Designation: D 6986 – 03

An American National Standard

Standard Test Method for Free Water, Particulate and Other Contamination in Aviation Fuels (Visual Inspection Procedures)[1]

This standard is issued under the fixed designation D 6986; 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.

INTRODUCTION

Fuel quality is paramount in aviation fuels because of their critical application. Many successive types of inspections are conducted to ensure quality protection. Rapid, visual inspections carried out at various locations in the fuel supply system are a critical part of the inspection program. Experience has shown that subjective evaluations such as described by this test method form an effective field alert system that is backed by other, more quantitative tests.

The present test method duplicates much of Test Method D 4176, a test method applicable to all distillate fuels. However, the present test method also includes field methods applicable especially to aviation fuels, and is therefore published as a separate test method.

1. Scope

1.1 This test method covers two procedures for establishing the presence of suspended free water, solid particulate, and other contaminants in aviation gasoline and aviation turbine fuels.

1.1.1 Both procedures are intended primarily for use as field tests with the fuel at handling temperature.

1.1.2 Procedure A uses transparent sample containers; Procedure B uses opaque containers.

1.2 Both procedures are rapid methods for contamination detection and include ratings of haze appearance and particulate presence.

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 2276 Test Methods for Particulate Contaminant in Aviation Fuel by Line Sampling

D 3240 Test Method for Undissolved Water in Aviation Turbine Fuels

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D 4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)

2.2 *ASTM Adjuncts:*

ADJD417601 Distillate Fuel Bar Chart [3]

ADJD417602 Distillate Fuel Haze Rating Standard[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *aviation fuels—as used in this standard*, the term includes both aviation gasoline and aviation turbine fuels.

3.1.2 *clear and bright*—a condition in which the fuel contains no visible water drops or particulates and is free of haze or cloudiness.

3.1.3 *free water*—water in excess to that soluble in the fuel at the temperature of the test and may appear in the fuel as a haze, cloudiness, droplets, or water layer.

3.1.4 *solid particulates*—small solid or semi-solid particles, sometimes referred to as silt or sediment, present in a fuel as the result of contamination by airborne dusts, corrosion by-products, or wear products.

4. Summary of Test Method

4.1 The test method describes two types of sampling containers for evaluating the appearance of aviation fuel samples. Procedure A covers transparent sample containers, including the open jar and the closed circuit sampler, while Procedure B uses opaque containers such as the white bucket.

---

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0 on Aviation Fuels.

Current edition approved Dec. 1, 2003. Published January 2004.

[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 ASTM International Headquarters. Order Adjunct No. ADJD417601.

[4] Available from ASTM International Headquarters. Order Adjunct No. ADJD417602.

4.2 In the open jar procedure, a minimum of 750 mL (24 oz) of fuel is placed into a clear one litre (1 qt) container and examined visually. The jar is then closed and the sample is swirled and examined for visual sediment and water at the bottom of the vortex. Additionally, fuel clarity may be rated by placing a standard bar chart behind the sample and comparing its visual appearance with the standard haze rating photographs. The presence or absence of free water and of particulates is reported.

4.3 In the closed circuit sampler procedure, approximately 3500 mL (0.9 U.S. gal) of fuel is placed into the sampler and is examined for clarity and for visual sediment or water droplets on the bottom of the sampler. Additionally, fuel clarity may be rated by placing a standard bar chart behind the sample and comparing its visual appearance with the standard haze rating photographs. The presence or absence of free water and of particulates is reported.

4.4 In the white bucket procedure fuel to a depth of approximately 15 cm (6 in.) is collected in a white porcelain coated or stainless steel bucket. The sample is examined for solids or sediment, or both, on the bottom of the bucket. Sample clarity can be checked by the appearance of a small, shiny coin on the bucket's bottom. If the fuel is dry, the raised letters on the coin should be easily readable. The amount of sediment can be described by a letter category using a rating guide.

4.5 In both procedures, the sample is inspected for color or other unusual appearance.

4.6 Field inspection procedures are performed immediately after sampling at fuel handling temperature conditions.

5. Significance and Use

5.1 The two procedures in the test method provide rapid methods for field detection of free water and solid contaminants, or any other visually apparent contamination. Uncertain or marginal results by either of these methods would normally result in the performance of methods such as D 2276, D 5452, or D 3240 for quantitative determination of contaminants.

5.1.1 Particulate determination in appearance tests is sensitive to sampling procedures. The presence of a small number of particles may indicate, for example, that the sample line was not flushed to provide a representative sample. The persistent presence of even a small number of particles, however, may be cause for further investigation depending on the situation.

5.2 Experience has shown that an experienced tester using a clear bottle can detect as little as 40 ppm of free, suspended water in the fuel. Thus, a fuel rated as *clear and bright* can still fail lower limits set by quantitative methods. A rater will also have difficulty resolving particles smaller than 40 µm. Smaller particles must be determined by other than visual methods such as D 2276, D 5452 or chemical field tests listed in Manual 5.[5]

5.3 Experience has shown the visual appearance of fuel in a white porcelain bucket to be the most suitable method for the detection of dye contamination or other unusual discoloration. In the U. S., the white porcelain bucket is used to detect the dye.

6. Apparatus

6.1 *Cylindrical Clear Container*, such as:

6.1.1 *Clear Container*, with lid, capable of holding 750 mL (nominal 1 U.S. qt) of fuel and having a diameter of 100 ± 10 mm (4 ± 0.4 in.). There should be no gasket in the lid.

6.1.2 *Closed Circuit Sampler*, holding about 4 L (1 gal U.S.) of fuel and being permanently mounted to receive fuel from a fuel line or a storage tank and having inlet and outlet valves to control filling and emptying of the container. The sampler base is normally conical and incorporates the fuel inlet and outlet. The fill port is designed to cause the fuel to swirl around the sides of the clear glass tube. The circuit sampler may also contain hydrometer and chemical water detection ports.

6.2 *Appearance Card and Photographs*:

6.2.1 *Paper Card (Bar Chart)*, laminated in clear plastic having five parallel lines of different widths (see ASTM adjunct ADJD417601).

6.2.2 *Appearance Photographs*, a series of standard photographs of the bar chart through a series of samples of different haze levels, numbered from one through six. Photograph No. 1 is the clearest, while No. 6 represents the densest haze (see ASTM adjunct ADJD417602). A fuel sample rated clear and bright will have a rating of "one."

6.2.2.1 The differences between these haze levels are arbitrary and are not intended to represent equivalent increases in suspended water content or particulates. It is essential, therefore, that only the proper approved bar charts and photographs be used.

6.3 *Opaque Sample Containers*:

6.3.1 *White Bucket*, a circular bucket with straight but non-parallel sides and a flat bottom and a minimum capacity of 7.5 L (2.0 U.S. gal) and approximately 20 cm (8 in.) high, either coated with white porcelain enamel or made of stainless steel. Porcelain coatings must be free of dark spots, chips, or other surface damage, most particularly on the bottom of the bucket. Stainless steel buckets shall be made of a rust-resistant steel and have a polished internal surface. The white porcelain bucket should be used for the optimum detection of unusual coloration.

NOTE 1—A quantitative description of acceptable white color is in preparation.

NOTE 2—Buckets made of white, hard plastic have been found to stain a yellow color over time, which can make it difficult to observe a haze or color changes. The use of plastic containers is also discouraged unless provision is made for bonding such containers to the filling line.

6.4 *Color and Particle Assessment Rating Guide*:[6]

6.4.1 This guide contains both a series of photographs of particulates of differing concentrations, each having a different letter rating, and a series of color photographs for rating filter membranes obtained by Test Methods D 2276. For this test method, only the particle rating scale is used. The particle

[5] Manual 5, *Aviation Fuel Quality Control Procedures*, 2nd Ed., ASTM International, W. Conshohocken, PA, 1995.

[6] The "Color and Particle Assessment Rating Guide," *SGTP-3940*, is available from Gammon Technical Products, Manasquan, NJ.

rating scale does not bear a direct relationship to the mass of particulates but is simply a way of communicating the amount of visible particulates in the sample.

7. Sampling

7.1 Sampling shall be consistent with the procedures in Practice D 4057.

7.2 Draw the sample for a field test directly into the test container using the following procedure:

7.2.1 Ensure that the sampling valve is free of loose solid contaminants. If rust or other loose encrustation is present, remove with a cloth; then flush the sampling valve prior to taking the actual sample.

7.2.2 Ensure the displacement the fuel volume in the piping between the sample tap and the storage tank This displacement volume should be discarded as it may not be representative of the fuel to be tested.

7.2.2.1 All fluid obtained from a filter sump should be kept as the sample.

7.2.3 Rinse a clean test container thoroughly with the fuel being sampled. (**Warning—**Flammable, keep away from heat, sparks, and open flames.)

7.2.4 Draw the sample continuously, opening the valve completely to obtain a full flush. Do not open or close taps or valves during sample draw as this action can affect sample quality.

7.3 If the test is to be conducted on fuel taken in a separate container for laboratory testing, the container should be shaken vigorously before decanting the fuel into the viewing equipment. Sample transfer should be rapid enough to avoid changes in sample temperature.

8. Procedures

8.1 *Procedure A—Clear, Transparent Containers*:

8.1.1 *Open Glass or Plastic Container*:

8.1.1.1 *Visual Observation*—Fill container about three-fourths full. Immediately check for evidence of water or particulate contamination by holding the sample to the light and visually examining for haze or lack of clarity. Close the container and swirl the sample to produce a vortex and examine the bottom of the vortex for particulate matter and water droplets. Also look for brown slime or a water layer on the bottom of the container. Record the particulate and water appearance rating of the sample using the ratings in Tables 1 and 2. Record the appearance of any other contaminant using Table 3 as a guide. Record the ambient temperature.

8.1.1.2 *Use of Bar Chart and Photographs*—Immediately on drawing a sample, place the container into a well-lighted area, avoiding light reflections on the front of the container as much as possible. Place the bar chart directly behind the container, with the lines toward the container and parallel with the bottom of the container. The narrowest line should be at the bottom of the container. Directly facing the container and bar chart, compare the appearance of the bar chart through the sample with the standard photographs. Place the photographs next to the container so that they are lighted similarly to the sample. Select the photograph closest in appearance to the sample. Notice that the differences between photographs consist both of the successive disappearance of lines as well as the gradual lightening of all the lines. Record the number of the thinnest line which is visible through the sample, or record "six" if no lines are visible.

TABLE 1 Particulate Appearance Ratings

Rating	Rating Guide	Description
Clear	A	no particles[A], silt, sediment, dye, rust, or solids.
Slight particulates	B-C	several fine to small size particles.
Particulate matter	D	many small particles floating or settled on bottom of container.
Dirty	E-1	discoloration or many particles dispersed in fuel or settled on bottom of container.

[A] Particulates determination is sensitive to sampling procedures. See 5.1.1.

TABLE 2 Water Contaminant Appearance Ratings

Rating	Description
Bright	no suspended or visible free water, sample is bright (slight sparkle). Air bubbles may cause hazy appearance immediately after the sample is drawn, but haze clears from the bottom up.
Hazy	fine droplets dispersed through sample, may be temporary due to sample cooling.
Cloudy	fine droplets dispersed through sample, giving it milky appearance.
Wet	droplets or water layer on bottom of container or clinging to sides.

8.1.2 *Closed Circuit Sampler*:

8.1.2.1 With fuel flowing under pressure in the main fuel line, open the fill valve wide, filling the glass jar to within about 25 mm (1 in.) from the top.

8.1.2.2 Let the product settle for 1 min or more, if necessary, to remove air bubbles. (**Caution**—The visual results may differ from the photographs if the circuit sampler has a diameter different from that of the 100 mm (4 in.) jar used in the photographs.)

8.1.2.3 Examine the glass sampler for hazy/cloudy conditions and the bottom for water droplets, solid contaminants, brown slimes, or a combination thereof. Record the particulate and water appearance ratings of the sample using the ratings in Tables 1 and 2. Record the appearance of any other contaminant using Table 3 as a guide. If desired, the bar chart and photos can be used to rate sample clarity as described in 8.1.1.2. Record the ambient temperature.

NOTE 3—While small water droplets and air bubbles may appear similar, air bubbles will rise while water droplets will settle upon standing.

8.1.2.4 If the sampler is fitted with an optional self-sealing valve assembly for a free water field testing kit, a fuel sample may be drawn at this time.

8.1.2.5 Open the drain valve to drain the sampler.

8.2 *Procedure B—Opaque Containers*:

8.2.1 *White Bucket*—In the U.S., only the white porcelain bucket is recommended for the optimum detection of red dye contamination.

8.2.1.1 Bond the bucket electrically to the fuel system or to the ground by using a bonding wire.

NOTE 4—When using a white porcelain bucket, the porcelain coating should not be thought of as an insulating layer for electrical bonding.

8.2.1.2 If necessary, wipe external contamination from the fill valve. Flush the sampling tap of loose contaminants at maximum flow rate prior to drawing the sample.

NOTE 5—Water lying on a flat surface forms a meniscus around the

TABLE 3 Other Contaminants

Description of Sample Appearance	Possible Cause[A]
Slime on bottom of container or at fuel/water interface, appearing as dark brown/black scum or lacy material floating in the fuel or at the interface with water.	surfactant or microbial contamination
The presence of anaerobic bacteria often causes a pungent odor, similar to rotten eggs.	microbiological activity
Unusual appearance, color or odor, or both.	other product cross-contamination
Fuel dyes can cause red, green, blue, or any color combination in aviation fuel.	dye contamination
Darkened, discolored, and possibly more viscous, fuel with abnormal odor.	fuel aging

[A] Final diagnosis should not be based on these descriptions. Further evaluation is required.

drain port. With low velocity, clean fuel goes through the port, leaving the water and other contaminants in place. Velocity breaks the meniscus, so that much of the surface accumulation can be entrained.

8.2.1.3 Open the fill valve as wide as possible to avoid the collection of contaminants behind a partially closed valve. Fill the bucket to a depth of about 150 mm (6 in.).

8.2.1.4 Allow the sample to stand for 1 min or more, if necessary, to remove air bubbles.

8.2.1.5 To concentrate any solids or water droplets, or both, in the center of the bottom, the contents can be swirled carefully by using a clean implement.

8.2.1.6 Inspect the bottom of the bucket for evidence of solids.

(1) Using Table 1, assign a letter rating which matches the appearance of the solids on the bottom of the bucket.

(2) If desired, the particle photographs of the Particle Assessment Rating Guide can be used to assist in the assignment of the letter rating.

8.2.1.7 Inspect for haze or water droplets. Haze can also be detected by dropping a shiny coin into the bucket. If the characteristics of the coin can easily be distinguished, the product is considered clear. Using Table 2, assign a rating for water contamination appearance.

8.2.1.8 Inspect for fuel color and other unusual appearance such as brown slime or scum. Record the ambient temperature.

NOTE 6—Unusual color in aviation fuel may indicate mixing with another product. Both clear and opaque containers can be used to observe product color. However, informal tests have shown the clean white porcelain bucket to be most suited to the detection of unusual color such as contamination with low concentrations of dyed fuel or color resulting from crude oil characteristics or refinery processing.

NOTE 7—At the time of this writing (2002), in the U.S., the required dye color for certain diesel fuels or heating oils is red.

NOTE 8—Sample clarity is best checked by viewing the sample illuminated with transmitted light through a clear container.

(1) Using a clean porcelain-coated bucket filled to a depth of about 150 mm (6 in.), look for visual evidence of unusual color, viewing the sample under normal daylight conditions or under daylight balanced light.

(2) The operator shall have normal, color vision and shall not wear tinted glasses.

(3) If there is doubt about whether unusual coloration is present, a consensus on the color should be obtained from several individuals.

8.2.1.9 Record the appearance of the sample, using one of the particulate and one of the water content ratings in Tables 1 and 2, respectively. Record any other observed contamination using Table 3 as a guide.

9. Report

9.1 *General Requirements*:

9.1.1 The report shall provide an adequate description of the sample including the type of fuel, the type of sample container, the source of the sample and the date, time, and approximate temperature of the sample. The report shall also indicate the approximate ambient temperature at which the test was run.

9.2 *Procedure A—Clear Container Procedure*:

9.2.1 The results shall be shown as one of the particulates and one of the water contamination ratings in Tables 1 and 2 respectively.

9.2.1.1 Example: Procedure A–clear and bright.

9.2.1.2 If the bar chart and photographs were used to rate the sample, the report shall include the haze rating (based on the number of lines visible in the sample) and a note as to whether particles or water droplets were found on the bottom of the sample container.

9.2.1.3 Example: Procedure A–clear and bright (bar chart = 1).

9.2.2 Any special or unusual observations, (examples are listed in Table 3) shall also be reported.

9.3 *Procedure B—Opaque Container Procedure*:

9.3.1 The results shall be shown as one of the particulates and one of the water contamination ratings in Tables 1 and 2.

9.3.1.1 Example: Procedure B–clear and bright.

9.3.2 Any special or unusual observations (examples are listed in Table 3).

10. Precision and Bias

10.1 It is not possible to specify the precision of Procedure A or B in this test method because both procedures are judged on a go-no go basis and are not quantitative measurements.

10.2 No justifiable statement can be made on the bias of either procedure because a fuel haze can be the result of a number of causes and a relationship with any single absolute quantitative measurement is not possible.

11. Keywords

11.1 aviation fuel appearance; free water; particulates; product contamination; sample containers; white bucket