Designation: G181 – 21

Standard Test Method for Conducting Friction Tests of Piston Ring and Cylinder Liner Materials Under Lubricated Conditions[1]

This standard is issued under the fixed designation G181; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers procedures for conducting laboratory bench-scale friction tests of materials, coatings, and surface treatments intended for use in piston rings and cylinder liners in diesel or spark-ignition engines. The goal of this procedure is to provide a means for preliminary, cost-effective screening or evaluation of candidate ring and liner materials. A reciprocating sliding arrangement is used to simulate the contact that occurs between a piston ring and its mating liner near the top-dead-center position in the cylinder where liquid lubrication is least effective, and most wear is known to occur. Special attention is paid to specimen alignment, running-in, and lubricant condition.

1.2 This test method does not purport to simulate all aspects of a fired engine's operating environment, but is intended to serve as a means for preliminary screening for assessing the frictional characteristics of candidate piston ring and liner material combinations in the presence of fluids that behave as use-conditioned engine oils. Therefore, it is beyond the scope of this test method to describe how one might establish correlations between the described test results and the frictional characteristics of rings and cylinder bore materials for specific engine designs or operating conditions.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D6838 Test Method for Cummins M11 High Soot Test (Withdrawn 2019)[3]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G40 Terminology Relating to Wear and Erosion

3. Terminology

3.1 For definitions, see Terminology G40.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *conditioned oil*—a lubricating oil whose viscosity, composition, and other function-related characteristics have been altered by use in an operating engine, such that the oil's effects on friction and wear reflect those characteristic of the long-term, steady-state engine operation.

3.2.2 *conformal contact*—in friction and wear testing, any macro-geometric specimen configuration in which the curvature of one contact surface matches that of the countersurface.

3.2.2.1 *Discussion*—Examples of conformal contact include a flat surface sliding on a flat surface and a ball rotating in a socket that conforms to the shape of the ball. A pair of surfaces may begin a wear or friction test in a non-conformal contact configuration, but develop a conformal contact as a result of wear.

3.2.3 *lubrication regime*—in liquid-lubricated sliding contact, a certain range of friction coefficients that results from a combination of contact geometry, lubricant viscosity characteristics, surface roughness, normal pressure, and the relative speed of the bearing surfaces.

[1] This test method is under the jurisdiction of ASTM Committee G02 on Wear and Erosion and is the direct responsibility of Subcommittee G02.50 on Friction.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

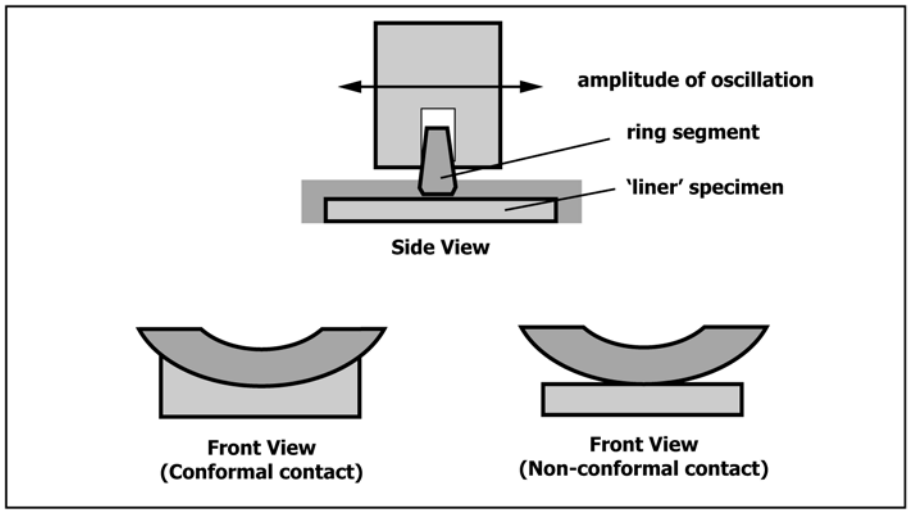

FIG. 1 Schematic Drawing of the Test Configuration Showing Conformal and Non-conformal Contact

3.2.3.1 *Discussion*—Common designations for lubrication regimes are boundary lubrication, mixed film lubrication, elasto-hydrodynamic lubrication and hydrodynamic lubrication.

4. Summary of Test Method

4.1 A reciprocating friction test apparatus is used to simulate the back-and-forth motion of a piston ring within a cylinder bore in the presence of a heated lubricant. Other types of motions, like ring rotation, ring-groove fretting motion, and ring rocking, are not simulated with this procedure. The contact geometry, selection of testing parameters, and the methods of specimen surface finishing and characterization are described. The lubricating fluid is selected to simulate the effects of used oil. A running-in procedure is used to increase the repeatability of results.

5. Significance and Use

5.1 The efficiency and fuel economy of spark ignition and diesel engines is affected in part by the friction between moving parts. Although no reliable, in situ friction measurements exist for fired internal combustion engines, it has been estimated that at least half of the friction losses in such engines are due to those at the ring and liner interface. This test method involves the use of a reciprocating sliding arrangement to simulate the type of oscillating contact that occurs between a piston ring and its mating cylinder bore surface near the top-dead-center position in the cylinder where most severe surface contact conditions occur. There are many types of engines and engine operating environments; therefore, to allow the user the flexibility to tailor this test to conditions representative of various engines, this standard test method allows flexibility in selecting test loads, speeds, lubricants, and durations of testing. Variables that can be adjusted in this procedure include: normal force, speed of oscillation, stroke length, duration of testing, temperature of testing, method of specimen surface preparation, and the materials and lubricants to be evaluated. Guidance is provided here on the set-up of the test, the manner of specimen fixturing and alignment, the selection of a lubricant to simulate conditioned oil characteristics (for a diesel engine), and the means to run-in the ring specimens to minimize variability in test results.

5.2 Engine oil spends the majority of its operating lifetime in a state that is representative of use-conditioned oil. That is, fresh oil is changed by exposure to the heat, chemical environment, and confinement in lubricated contact. It ages, changing viscosity, atomic weight, solids content, acidity, and chemistry. Conducting piston ring and cylinder liner material evaluations in fresh, non-conditioned oil is therefore unrealistic for material screening. But additive-depleted, used oil can result in high wear and corrosive attack of engine parts. The current test is intended for use with lubricants that simulate tribological behavior after in-service oil conditioning, but preceding the point of severe engine damage.

6. Reagents

6.1 *Cleaning Solvents*—Suitable solvents may be used to degrease and clean specimens prior to conducting the described procedure. No specific solvents are recommended here, except that they should not chemically attack the test surfaces, nor leave a residual film or stain after cleaning.

6.2 *Lubricants*—Lubricants shall be handled appropriately with awareness of, and precautions taken against, any hazards indicated in the Material Safety Data Sheets for those lubricants. A description of engine-conditioned oil is given in Appendix X2.

7. Apparatus and Specimen Preparation

7.1 *Description of the Test Apparatus*—A schematic representation of the reciprocating contact geometry is shown in Fig. 1. Two versions of this test are shown. In the first case (Fig. 1, bottom left), the lower specimen conforms to the shape of the ring segment. In the second case (Fig. 1, bottom right), the ring segment slides on a flat lower specimen. Specimens are placed in a heated, temperature-controlled bath of lubricant. Alternate means of supplying the lubricant, such as drip feed, may be used.