



# Standard Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus at 30 and 90 Cycles<sup>1</sup>

This standard is issued under the fixed designation D7109; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This test method covers the evaluation of the shear stability of polymer-containing fluids. The test method measures the viscosity loss, in  $\text{mm}^2/\text{s}$  and percent, at  $100^\circ\text{C}$  of polymer-containing fluids when evaluated by a diesel injector apparatus procedure that uses European diesel injector test equipment. The viscosity loss reflects polymer degradation due to shear at the nozzle. Viscosity loss is evaluated after both 30 and 90 cycles of shearing.

NOTE 1—This test method evaluates the shear stability of oils after both 30 and 90 cycles of shearing. For most oils, there is a correlation between results after 30 cycles and results after 90 cycles of shearing, but this is not universal.

NOTE 2—Test Method D6278 uses essentially the same procedure with 30 cycles only instead of both 30 and 90 cycles. The correlation between results from this test method at 30 cycles and results from Test Method D6278 has not been established.

NOTE 3—Test Method D2603 has been used for similar evaluation of shear stability; limitations are as indicated in the significance statement. No detailed attempt has been undertaken to correlate the results of this test method with those of the sonic shear test method.

NOTE 4—This test method uses test apparatus as defined in CEC L-14-A-93. This test method differs from CEC-L-14-A-93 in the period of time required for calibration.

NOTE 5—Test Method D5275 also shears oils in a diesel injector apparatus but may give different results.

NOTE 6—This test method has different calibration and operational requirements than withdrawn Test Method D3945.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific warning statements are given in Section 8.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.07 on Flow Properties.

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## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D2603 Test Method for Sonic Shear Stability of Polymer-Containing Oils

D5275 Test Method for Fuel Injector Shear Stability Test (FISST) for Polymer Containing Fluids

D6278 Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus

D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance

2.2 Coordinated European Council (CEC) Standard:  
CEC L-14-A-93 Evaluation of the Mechanical Shear Stability of Lubricating Oils Containing Polymers<sup>3</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *kinematic viscosity, n*—a measure of the resistance to flow of a fluid under gravity.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *calibration pressure, n*—the recorded gauge pressure when calibration fluid RL233 undergoes a viscosity loss of 2.7 to 2.9  $\text{mm}^2/\text{s}$  when the recorded gauge pressure is within the range of 13.0 to 18.0 MPa.

3.2.2 *percent viscosity loss, n*—viscosity loss, as defined in 3.2.3, divided by the pre-sheared viscosity, and reported as a percent.

3.2.3 *viscosity loss, n*—the loss in viscosity determined from the difference in kinematic viscosity at  $100^\circ\text{C}$  of pre-sheared and post-sheared fluid.

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

<sup>3</sup> Available from CEC Secretariat, Interlynk Administrative Services, Ltd., Lynk House, 17 Peckleton Lane, Desford, Leicestershire, LE9 9JU, United Kingdom.

\*A Summary of Changes section appears at the end of this standard

#### 4. Summary of Test Method

4.1 A polymer-containing fluid is passed through a diesel injector nozzle at a shear rate that may reduce its kinematic viscosity. The percent viscosity loss is a measure of the mechanical shear stability of the fluid.

NOTE 7—This test method may also be used for oils not containing polymer. It might not be known whether an oil submitted for test contains a polymer.

#### 5. Significance and Use

5.1 This test method evaluates the percent viscosity loss of fluids resulting from physical degradation in the high shear nozzle device. Thermal or oxidative effects are minimized.

5.2 This test method may be used for quality control purposes by manufacturers of polymeric lubricant additives and their customers.

5.3 This test method is not intended to predict viscosity loss in field service in different field equipment under widely varying operating conditions, which may cause lubricant viscosity to change due to thermal and oxidative changes, as well as by the mechanical shearing of polymer. However, when the field service conditions, primarily or exclusively, result in the degradation of polymer by mechanical shearing, there may be a correlation between the results from this test method and results from the field.

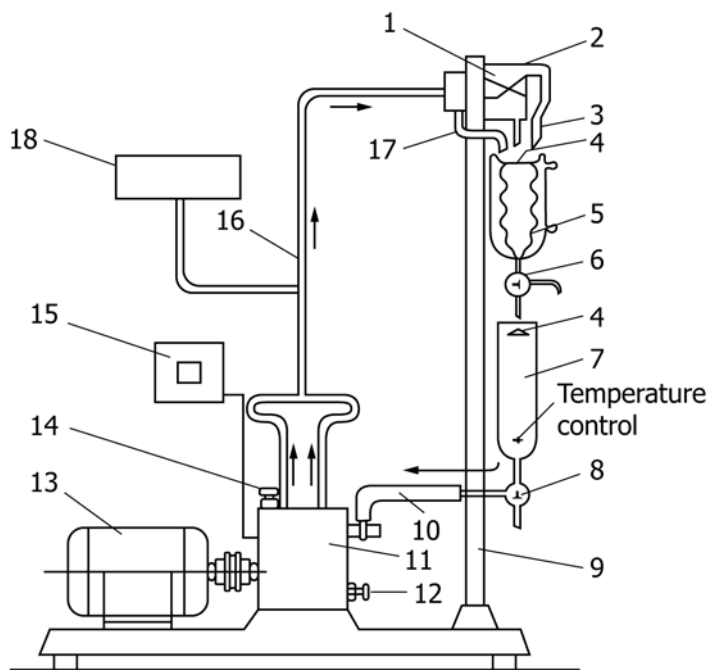
#### 6. Apparatus

6.1 The apparatus consists of a fluid reservoir, a double-plunger pump with an electric motor drive, an atomization chamber with a diesel injector spray nozzle, and a fluid cooling vessel, installed in an area with an ambient temperature of 20 to 25°C (68 to 77°F). Fig. 1 shows the schematic representation of equipment.<sup>4</sup>

6.1.1 *Fluid Reservoir*—In Fig. 1, the fluid reservoir (7) is open on the top, has approximately a 250 mL capacity, has a 45-mm (1.772-in.) inner diameter, and is calibrated in units of volume. It is fitted with an internal fluid distributor as detailed in Fig. 2. A 40-mm (1.575-in.) diameter watch glass with serrated edges is an acceptable distributor plate. The distributor reduces the tendency of fluid channeling. Temperature is measured by a thermometer suspended in the center of the fluid reservoir. The bottom of the thermometer bulb shall be 10 to 15 mm above the entrance to the drain tube opening. Other temperature-measuring equipment positioned at the same location may also be used. The outlet is equipped with a three-way stopcock (8). The three-way stopcock is of a cone type with a nonexchangeable solid plug with an 8-mm (0.315-in.) nominal bore size. Transparent plastic tubing, (10) in Fig. 1, is used to connect the three-way stopcock to the pump inlet.

6.1.2 *Double-Plunger Injection Pump*—In Fig. 1, the injection pump (11) is defined as Bosch PE 2 A 90D 300/3 S2266. This pump is equipped with a stroke counter (15), venting screw (14), and a flow rate adjusting screw (12).

6.1.3 *Injection Pump*, driven by a three-phase electric motor (13) in Fig. 1, rated at a speed of 925 ± 25 rpm.



- Legend:
- (1) Spray nozzle
  - (2) Atomization chamber
  - (3) Outlet of the atomization chamber
  - (4) Distributor plate
  - (5) Glass container fluid reservoir
  - (6) Three-way cock downstream of glass
  - (7) Glass container fluid reservoir
  - (8) Three-way cock downstream of glass container
  - (9) Support column
  - (10) Connection with pump-suction opening
  - (11) Double-plunger injection pump
  - (12) Pump setting screw
  - (13) Electric motor
  - (14) Venting screw/pump
  - (15) Stroke counter
  - (16) Pressure tubing from pump to injector
  - (17) Return line for overflowing liquid
  - (18) Pressure sensing device

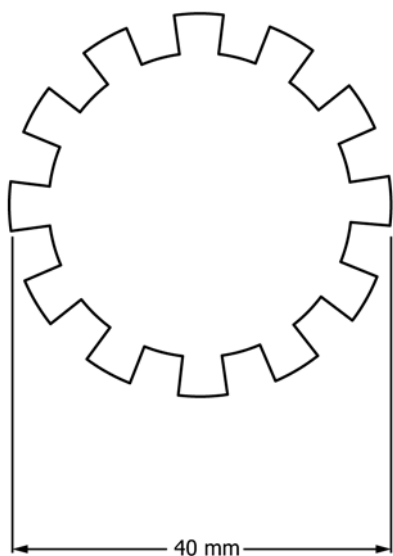
FIG. 1 Apparatus for Shear Stability Testing

6.1.3.1 This motor runs at 925 rpm on the 50 Hz current prevalent in Europe; it will run at approximately 1100 rpm on 60 Hz current. The 1100 rpm speed is not acceptable in this procedure. A suitable means shall be taken to ensure the prescribed 925 ± 25 rpm speed to the injection pump. One acceptable method is to use a 6 to 5 speed reducer.

6.1.4 *Outlet of Injection Pump*, connected to the atomization chamber using high pressure steel tubing. The atomization chamber (2) in Fig. 1, is defined in more detail in Fig. 3. To minimize foam generation, the spray chamber is designed so that the fluid under test exits from the nozzle into a chamber filled with the test fluid. A drain tube (17) fitted with a two-way stopcock is included to minimize contamination from the previous test during the system cleaning steps. The diesel injector nozzle is a Bosch DN 8 S 2-type pintle nozzle injector, number 0434 200 012, installed in a Bosch KD 43 SA 53/15 nozzle holder. The nozzle holder includes a filter cartridge.

NOTE 8—Exercise great care to avoid damage to the precision parts of the fuel injection equipment (the plunger and barrel in the pump and the nozzle valve assembly). Service work on the equipment should be

<sup>4</sup> Throughout, the numbers in parentheses refer to the legend in Fig. 1.



NOTE 1—Dimensions are given in millimetres.

FIG. 2 Distributor Plate

performed by a diesel fuel injector pump specialist or with reference to the manufacturer's service manual.<sup>5</sup>

NOTE 9—An unusually rapid rise in gauge pressure during testing may signify filter blockage. When this occurs, the filter cartridge shall be replaced.

6.1.5 *Pressure Sensing Device* (18), such as a glycerol-filled pressure gauge or electronic, digital display pressure indicator, shall be installed and separated from the line by a pressure snubber or needle valve to suitably dampen pressure surges. The pressure device shall be occasionally pressure tested to ensure accuracy.

6.1.6 *Fluid Cooling Vessel*, ((5) in Fig. 1), used to maintain the specified temperature of the test fluid, as indicated at the outlet of the fluid reservoir. This vessel is a glass container with exterior cooling jacket constructed so that the heat transfer surface of the jacket is spherical. The exterior jacket diameter,  $d_1$ , is approximately 50 mm (1.969 in.). The interior heat transfer surface,  $d_2$ , is approximately 25 mm (0.984 in.) in diameter. The overall length,  $L$ , is approximately 180 mm (7.087 in.). A distributor plate, similar in design to the distributor plate in the fluid reservoir, is positioned in the upper portion of the fluid cooling vessel to ensure contact between the fluid and the cooling surface. The discharge from the fluid cooling vessel is through a three-way stopcock of the same design used on the discharge of the fluid reservoir. The exterior cooling jacket shall be supplied with an adjustable volume of cold water.

## 7. Materials

7.1 *Diesel Fuel (No. 2)*, initially required to adjust the diesel injector nozzle valve opening pressure.

7.2 *Calibration Fluid*, used to ensure that when the apparatus is adjusted within a prescribed pressure range, the correct viscosity loss is obtained.

7.3 *Calibration Fluid RL233*, used to ensure that when the apparatus is adjusted within a prescribed pressure range, the correct viscosity loss is obtained.

NOTE 10—RL233 meets the requirements of this test method and is acceptable during a transition period between suppliers. See research report for details of the equivalence testing.<sup>6</sup>

## 8. Hazards

8.1 (**Warning**—Use a safety shield between the high-pressure components and the operator during use of equipment.)

8.2 (**Warning**—During operation, the line between the pump and nozzle, ((16) in Fig. 1), is under a pressure of at least 13.0 MPa (130 bar or 1885 psi). Pressures above the upper limit of 18.0 MPa (180 bar or 2611 psi) are possible if filter plugging occurs. Shut off the pump prior to tightening any fitting that is not properly sealed.)

## 9. Sampling

9.1 Approximately 650 mL of fluid is needed per test.

9.2 The test fluid shall be at room temperature, uniform in appearance, and free of any visible insoluble material prior to placing it in the test equipment.

9.3 Water and insolubles shall be removed before testing, or filter blocking and nozzle wear may occur. Filter blocking can be detected by a sudden change in gauge pressure. The transport of insolubles to the shear zone will shorten nozzle life.

## 10. Calibration and Standardization

10.1 *Nozzle Adjustments*—If the nozzle to be used is new or has not been pre-calibrated, adjust the diesel injector nozzle holder with the nozzle in place. Adjust the nozzle using diesel fuel and a nozzle tester so that the valve opening pressure is 13.0 MPa (1885 psi) under static conditions. If the nozzle has been pre-calibrated with RL233 calibration oil, adjust the valve opening pressure to the calibration pressure prescribed, which must be between 13.0 MPa (1885 psi) and 18.0 MPa (2611 psi).

10.1.1 Install the nozzle and the nozzle holder in the test apparatus. The pintle/spray nozzle shall be tightly fitted in the chamber to avoid leakage of oil around the external surface of the spray nozzle.

10.2 *Measurement of Residual Undrained Volume,  $V_{res}$* :

10.2.1 The residual undrained oil volume of the system is the volume of the system between the three-way stopcock below the fluid reservoir (8) in Fig. 1, and the injector nozzle orifice (1).  $V_{res}$  does not include the atomization chamber volume. When the residual undrained volume is known, go to 10.3.

<sup>5</sup> Repair Instructions for Diesel Injection Pumps Size A, B, K and Z, Bulletin WJP 101/1 B EP, Robert Bosch GmbH, 2800 South 25th Ave., Broadview, IL 60153.

<sup>6</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1629.