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 (e) 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; Pro-
cedure B uses opaque containers.

1.2 Both procedures are rapid methods for contamination
detection and include ratings of haze appearance and particu-
late 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 Avia-
tion Fuel by Line Sampling
D 3240 Test Method for Undissolved Water in Aviation
Turine Fuels
D 4057 Practice for Manual Sampling of Petroleum and
Petroleum Products

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 con-
tainers 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
D02.30 on Aviation Fuels.


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.

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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.

6.4 Color and Particle Assessment Rating Guide:

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
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 visually examining for haze or lack of clarity. Close the container and swirl the sample to produce a vortex and visually examining for haze or lack of clarity.

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 5—Water lying on a flat surface forms a meniscus around the ground by using a bonding wire.

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.

8.2.1.2 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 4—When using a white porcelain bucket, the porcelain coating should not be thought of as an insulating layer for electrical bonding.

TABLE 1 Particulate Appearance Ratings

<table>
<thead>
<tr>
<th>Rating</th>
<th>Rating Guide</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>A</td>
<td>no particles, silt, sediment, dye, rust, or solids.</td>
</tr>
<tr>
<td>Slight particulates</td>
<td>B-C</td>
<td>several fine to small size particles.</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>D</td>
<td>many small particles floating or settled on bottom of container.</td>
</tr>
<tr>
<td>Dirty</td>
<td>E-1</td>
<td>discoloration or many particles dispersed in fuel or settled on bottom of container.</td>
</tr>
</tbody>
</table>

A Particulates determination is sensitive to sampling procedures. See 5.1.1.
TABLE 3 Other Contaminants

<table>
<thead>
<tr>
<th>Description of Sample Appearance</th>
<th>Possible Cause(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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. The presence of anaerobic bacteria often causes a pungent odor, similar to rotten eggs. Unusual appearance, color or odor, or both. Fuel dyes can cause red, green, blue, or any color combination in aviation fuel. Darkened, discolored, and possibly more viscous, fuel with abnormal odor.</td>
<td>surfactant or microbial contamination</td>
</tr>
<tr>
<td></td>
<td>microbiological activity</td>
</tr>
<tr>
<td></td>
<td>other product cross-contamination</td>
</tr>
<tr>
<td></td>
<td>dye contamination</td>
</tr>
<tr>
<td></td>
<td>fuel aging</td>
</tr>
</tbody>
</table>

\(^a\) Final diagnosis should not be based on these descriptions. Further evaluation is required.

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