2	test ball	5	heating bath
3	test mass	6	oscillating motion

Figure 1 — Schematic of the high-frequency reciprocating rig

The fluid reservoir shall be capable of holding a test plate in a rigid manner and shall also contain the test fluid. The temperature of this reservoir, and consequently the test fluid contained in it, should be achieved by means of an electrically controlled heater pad to which the fluid reservoir is closely attached.

The apparatus control unit for controlling variable parameters shall include provision for electronic data storage and retrieval, and for electronic calibration of the stroke length.

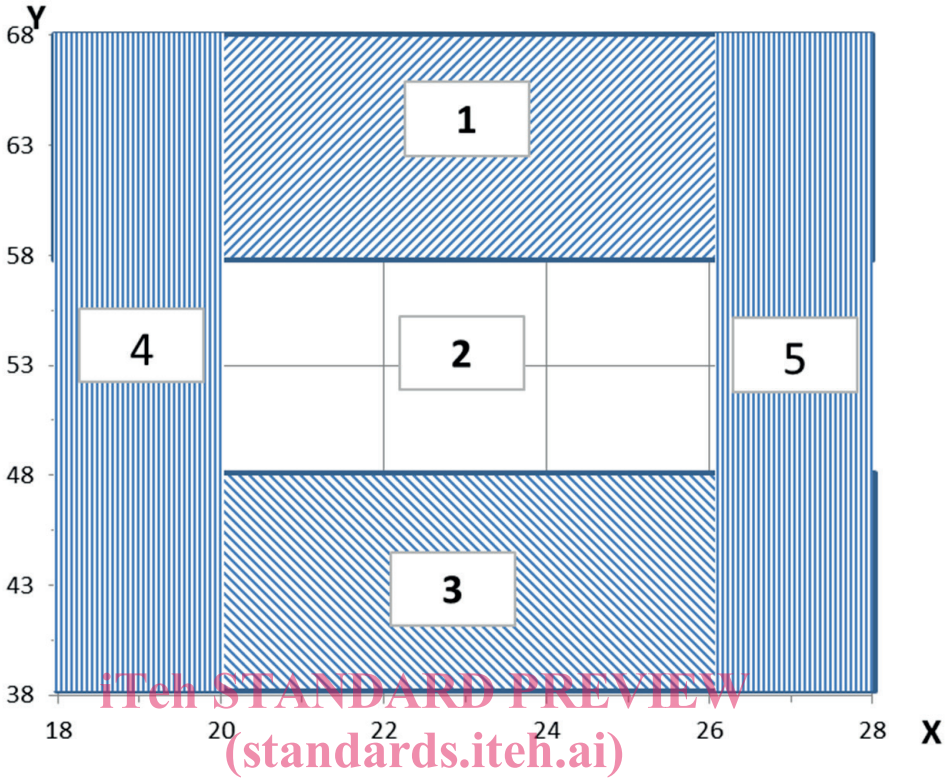
6.2 Test plate[4], steel ISO 683-17-100Cr6 machined from annealed rod, having a Vickers hardness "HV 30" scale number of 190 to 210 (according to ISO 6507-1). It shall be lapped and polished to a surface finish of Ra < 0,02 µm, measured according to ISO 4288.

6.3 Test ball[4], 6,00 mm diameter, grade 28 (G28) according to ISO 3290-1 of steel ISO 683-17-100Cr6. It shall have a Rockwell hardness "C" scale (HRC) number of 58 to 66 (according to ISO 6508-1).

6.4 Microscope with digital camera (Method "A")[4], capable of 100× magnification, installed and calibrated according to manufacturer instructions, capable of capturing a crisp image of the wear scar. Camera system resolution should be a minimum of 2 048 × 1 536 pixels. The measurement system should allow horizontal and vertical measurement devices or cursors to be positioned at the wear scar boundaries with an accuracy of 1 µm.

4) Suitable test specimens and microscopes (with and without camera) are available from PCS Instruments, 78 Stanley Gardens, London W3 7SZ, U.K. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

6.5 Microscope[4] **(Method "B")**, metallurgical type, suitable for measuring the wear scar on the test ball to the nearest 1 µm.



Key

1 unacceptable range of conditions — too moist
2 acceptable range of conditions
3 unacceptable range of conditions — too dry
4 unacceptable range of conditions — too cold
5 unacceptable range of conditions — too warm
X air temperature, °C
Y relative humidity, %

Figure 2 — Laboratory air conditions

6.6 Desiccator, containing a drying agent, capable of storing test plates, balls, and hardware.

6.7 Cleaning bath, ultrasonic type, with a seamless stainless steel tank of adequate capacity and a cleaning power of 40 W or greater.

6.8 Time-measuring device, mechanical or electronic, capable of measuring (75 ± 0,1) min.

7 Sampling

7.1 Unless otherwise specified, samples shall be taken according to ISO 3170 or ISO 3171.

7.2 Because of the sensitivity of lubricity measurements to trace materials, sample containers shall be only fully epoxy-lined metal or amber borosilicate glass with an aluminium foil-lined insert cap, cleaned and rinsed thoroughly at least three times with the product to be sampled before use, as specified under "Containers for Lubricity Testing" in ASTM D4306.

7.3 New sample containers are preferred, but if not available, the "Containers for Lubricity Testing" section of ASTM D4306 gives guidance on suitable cleaning procedures for each type of container.