Designation: D8049 – 16

Standard Test Method for Determining Concentration, Count, and Size Distribution of Solid Particles and Water in Light and Middle Distillate Fuels by Direct Imaging Particle Analyzer[1]

This standard is issued under the fixed designation D8049; 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 uses a direct imaging particle analyzer (DIPA) to count and measure the size and shape of dispersed solid particles and water droplets in light and middle distillate fuels in the overall range from 4 µm to 100 µm and in size bands of ≥4 µm, ≥6 µm, and ≥14 µm.

NOTE 1—Particle size data from 0.7 µm through 300 µm is available for use or reporting if deemed helpful.

NOTE 2—Shape is used to classify particles, droplets, and bubbles and is not a reporting requirement.

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

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

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

2.2 *ISO Standard:*[3]

ISO 12103-1 Road Vehicles—Test Contaminants for Filter Evaluation—Part 1: Arizona Test Dust

ISO 11171 Hydraulic Fluid Power—Calibration of Automatic Particle Counters for Liquids

2.3 *MIL Standard:*[4]

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordinance

3. Terminology

3.1 For definitions of terms used in this standard, refer to Terminology D4175.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air bubble, n*—non-fuel, gaseous formations within the fuel, generally spherical in shape and visible as a heavy wall ring due to the diffraction of light around and through them.

3.2.2 *droplet, n*—non-fuel liquid formations within the fuel, generally spherical in shape and visible as a thin wall ring due to the diffraction of light around and through them.

3.2.3 *major particle diameter µm, n*—the maximum two-dimensional length of the particle measured

3.2.4 *minor particle diameter µm, n*—the maximum two-dimensional length of the particle measured perpendicular to the *major particle diameter*.

3.2.5 *particle, n*—non-liquid, non —gaseous, solid objects in the fuel.

3.2.6 *projected equivalent particle diameter µm, n*—the diameter calculated from the projected area of a particle if that area formed a circle, and in equation form is:

$$\text{Projected Equivalent Particle Diameter} = \sqrt{(\text{area}/0.785)}$$

[1] 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 D02.14 on Stability and Cleanliness of Liquid Fuels.

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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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] For referenced MIL standards, visit the Defense Logistics Agency, Document Services website at http://quicksearch.dla.mil

3.3 *Abbreviations:*

3.3.1 *DIPA*—Direct Imaging Particle Analyzer

4. Summary of Test Method

4.1 The optical measurement cell comprises a light source and an optical sensor. The principle of operation is the illumination and digital capture of actual particle images which are then analyzed for size and shape by the system software. The visual capability of the instrument allows for the differentiation between solid, water, and air particles and thus the detection of water and elimination of air bubbles from the analysis.

4.2 The test specimen, approximately 4 L, is agitated in its container. The container is then fitted with a spigot to allow delivery to the direct imaging particle analyzer (DIPA). Fluid flows through the DIPA and is analyzed for solids and water content. Larger or smaller volume test specimen may be used as appropriate for the instrument.

4.3 The method requires reporting of particle and droplet counts in the ≥4 µm , ≥ 6 µm, and ≥14 µm categories, however particle counts in the 0.7 µm to <4 µm size range may also be reported as well as additional ranges the user deems important. Particle size for this test method shall be determined using the definition per 3.2.6.

5. Significance and Use

5.1 This test method is intended for use in the laboratory or in the field for evaluating the cleanliness of fuels identified in the scope.

5.2 Detection of particles and water can indicate degradation of the fuel condition. Particles, whether inorganic or organic, can cause fouling of fuel filters and damage pumps, injectors, and pistons. Knowledge of particle size in relation to metallurgy can provide vital information, especially if the hardness of the solid particles are known from other sources.

NOTE 3—The method includes the detection of water, solids, and air bubbles. The air bubbles are screened out of the data prior to analysis of results, based on shape and transparency, and are not reported in the results.

6. Apparatus[5]

6.1 Laboratory or Field Usage

6.1.1 *Direct Imaging Particle Analyzer (DIPA)*—Operating on visual imaging principles, comprising a flow cell with camera/optics, light, test specimen container, and stand and software to analyze the test specimen and display the particle measurement data.

6.1.2 *Test Specimen Container*—A clean fuel container for sample storage, transport, and transfer into the DIPA. An epoxy-lined container of approximately 5 L in volume has been found to be suitable, along with a nominal 19 mm or larger opening in the top lid for installation of a tube manifold assembly to allow fuel transfer to the DIPA and air into the epoxy-lined container for venting.

6.1.3 *Tube Manifold Assembly*—Consists of a stopper or threaded cap, which inserts into the top opening in the test specimen container to seal it, and has through-holes which accept tubing for venting and tubing for flow of fuel to the DIPA.

6.1.4 *Flow Controller*—The flow of fuel through the DIPA is controlled by an orifice located in the outflow line to the collection container.

6.1.5 *Collection Container*—For collecting analyzed fuel specimen for possible retesting. Equivalent to the test specimen container.

7. Reagents and Materials

7.1 *Heptane*—Reagent grade filtered through 0.45 µm filter.

7.2 Reticle, NIST, or other widely recognized standards body, traceable, for calibration of system. A 19 mm diameter reticle with 100 µm grids and 10 µm subdivisions has been found to work well for use in calibrating the instrument.

7.3 *Partistan Resolution Standard,* mono disperse polymer beads, coefficient of variation <10 %.

7.4 *Verification Standard Partistan 2806,* containing ISO Medium Test Dust, ISO 12103-A3 traceable to NIST.

7.5 *Partistan Super Clean Fluid.*

8. Sampling

8.1 Sample into the test specimen container. Ensure it is new and unused, or in clean, new condition (see Practice D4306). Take precautions not to introduce contamination during the sampling process.

8.2 Take a representative sample. Refer to Practice D4057, Practice D4177, or other similar sampling practices.

8.3 Confirm that the container is approximately 80 % filled (~4 L).

9. Preparation of Apparatus

9.1 Ensure the DIPA is set up according to manufacturer's instructions.

9.2 Ensure instrument is clean and ready for use by flushing with a filtered, fast drying solvent such as heptane. Clean sampling valve and tubing in the same manner. System cleanliness may be checked by running a sample of filtered heptane through it. If the test specimen has a ≥4 µm count in excess of 200 µm ⁄mL the system requires cleaning by continued flushing with filtered heptane until the count falls below 200.

10. Test Specimen Preparation

10.1 Gently shake the test specimen in its container for at least 1 min to ensure that it is well mixed.

10.1.1 To achieve a consistent agitation it is recommended to either: (*a*) tumble the test specimen container by hand or appropriate mechanical shaking device, (*b*) invert the container back and forth for a minimum of 60 times at approximately 1 Hz (cycle/second), or (*c*) use a roller device and roll for a

[5] The sole source of supply of the apparatus known to the committee at this time is Jet Fuel InFlow available from J.M. Canty Inc, 6100 Donner Rd., Lockport, New York USA 14094. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.