



Designation: D7872 – 13 (Reapproved 2022)

Standard Test Method for Determining the Concentration of Pipeline Drag Reducer Additive in Aviation Turbine Fuels¹

This standard is issued under the fixed designation D7872; 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 the measurement of high molecular weight polymers, in particular pipeline drag reducer additive (DRA), in aviation turbine fuels with a 72 $\mu\text{g/L}$ lower detection limit. The method cannot differentiate between different polymers types. Thus, any non-DRA high molecular weight polymer will cause a positive measurement bias. Further investigation is required to confirm the polymer detected is DRA.

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 **Warning**—Mercury has been designated by many regulatory agencies as a hazardous substance that can cause serious medical issues. Mercury, or its vapor, has been demonstrated to be hazardous to health and corrosive to materials. Use Caution when handling mercury and mercury-containing products. See the applicable product Safety Data Sheet (SDS) for additional information. The potential exists that selling mercury or mercury-containing products, or both, is prohibited by local or national law. Users must determine legality of sales in their location.

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.*

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.J0.01 on Jet Fuel Specifications.

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2. Referenced Documents

2.1 ASTM Standards:²

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products

2.2 Other Reference:

CRC Report No. 642 Investigation of Pipeline Drag Reducers in Aviation Turbine Fuels

3. Terminology

3.1 Definitions:

3.1.1 *bumping*, v —violent boiling which displaces liquid into the distillation flask.

3.1.2 *drag reducing additive (DRA)*, n —a material comprised of very high molecular weight hydrocarbon polymers that is soluble in petroleum products and used to reduce the fluid friction during pipeline transportation.

3.1.3 *rotary evaporation*, n —a distillation process utilizing heat, reduced pressure and a rotating flask which evaporates fluid to reduce the volume of a sample of material.

3.1.3.1 *Discussion*—The apparatus, consisting of a round-bottomed flask in a heated bath, is operated under vacuum (reduced pressure) to lower the boiling point of the fluid, and the rotational motion accelerates evaporation of the liquid by creating additional surface area of the fluid being distilled off.

3.1.4 *sheared DRA*, n —the very long hydrocarbon polymers of drag reducing agent that have been shortened by severe physical processes such that the resulting material is no longer effective at reducing fluid friction.

3.1.4.1 *Discussion*—Severe physical and mechanical processes include large pressure changes which can occur at control valves, pumps, meters, reductions in pipe diameter which affect fluid velocity, and ultrasonication in a laboratory process, resulting in shorter polymeric chains which are still very large compared to the fuel molecules and are non-distillable.

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.

3.1.5 *total exclusion, n*—polymers larger than the pore size cannot enter the pores and elute together as the first peak in the chromatogram.

3.2 Abbreviations:

3.2.1 *DRA*—drag reducing additive

3.2.2 *GPC*—gel permeation chromatography

3.2.3 *RI*—refractive index

3.2.4 *THF*—tetrahydrofuran

4. Summary of Test Method

4.1 The method employs a rotary evaporator (also called a rotovap) to concentrate the DRA in a base sample followed by GPC to separate and quantify the DRA from the remaining jet fuel. Rotovaping is a rapid vacuum distillation process used to reduce the volume of jet fuel which effectively increases the relative DRA concentration. The GPC method uses heptane or THF as the mobile phase, a single separation column and refractive index detection. The separation column contains particles with pore sizes that totally exclude sheared and unsheared DRA polymers to give a sharp chromatographic DRA peak.

4.2 An approximate 400 g sample of jet fuel is concentrated through rotary evaporation and analyzed by GPC. The DRA concentration is quantified by integrating the area under the DRA peak. Comparing this area to a calibration curve allows a determination of the weight fraction of the DRA component in the concentrated jet fuel. The original concentration is obtained by correcting for the concentrating in the rotary evaporation of the jet fuel. The detector is calibrated using standards of sheared DRA in jet fuel in the low mg/L concentration range.

5. Significance and Use

5.1 DRA is frequently added into multiproduct pipelines to increase throughput or reduce energy requirements of fuel movement. Although these additives are not used in jet fuel, contamination can occur from other products if proper batching guidelines are not followed or by other cases of human error. CRC Report No. 642 reviewed the impact of DRA on jet fuel fit-for-purpose performance and concluded that the fuel spray angle and atomization capability of several engine-type fuel nozzles can be adversely affected impacting high altitude relight performance at elevated concentrations. A method that accurately quantifies the amount of DRA in jet fuel can be useful in confirming the absence of significant contamination to protect the safety of aviation operations. This test method is designed to measure down to sub-100 µg/L levels of DRA in aviation fuel.

6. Interferences

6.1 This test method has no particular specificity for DRA and will also measure any other high molecular weight compounds present in the sample making it susceptible to interferences. However, no high molecular weight polymers are approved for blending into aviation fuels. Stadis 450 has a low molecular weight polymer and was checked. No interference was found. The presence of non-DRA high molecular weight polymers would create a positive measurement bias.

However, detection sensitivity of the non-DRA high molecular weight polymers may not be the same because of polymer type differences. Thus, non-DRA high molecular weight polymers should not be quantified by this test method.

7. Apparatus

7.1 *Vacuum source*, such as a vacuum pump capable of reducing the pressure in a rotary evaporator to 6.77 kPa (28 in. of mercury below atmospheric pressure).

7.2 *Rotary evaporator*, equipped with a silicone oil heating bath that can accommodate flasks capable of holding 400 g of jet fuel. A bump trap may be connected to the evaporation flask. Any silicone oil bath capable of reaching 180 °C is suitable. There are a variety of high temperature silicone bath oils that may be used and are commercially available. Water may be used to cool the rotovap condenser. Details of the rotovap are described in Table 1.

NOTE 1—Bumping can cause loss of polymer from the flask that would create a lower than actual detection value.

7.3 *Gel permeation chromatography system*, described in Table 2. The method includes flexibility in the selection of GPC hardware and conditions; however, a refractive index detector is required.

7.4 Any GPC apparatus may be used, provided the RI detector response to the DRA peak has a signal to noise (S/N) ≥ 10 for a 50 µg/L DRA in jet fuel sample after rotary evaporation (this translates into 10 mg/L if rotary evaporation provided a reduction of 400 g to 2 g for a jet fuel sample containing 50 µg/L DRA).

7.5 To achieve sub 100 µg/L DRA detection, a column that exhibits total exclusion of the sheared DRA is required. Total exclusion leads to sharper elution peaks providing easier detection. In addition, polymers are susceptible to shearing while passing through a GPC column. Columns packed with large particle size stationary phase avoid shearing, 5 µm or 10 µm particle sizes are recommended.

8. Reagents and Materials

8.1 All chemicals are American Chemical Society grade chemicals or better unless specified otherwise.

8.2 Drag reducing additive, available from appropriate additive supplier in “sheared” form for use in preparing standards.

9. Sampling

9.1 Fuel samples are typically drawn from pipelines. Consult Practice D4057 for guidance on proper sampling procedures. Consult Practice D4177 for guidance on auto sampling.

TABLE 1 Rotovap Conditions

Pressure	3.1 kPa to 6.5 kPa (28 in. to 29 in. Hg below atmospheric pressure)
Temperature	120 °C to 180 °C
Approximate time	1 h to 3 h (depending on vacuum pressure and temperature)