Aviation Fuel

Quality Control Procedures

4th Edition

Jim Gammon
Editor

ASTM INTERNATIONAL
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Aviation Fuel Quality Control Procedures: 4th Edition

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Foreword

This manual is sponsored by ASTM Subcommittee J on Aviation Fuels, Committee D02 on Petroleum Products and Lubricants. It provides guidance on common procedures used to assess and protect aviation fuel quality. Even though the manual was not subject to full Society consensus balloting, a ballot vote by task force members of Subcommittee J was conducted before publication. The task force members who wrote or reviewed this manual are listed in the Introduction.

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Introduction

This Manual is sponsored by ASTM International Subcommittee J on Aviation Fuels, Committee D-2 on Petroleum Products and Lubricants. It was written and reviewed by a task force under Sec. 5 on Fuel Cleanliness. The task force membership listed below represents a broad spectrum of interests including oil companies, airlines, pipeline companies, third party refueling companies, filter companies, fueling vehicle builders, consultants, aviation products distributors, and other aviation associated organizations.

This manual provides guidance material on common procedures that are used to assess and protect aviation fuel quality. Aviation fuel, by its unique use, is one of the most carefully controlled petroleum products, and therefore, is required to meet exacting fuel quality standards. In many cases, the field procedure or test method listed herein is a simplified version of the corresponding ASTM method or standard practice. It should be emphasized that the formal ASTM standard method supersedes the instructions given in this publication. In other cases, when there is no ASTM procedure, a non-ASTM procedure is included for purposes of making this publication as complete a reference as possible. Some of the procedures have resulted from practical experience in dealing with numerous airport systems.

This document explains a number of ASTM test methods used as field tests. For a complete list methods used to qualify an aviation fuel, reference should be made to the pertinent ASTM fuel specification.

Obviously, not all field situations can be predicted. However, the purpose of presenting the extra information is to acquaint the reader with as many aspects of aviation fuel handling as possible. It is the intent of this publication to provide sufficient information for fuel handlers to make an informed approach to aviation fuel quality. In particular, this manual should be useful to third-party refueling organizations and independent fixed base operators.

Ballot vote by members of ASTM Committee D-2, Subcommittee J, was required for publication of this manual. However, the methods in this manual were not subjected to full Society consensus; therefore, these methods have not been subjected to collaborative study (round robins). Detailed information can be obtained from the unabridged methods referenced throughout the manual. All methods in the manual will be periodically reviewed by the subcommittee.

The procedures presented in this manual may involve hazardous materials, operations, and equipment. This manual does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use.

Scope

This document is produced to provide both procedures and educational information regarding the handling of aviation fuels on the airport. Some elements of this document may also be applied to fuel handling at terminals and refineries. This document is not a specification. As a reference, it is not meant to cover any subject in its entirety.

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Glossary

Adsorption—A separation method where certain components are concentrated on the surface of a porous solid. Surfactants (surface active agents) are separated from jet fuel by adsorption on clay.

API Gravity—The US petroleum industry's scale and method of measuring density of petroleum products at a given temperature.

Ambient Temperature—The air temperature surrounding a specific area.

Aviation Gasoline (avgas)—Specially blended gasolines used to power reciprocating piston aircraft engines.

Clay Treater—A treating unit that uses activated clay (Fuller's earth) to remove surfactants from turbine fuel.

Coalescence—The property of a filter cartridge to bring together very fine droplets of free and entrained water to form large droplets that are heavy enough to fall to the bottom of the filter/separator vessel.

Contaminants—Substances either foreign or native that may be present in fuel that detract from its performance.

Cyclone Separator—A device that uses the principle of centrifugal force to cause the contaminate in a fuel to settle to the bottom of the vessel without the use of filter media.

Density—The amount of mass (weight) in a unit volume of a material at a given temperature.

Differential Pressure (Delta P)—The measured difference in pressure between any two points, generally at the inlet and outlet of a filter, monitor, or a filter separator.

Disarming Action—As applied to filter/separators, the rendering of the elements incapable of performing their designed functions; for example, coalescer elements incapable of coalescing water and separator elements incapable of separating water from fuel.

Dissolved Water—Water that is in solution in the fuel. This water is not free water and cannot be removed by conventional means or measured by field equipment.

Effluent—Stream of fluid at the outlet of a filter or filter/separator. This is the opposite of influent.

Emulsion—Liquid dispersed in another, immiscible liquid, usually in the form of droplets. (Two liquids, that will not dissolve completely into one another, mixed so that one is fine drops in the other)

Entrained Water—Small droplets of free water in suspension that may make fuel appear hazy.

Fixed Base Operator (FBO)—Common title for aviation fuel dealer at the airport.

Filter—A device to remove solid contaminants from fuel.

Filter Membrane (Millipore) Test—A standard test in which fuel is passed through a fine filter membrane housed in a plastic holder. The cleanliness of the fuel can be determined by examining the membrane.

Filter/Separator—A mechanical device used to remove entrained particulate contaminants and free water from a fuel.

Flash Point—The lowest fuel temperature at which the vapor about the fuel can be ignited by an outside ignition source.

Floating Suction—A floating device used in a tank for drawing product from the upper level of the fuel.

Free Water—Water in the fuel other than dissolved water. Free water may be in the form of droplets or haze suspended in the fuel (entrained water) and/or a water layer at the bottom of the container holding the fuel. Free water may also exist in the form of an emulsion that may be so finely dispersed as to be invisible to the naked eye.

Freezing Point (Fuel)—The lowest fuel temperature at which there are no solid phase wax crystals.

Haze—Undissolved free water dispersed in fuel that is visible to the eye (usually more than 30 ppm in jet fuel). Fuel appears hazy or cloudy, that is, **not** clear and bright.

Hydrophilic—Water accepting or water wettable.

Hydrophobic—Water repelling; lacking affinity for water.

Immiscible—Liquids that are mutually insoluble. (Will not dissolve into one another.) This is the opposite of miscible.

Influent—Stream of fluid at the inlet of a filter or filter/separator. This is the opposite of effluent.

Metric Density—Weight of a liquid measured in kilograms per cubic meter at a given temperature.

Micron (μm)—A unit of linear measurement. One micron is equal to 10^{-6} m, or 0.00039 in., and approximately 25 400 μm equals 1 in. For example, the average human hair is about 100 μm in diameter.

Miscible—Liquids that are mutually soluble. This is the opposite of immiscible.

Monitor—A device that shows or gives warning of improper performance (noun); or to test or check performance on a continuing basis (verb).

Particulate Matter—Solid contaminants (for example, dirt, rust, scale, sand, and so forth) sometimes found in fuel.

Prefilter—A filter that has a high dirt-holding capacity that is installed upstream of other filtration equipment.

Pressure Drop—See **Differential Pressure**.

Relative Density (Specific Gravity)—In fuel, this is the ratio of weight of any volume of fuel to the weight of an equal volume of water.

Settling Time—The time allowed for water or dirt entrained in the fuel to drop to the bottom of the storage tank.

Slime—Soft, jelly-like substance.

Specific Gravity—See **Relative Density**.

Sump—A low point in a system for collection and removal of water and solid contaminants.

Surfactants (Surface Active Agents)—Chemical substances that make it difficult to separate fuel and water and that disarm filter/separators.

Suspended Water—Undissolved free water that is so finely dispersed as to be invisible to the naked eye (see **Haze**).

Synthetic Separator—Separator made of media that is synthetic mesh material with chemically bonded hydrophobic treatment.

Thief (Sump) Pump—A small pump having a suction line that extends to the low point of a tank for the purpose of drawing off water that may have accumulated.

Turbine Fuel—A group of various kerosines (or more rarely, wide-cut) fuels used to power aircraft turbine engines.

Water Slug—A large amount of free water.

A

General Fuel Handling

A.1 VISUAL APPEARANCE TESTS

A.1.1 Introduction and Purpose

The purpose of these field tests (Glass Jar—Sec. A.1.4.2, White Bucket—Secs. A.1.4.3+A.1.4.4, and Visual Fuel Sampler—Sec. A.1.7) is to detect possible water, solid contaminants, microbial debris, surfactants (Surface Active Agents), and/or other petroleum products in aviation fuel by visual inspection. These tests are not precision tests; they are considered subjective. Experience is the important element; any condition that varies from the normal is a cause for concern. Questionable or unsatisfactory results obtained from these simple tests must be reported to the appropriate authority and may require that certain specification tests must be performed to determine if the product is indeed on specification or not.

These are the simplest tests, low cost and easy to run.

A.1.2 References

ASTM D4176—Standard Test for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures) from ASTM Vol. 05.02.

ASTM Distillate Fuel Bar Chart, Adjunct 12-441761-12.

A.1.3 Description of Test Types and Equipment

a. Glass Jar—Using a clear, wide mouth glass jar or other similar transparent container a minimum of 3 in. (7.5 cm) in diameter, the fuel is visually observed for proper appearance. A white paper or light background allows visual detection of contaminant in the fuel. A paper with black print or a bar chart (See ASTM Adjunct 12-441761-12) may be used as a background to enhance the detection of water haze.
b. White Bucket—Using a white (not tinted) porcelain lined bucket, the fuel is visually observed for proper appearance. The bucket must be of at least 8 quarts (7.5 L) capacity. (Do not use a plastic, epoxy lined or painted bucket for color determination.) A coin with well-defined features is a useful additional tool for further observing and evaluating a water haze. If the bucket is not equipped with a static bonding cable, a separate cable must be provided.

A.1.4 Sampling Methods

A.1.4.1 Cautions

Use care when opening any pressurized sample drain or tap to prevent splash or spill.

Operators should wear sufficient protective equipment to prevent contact with fuel, including eye protection, gloves, and appropriate clothing to prevent contact with fuel.

To minimize the risk of fire due to static electricity (electrostatic discharge), conductive containers must be properly bonded to the equipment from which the sample is being drawn. This bond must be maintained for 30 s after the sample is taken if drawn from a filter vessel or a sample tap downstream of a filter vessel.

A.1.4.2 Procedure for Glass Jar Test (From Sample Tap or Sump Drain)

A.1.4.2.1 Jar must be clean and free of water. Any volume in the drain or sample line should be removed/displaced to ensure that an accurate sample of what is in the sump is taken. Preferably with the system pressurized, draw a sample as quickly as possible from a sump or sample tap. Obtaining the sample under high velocity will flush debris from the system better than a sample taken at low velocity.

A.1.4.2.2 Allow air bubbles to rise to the surface for 1 min and observe (see Sec. A.1.5).

A.1.4.3 Procedure for Glass Jar Test (From Bucket)

A.1.4.3.1 Jar must be clean and free of water. Immediately after taking a white bucket sample as described in Sec. A.1.4.2, dip the jar into the bucket.

A.1.4.3.2 Allow any air bubbles to rise to the surface for 1 min and observe (see Sec. A.1.5).

A.1.4.4 Procedure for White Bucket Test

A.1.4.4.1 Bucket must be clean and free of water. With system pressurized (except when obtaining sample from a transport trailer or storage tank) obtain a sample with the sample valve open as far as possible without causing a spill. Any volume in the drain or sample line should be removed/displaced to ensure that an accurate sample of what is in the sump is taken. Fill the bucket to a depth of at least 6 in. (15 cm). A static bonding cable or wire must be connected between the bucket and the sample valve or associated pipe. A coin with well-defined features should be dropped into the bucket to assist in observing haze unless a jar sample is also taken. The features of the coin will be clearly visible if there is no haze

A.1.5 Evaluation of Sample

A.1.5.1 The white porcelain bucket is the sole proper means for evaluating product color in the fuel.

A.1.5.2 Observe the sample. If contamination is slight, swirling the sample will cause dirt or water to collect at the center of the sample container for easier observation.

A.1.5.3 Look for water droplets, particles, unusual color, haze, floating materials, lace-like layers and anything else that is not clean fuel.

A.1.5.4 If water is present, notice the color and the appearance of the surface of the water where it contacts the fuel.

A.1.5.5 Even if the sample does not appear to be cloudy, this does not ensure that the bucket is not full of water. Drop some food coloring or coffee into the sample. If the colored liquid added settles to the bottom as a colored drop, the sample is fuel, if the colored liquid dissolves into the sample, the sample is not fuel, but water. This is, of course, a serious concern and requires that a report of the test results be made immediately to an authority for determination of the proper action. Additional sampling will be required to remove all water, but in the case of a fuel delivery truck, it may be determined to simply refuse the load.

A1.5.6 Observe the color of the sample for any change in appearance from samples previously taken. Jet fuel should be colorless to a light straw and the color should be consistent with previous tests. Avgas color should be blue, green, red, brown (or possibly purple), according to grade.

A.1.5.7 Use the following tables to determine ratings for the tests and record the results. If a test result is significantly different from previous samples, report the results immediately to an authority for determination of the proper action.

A.1.6 Appearance Descriptions

The following tables make it easy to report a test result for permanent records and when necessary to communicate results to others.

A.1.6.1 Particle Appearance Ratings

Rating	Rating Guide (Optional)	Description
Clear	A	No visible particles, silt, sediment, dye (unusual fuel color), rust or solids
Slight particulate	B–C	Some fine to small size sized particles
Particulate matter	D	Many small particles either floating or settled on bottom
Dirty	E–I	Discoloration of the sample or many particles, either floating in fuel or settled on bottom

A.1.6.2 Water Contamination Appearance Ratings

Rating	Description
Bright	No water present either as liquid in bottom, drops on jar or haze. (Air bubbles may cause hazy apearance immediately after sample is drawn, but haze caused by air bubbles clears within 1 min.)
Hazy	Fine water droplets dispersed through sample. If the sample warms these may go away, but must be reported.
Cloudy	Sample appears cloudy, milky
Wet	Droplets or a layer of water; droplets may be found on side or bottom of container

A.1.6.3 Other Contaminant Appearance Ratings

Description of Sample Appearance and Possible Causes

Surfactant or Microbial

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.

Other Product Cross-Contamination

Unusual Appearance, Color, and/or Odor

Dye Contamination

Fuel dyes can cause red, green, blue, or any color combination in aviation fuel.

Fuel Aging

Darkened, discolored, and possibly more viscous, fuel with abnormal odor.

A final diagnosis should not be based on these descriptions. Further evaluation is required.

A.1.7 Visual Fuel Sampler Vessel ("Visijar")

1. In recent years, an additional method of performing the "Clear and Bright" or "White Bucket" test has been developed, the closed circuit sampler, also know as a visual fuel sampler or (Visijar.) A fuel sample is drawn from a sampling connection of a refueler or servicer monitor or filter/separator vessel (or from a fixed filter/separator or tank sump) into a Visijar and observed for water, solids, or indications of surfactants (Fig. 1).
2. The Visijar equipment is usually a 4 L (1 gal) capacity clear glass tube sandwiched between a base and hinged lid assembly. The base incorporates a drain valve and fill port. The internal surface of the base is conical in profile and finished in a white epoxy or similar fuel resistant coating. The Visijar can be installed in sample lines from filter/separators or monitors, or in sample lines from tank sumps.
3. To operate the Visijar, ensure the glass tube is clean. Open the fill valve. The fill port is designed to cause the fuel sample to swirl around the sides of the clear glass tube. The resultant rapid movement of the fuel assists in visual

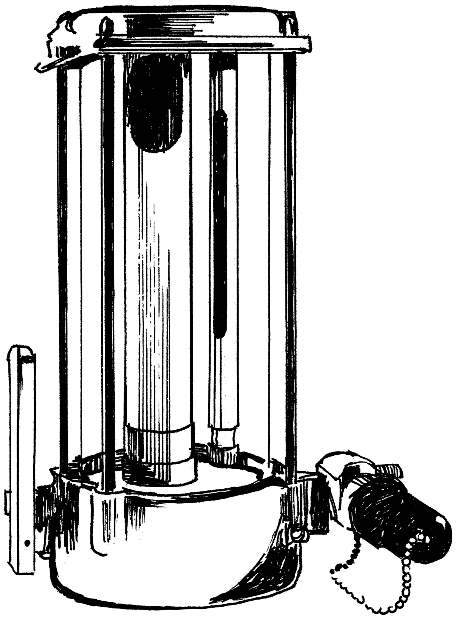


FIG. 1—Closed-circuit sampler (Visijar).

detection of any free water and/or dirt particles or indication of surfactants at the bottom of the Visijar.

   a. Let the sample settle for 1 min to remove air bubbles.
   b. Inspect the bottom for water droplets, solid contaminants, hazy/cloudy condition and/or brown slimes (see Sec. A.1.5.)
   c. If fitted with an optional self-sealing valve assembly for a Chemical Water Detector Test (Sec. C) draw a fuel sample from the base at this time.
   d. Open the drain valve to drain the glass tube.

4. Refer to Sec. A.1.6 for Cautions and Interpretation of Test Results.

A.2 API GRAVITY AND METRIC DENSITY

A.2.1 Introduction and Purpose

This procedure describes the means for measuring the gravity or density of aviation fuel with a hydrometer. A significant change in gravity or density may indicate contamination by another liquid product. Hydrometers may be calibrated in metric density, relative density, API gravity, or specific gravity. In this procedure, only API gravity and metric density will be discussed.

Note: API gravity is the primary measurement of fuel density used in the USA. Outside the USA, metric density is most commonly used. These two measures differ in several ways:

(1) API gravity is like specific gravity because it is related to the density of water. Finding the weight of a volume of fuel when only API gravity is known requires the use of ASTM 1250 tables or a specially designed calculator. Metric density is simply kilograms per cubic meter with no reference to the density of water. Finding the weight of a known volume of fuel when the metric density is known simply requires multiplying the volume times the metric density. Higher API gravity values indicate lighter fuels, whereas higher metric density values indicates heavier fuels.

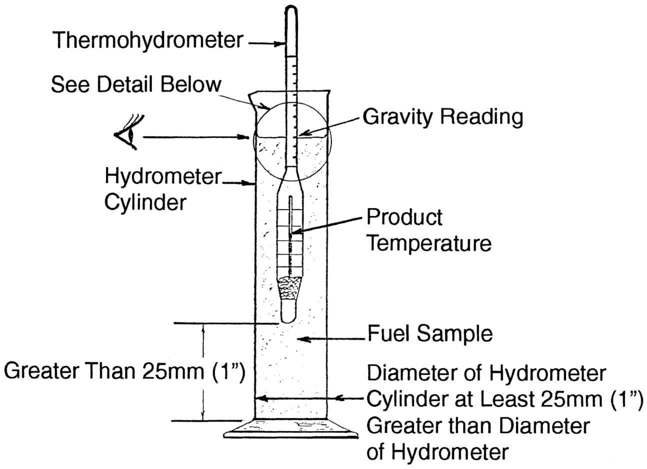


FIG. 2—Hydrometer cylinder and thermohydrometer for measuring API gravity.

(2) The standard temperature (defined temperature for comparing results from different batches or products) for API gravity is 60°F, whereas the standard temperature for metric density is 15°C (59°F).

(3) API gravity is related to specific gravity at 60°F by using the following equation:

■API = 141.5/(sp gr at 60°F)—131.5 where sp gr is specific gravity

A.2.2 References

ASTM D287—Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method).

ASTM D1250—Guide for Petroleum Measurement Tables (description only; tables published separately in 12 volumes).

ASTM D1298—Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.

ASTM E1—Specification for ASTM Thermometers.

ASTM E100—Specification for ASTM Hydrometers.

A.2.3 Description

The scale reading at the intersection of the fuel surface on a freely floating hydrometer and the temperature of the fuel at the time of the test are observed and recorded. The observed readings are then used to correct the gravity or density to the standard temperature applicable for the test.

A.2.4 Equipment

NOTE: ASTM and API have developed new standards to cover nonmercury thermometers, but nonmercury thermohydrometers (hydrometers with built-in thermometers) are not yet covered by an ASTM specification as of this printing.

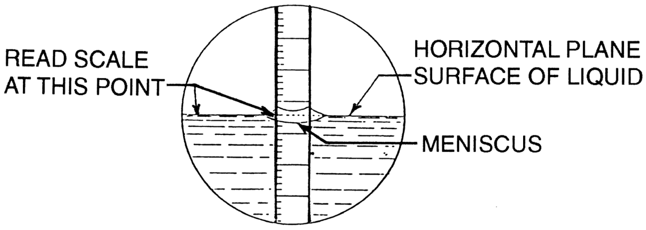


FIG. 3—Obtaining the observed hydrometer reading.

When these are available, this document will be modified accordingly. Nonmercury thermometers are now available. When used, it is recommended to use them in conjunction with plain hydrometers.

A. ASTM hydrometer and thermometer or thermohydrometers. ASTM specified hydrometers and thermohydrometers do not normally match any specific products, so two hydrometers may be needed to cover the range of fuels available. The Note showing "single span" indicates that this hydrometer covers the entire range of available fuels of this type (jet of avgas) typically found in use.

B. ASTM thermohydrometers include both a hydrometer and a thermometer in one device. ASTM plain form hydrometers, which do not contain a built-in thermometer, may be used with a separate thermometer.

C. Thermometers specified by ASTM E1 are graduated in either °F or °C. The specific thermometers recommended for aviation density measurements are the ASTM 12F (mercury type, graduated in °F) or the ASTM 12C (mercury type, graduated in °C). Corresponding nonmercury thermometers are ASTM S 12F and ASTM S 12C.2. Glass, plastic, or metal hydrometer cylinder as shown in Fig. 2. Clear glass or clear plastic cylinders are preferred, except in the "spill-over" type design.

API gravity	Type	Range	ASTM	Note
Avgas	Plain form hydrometer	59–71	7H	
""	Plain form hydrometer	69–81	8H	
""	Plain form hydrometer	64–76	12H	Single span
""	Thermohydrometer	59–71	7HL	
""	Thermohydrometer	69–81	8HL	
""	Thermohydrometer	64–76	258H	Single span
Jet A/A1	plain form hydrometer	29–41	4H	
""	Plain form hydrometer	39–51	5H	
""	Plain form hydrometer	37–49	11H	Single Span
""	Thermohydrometer	29–41	54HL	
""	Thermohydrometer	39–51	55HL	
""	Thermohydrometer	37–49	255H	Single span
Metric density	Type	Range	ASTM	Note

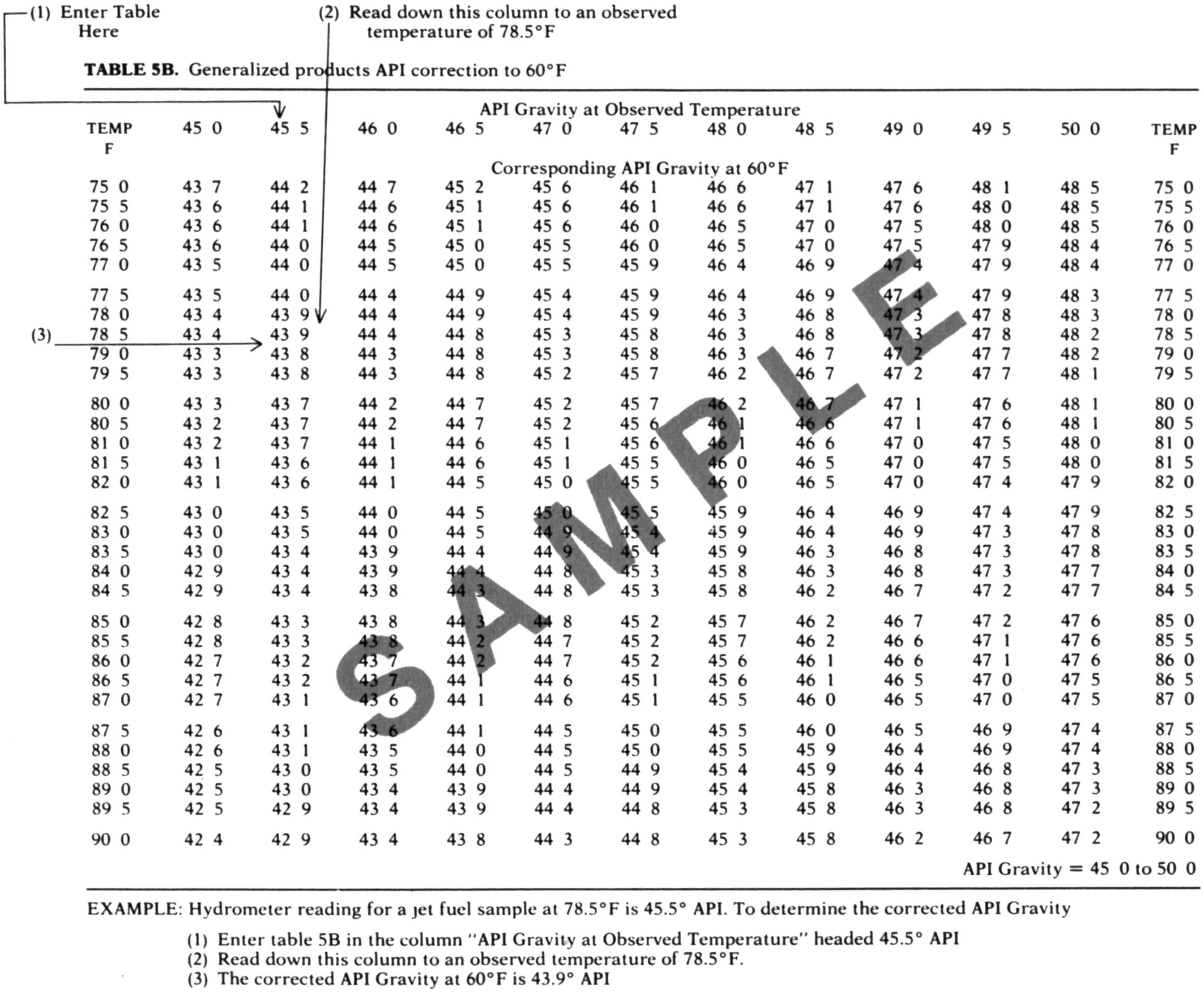
API gravity	Type	Range	ASTM	Note
Avgas	Plain form hydrometer	650–700	312H	
""	Plain form hydrometer	700–750	313H	
""	No single span hydrometer ASTM number assigned			
""	Thermohydrometer	650–700	301HL	
""	Thermohydrometer	700–750	302HL	
""	No single span thermohydrometer ASTM number assigned			
Jet A/A1	plain form hydrometer	750–800	314H	
""	Plain form hydrometer	800–850	315H	
""	Plain form hydrometer	775–825	321H	Single span
""	Thermohydrometer	750–800	303HL	
""	Thermohydrometer	800–850	304HL	
""	Thermohydrometer	775–825	345H	Single span*

* This thermohydrometer is not for use in very cold or very hot climates; it has a temperature range of only −10 to +40 °C.

A.2.5 Procedure

1. Collect the sample in a clean hydrometer cylinder and place it in a vertical position in a location free from air currents. Allow 1–2 min. for air bubbles to disappear. Remove any air bubbles that remain on the surface of the sample by touching them with the corner of a clean paper towel.
2. When using a thermohydrometer, gently lower it into the sample. When it has settled, depress it about two scale divisions into the liquid and then release it. Gently spin the hydrometer when releasing it. This will assist in bringing it to rest, floating freely away from the cylinder walls.

   When the thermohydrometer has come to rest and the thermometer is showing a steady reading, read and record the temperature of the sample to the nearest 0.5 °C or 1 °F. Read the hydrometer to the nearest scale division and record the value. The correct hydrometer reading is that point on the hydrometer scale at which the principal surface of the liquid cuts the scale (Fig. 3).
4. When using a plain form hydrometer, first measure temperature with an approved thermometer. Continuously stir the sample with the thermometer taking care that the mercury or mercury substitute liquid is kept fully immersed. As soon as a steady reading is obtained, read and record the temperature of the sample to the nearest 0.5 °C or 1 °F and then remove the thermometer. To obtain the hydrometer reading, follow the procedure described in paragraphs two and three above substituting a hydrometer for the thermohydrometer.
5. Correct the observed hydrometer reading to the standard temperature of (API) 60 °F (15.5 °C) or (metric) 20 °C. See Fig. 4.
6. Determine the corrected gravity measurement using the ASTM tables or a specifically designed calculator and report the value as API gravity.



(1) Enter Table Here

(2) Read down this column to an observed temperature of 78.5°F

(3)

TABLE 5B. Generalized products API correction to 60°F

API Gravity at Observed Temperature

Corresponding API Gravity at 60°F

TEMP F	45 0	45 5	46 0	46 5	47 0	47 5	48 0	48 5	49 0	49 5	50 0	TEMP F
75 0	43 7	44 2	44 7	45 2	45 6	46 1	46 6	47 1	47 6	48 1	48 5	75 0
75 5	43 6	44 1	44 6	45 1	45 6	46 1	46 6	47 1	47 6	48 0	48 5	75 5
76 0	43 6	44 1	44 6	45 1	45 6	46 0	46 5	47 0	47 5	48 0	48 5	76 0
76 5	43 6	44 0	44 5	45 0	45 5	46 0	46 5	47 0	47 5	47 9	48 4	76 5
77 0	43 5	44 0	44 5	45 0	45 5	45 9	46 4	46 9	47 4	47 9	48 4	77 0
77 5	43 5	44 0	44 4	44 9	45 4	45 9	46 4	46 9	47 4	47 9	48 3	77 5
78 0	43 4	43 9	44 4	44 9	45 4	45 9	46 3	46 8	47 3	47 8	48 3	78 0
78 5	43 4	43 9	44 4	44 8	45 3	45 8	46 3	46 8	47 3	47 8	48 2	78 5
79 0	43 3	43 8	44 3	44 8	45 3	45 8	46 3	46 7	47 2	47 7	48 2	79 0
79 5	43 3	43 8	44 3	44 8	45 2	45 7	46 2	46 7	47 2	47 7	48 1	79 5
80 0	43 3	43 7	44 2	44 7	45 2	45 7	46 2	46 7	47 1	47 6	48 1	80 0
80 5	43 2	43 7	44 2	44 7	45 2	45 6	46 1	46 6	47 1	47 6	48 1	80 5
81 0	43 2	43 7	44 1	44 6	45 1	45 6	46 1	46 6	47 0	47 5	48 0	81 0
81 5	43 1	43 6	44 1	44 6	45 1	45 5	46 0	46 5	47 0	47 5	48 0	81 5
82 0	43 1	43 6	44 1	44 5	45 0	45 5	46 0	46 5	47 0	47 4	47 9	82 0
82 5	43 0	43 5	44 0	44 5	45 0	45 5	45 9	46 4	46 9	47 4	47 9	82 5
83 0	43 0	43 5	44 0	44 5	44 9	45 4	45 9	46 4	46 9	47 3	47 8	83 0
83 5	43 0	43 4	43 9	44 4	44 9	45 4	45 9	46 3	46 8	47 3	47 8	83 5
84 0	42 9	43 4	43 9	44 4	44 8	45 3	45 8	46 3	46 8	47 3	47 7	84 0
84 5	42 9	43 4	43 8	44 3	44 8	45 3	45 8	46 2	46 7	47 2	47 7	84 5
85 0	42 8	43 3	43 8	44 3	44 8	45 2	45 7	46 2	46 7	47 2	47 6	85 0
85 5	42 8	43 3	43 8	44 2	44 7	45 2	45 7	46 2	46 6	47 1	47 6	85 5
86 0	42 7	43 2	43 7	44 2	44 7	45 2	45 6	46 1	46 6	47 1	47 6	86 0
86 5	42 7	43 2	43 7	44 1	44 6	45 1	45 6	46 1	46 5	47 0	47 5	86 5
87 0	42 7	43 1	43 6	44 1	44 6	45 1	45 5	46 0	46 5	47 0	47 5	87 0
87 5	42 6	43 1	43 6	44 1	44 5	45 0	45 5	46 0	46 5	46 9	47 4	87 5
88 0	42 6	43 1	43 5	44 0	44 5	45 0	45 5	45 9	46 4	46 9	47 4	88 0
88 5	42 5	43 0	43 5	44 0	44 5	44 9	45 4	45 9	46 4	46 8	47 3	88 5
89 0	42 5	43 0	43 4	43 9	44 4	44 9	45 4	45 8	46 3	46 8	47 3	89 0
89 5	42 5	42 9	43 4	43 9	44 4	44 8	45 3	45 8	46 3	46 8	47 2	89 5
90 0	42 4	42 9	43 4	43 8	44 3	44 8	45 3	45 8	46 2	46 7	47 2	90 0

API Gravity = 45 0 to 50 0

EXAMPLE: Hydrometer reading for a jet fuel sample at 78.5°F is 45.5° API. To determine the corrected API Gravity

(1) Enter table 5B in the column "API Gravity at Observed Temperature" headed 45.5° API
(2) Read down this column to an observed temperature of 78.5°F.
(3) The corrected API Gravity at 60°F is 43.9° API

FIG. 4—Correction of observed API gravity to standard temperature. (Reprinted courtesy of the American Petroleum Institute, Washington, DC, Bulletin 1542.)

A.2.6 Cautions

1. The hydrometer must float freely to obtain a correct reading. It must not come to rest against the side or bottom of the cylinder during the test.
2. The thermometer should not be completely removed from the liquid to read temperature. Evaporation of liquid from the thermometer stem and bulb will lower the temperature and cause an incorrect reading.
3. Hydrometers and thermometers must be inspected periodically to be sure that they are not cracked or that there are no separations of the mercury or oil/alcohol column.

A.2.7 Interpretation of Results

1. Once a batch of fuel is produced, its gravity, or density, corrected to a standard temperature does not significantly change. While test results may differ within the method's limitations of reproducibility, a change greater than ±1.0 deg API or 4 kg/M^3 should warrant an investigation to confirm that contamination has not occurred. If test results in a differ more than usual, but less than 1.0 API or 4 kg/M^3, heightened awareness should be exercised in evaluating other quality tests such as the white bucket and membrane tests.
2. If a gravity/density reading in one set of units must be compared to one that was reported in a different set of units, use conversion tables in ASTM D1250. Alternatively, the following equations may be used to convert between deg API and relative density (specific gravity), but not metric density (see Sec. A.2.1 Para 4):
   Degrees API = (141.5/relative density) − 131.5
   Relative density = (141.5/deg API + 131.5)
3. The procedure presented here is used to help detect possible cross-contamination (by other miscible liquids) of a

fuel by comparing gravity measurements. It is necessary to correct hydrometer readings to a standard temperature.

4. Another use of hydrometers at an airport is to determine fuel weight at the fueling temperature. In this case, temperature correction must **NOT** be made. This measurement must be taken immediately and reported as "observed."

A.3 SUMP SAMPLING

A.3.1 Introduction and Purpose

The purpose of sump sampling is to check for the presence of water and other contaminants in any fuel handling system. With adequate settling time, much of the free water and solid particles, if present, will normally drop to the tank bottom or system low point. Removal of these contaminants is accomplished by completely drawing off the water through a sump drain valve. This is done to help maintain a clean fuel environment and show any changes from the appearance of previous samples, which might indicate a fuel problem and/or an equipment or filter failure.

White buckets are preferred, but in some cases stainless steel buckets are also used. Please note a white bucket is required in the detection of fuel color problems.

A.3.2 References

There is no known published test standard on this subject.

A.3.3 Description

Fuel is drawn off at various locations throughout a system. These samples are usually taken in a clean white bucket or similar container. The fuel volume required to effectively flush and evaluate that point of the system will depend on the design and type of equipment being sumped.

A.3.4 Equipment

1. Clean white porcelain (for color determination) enamel or stainless steel bucket.
2. Thief or scavenger pump (for underground tanks and barges).

A.3.5 Procedure

Sampling in all cases should be done in accordance with the White Bucket test method (Sec. A.1.4.4). A sample may be further evaluated by the Clear and Bright test and the Odor test methods (Sec. A.1.6).

1. Above Ground Tanks

Open drain valve quickly and far enough to ensure that the settled contaminants at the tank low point (sump) are drawn into the drain line. Sufficient, but not excessive, quantity should be drained to ensure that the pipe extending into the tank sump is completely flushed (see NOTE after 3 below). Now draw a sample for evaluation. Be sure to draw fuel from the system sufficient to remove the debris and/or water from inside the tank, and do not flush before taking the sample, as you will then not see that contamination. Very large tanks, with large drain lines may require many gallons of fuel to be drained (to displace the fuel already in the drain line) before you actually see the contaminants removed from the sump. Special consideration should be given to open, floating roof tanks that require more attention after heavy rain than a covered tank. Flat bottom tank designs present additional problems requiring attention. These designs make it impossible to remove all the water from the bottom of the tank, even with proper sump draining. Because of these special considerations, sump sampling frequency must be tailored for each installation.

2. Barges and Underground Tanks

These are sumped with the use of a thief or scavenger pump. The sumping of these vessels should be accomplished at the lowest point of the tank. Sufficient quantity should be pumped to ensure that the line content plus water and other contaminants have been removed. The sump samples should then be evaluated. (See note after 3 below).

3. Filter Vessels

Filter vessel sumping should be done under pressure to ensure that water and other contaminants in the sump and its immediate area have been removed from the vessel. Depending on use and design of the system, frequency of sump sampling should be tailored to each facility.

NOTE

For example, 25 ft (7.62 m) of 1 in. (2.54 cm) pipe will hold about 1 gal (3.8 L), whereas the same length of 3 in. (7.62 cm) pipe will hold about 9 gal (34 L). A small drain line is preferred.

4. Tank Trucks/Railroad Tank Cars

The vehicle should stand as long as practical, but no less than 10 min, to allow any water or other contaminant that might be present to settle. Sump each compartment and piping low point before unloading the vehicle. This will ensure that all water and other contaminants that may have collected at these low points will be removed from the vehicle prior to unloading into the system. Each sump sample should be evaluated.

5. Aircraft Refueling Vehicles

Vehicle low point and filter sumps should be drained at least daily at all compartment low point drains. Draw off a sufficient quantity to ensure that the sump and the line going to that sump have been drained. The sump sample should be taken at a high flow rate to drain off all water and other contaminants that may have collected at or around each sump inside the compartment. The sump sample should then be evaluated.

6. Pipe System Low Points

Hydrant and pipe line delivery systems normally have low point drains that can be used to remove water or other contaminants. When sumping low points on a pipe line, the line must be under pressure but not flowing. A sufficient quantity must be removed to completely flush the low point and its drain line. Low point samples should then be evaluated.

A.3.6 Cautions

1. All samples should be disposed of or recycled in an approved manner.
2. Equipment should be properly bonded to prevent electrostatic spark discharge.

A.3.7 Interpretation and Limitation of Results

A sump sample that consists of "clear and bright" fuel is considered satisfactory (see **NOTE**). Any sump sample that is not clear and bright indicates a need for additional sumping. If, after reasonable amounts of fuel have been drained the sample is still not acceptable, supervision should be notified for further action.

Records of all sump draining should be maintained and should indicate the condition of the fuel when first evaluated and the amount and nature of any contaminant found.

NOTE

If there is any question whether the sample is fuel or water, refer to Sec. C, Water Detection.

A.4 ELECTRICAL CONDUCTIVITY—PORTABLE METER METHOD

A.4.1 Introduction and Purpose

Conductivity of aviation fuels, while normally very low, can be increased with the use of static dissipater additives. By sufficiently increasing the electrical conductivity, the potentially dangerously high static charges that are generated during normal pumping and filtration operations are readily dissipated and prevented from accumulating in a receiving tank. (See Sec. A.14.8 for additional information.) When these additives are used, fuel conductivity should be within limits specified in the fuel specifications, for example, ASTM Specification for Aviation Turbine Fuels (D 1655).

A.4.2 References

ASTM D1655—Specification for Aviation Turbine Fuels.

ASTM D2624—Test Methods for Electrical Conductivity of Aviation and Distillate Fuels.

ASTM D4306—Practice for Sampling Aviation Fuel for Tests Affected by Trace Contamination.

A.4.3 Description

The test probe is immersed in the fuel. The conductivity of the fuel will be indicated on the meter when the instrument is energized.

A.4.4 Equipment

Portable Meters—EMCEE conductivity meters or Maihak conductivity indicator (refer to ASTM D2624.)

A.4.5 Procedure

Rinse the probe and sample container using the fuel under test. Calibrate the meter following the manufacturer's instructions. Immerse the probe in the fuel, energize the instrument, wait for approximately 3 s (see manufacturer's instructions) and read the conductivity in conductivity units (C.U.)—C.U. $= \text{pS/m} = \text{Pico Siemens per m} = 10^{-12}\ \Omega^{-1}/\text{m}$.

A.4.6 Cautions

1. If checking conductivity within a storage tank, wait at least 30 min after pumping into the tank before inserting the equipment probe. Just prior to inserting the probe, bond the meter to the storage tank to prevent static discharge in case the fuel is charged.
2. Do not use probe in areas where water may be present. If the probe has contacted moisture or wet fuel, follow the manufacturer's instructions for proper cleaning.
3. If a sampling container is used, ensure that the container is metallic and properly bonded to the instrument; see ASTM D4306 for recommended containers.
4. Ensure cleanliness of sampling container by flushing with some of the test sample.
5. The conductivity of fuels (in clear glass containers) that contain static dissipater additives is affected by sunlight and other strong light sources.
6. Conductivity is a function of temperature. Typically conductivity will increase/decrease 2–3 C.U. per one degree change in temperature.

A.4.7 Interpretation and Limitation of Results

Conductivity of untreated fuel is generally less than 10 C.U. Properly treated fuel ranges between 50 and 600 C.U. These readings reflect the amount of additive in the fuel and are affected by temperature and time. Due to the effects that temperature and time have on treated fuel, discrepancies in repeatability of readings may occur.

A.5 FLASH POINT BY SMALL SCALE CLOSED TESTER

A.5.1 Introduction and Purpose

This test may be used to: (1) determine whether a kerosene type jet fuel will flash at a specified temperature, (2) determine the actual flash point temperature of the fuel, and (3) determine the presence of volatile contaminants in the fuel.

Flash point is defined as the lowest temperature of the fuel sample at which application of an ignition source causes the vapors above the sample to ignite under specified test conditions.

A.5.2 References

ASTM D3828—Test Methods for Flash Point by Small Scale Closed Tester.

A.5.3 Description

The tester is preheated and stabilized at the desired target temperature. A 2 mL sample is injected through a self-sealing filler port into the closed sample cup of the tester. After 1 min, the test flame is introduced into the sample cup and the observation of a flash or no flash is made and recorded for that target temperature. Since it is portable, this test may be used for fuels throughout the entire distribution system, from the point of fuel manufacture to the aircraft fuel tank.

A.5.4 Equipment

1. Small Scale Closed Cup Tester

The complete instrument meeting all the requirements of ASTM D3828 is available commercially through laboratory supply houses.

2. Sample Containers

Either clean screw cap metal cans or clean glass bottles with tight fitting corks or stoppers must be used.

3. Test Flame Gas Supply

The test flame may be fueled by either natural gas (at fixed locations) or by a portable, self-contained gas supply, for example, butane or propane cylinders.

A.5.5 Method A Procedure—Flash/No Flash Test

1. Obtain a representative sample of the product in question by filling the sample container to approximately one quarter full, capping it, and shaking thoroughly. Discard this rinse fluid; this should be done three times. Completely fill the rinsed sample container to its maximum safe working level (usually about 95% full) and cap it securely.
2. Connect tester to appropriate electrical and gas services, switch on, then turn coarse temperature control knob fully clockwise. Observe the thermometer periodically. When the thermometer is about 5 °F (2.75 °C) below the target temperature, adjust heat input by turning coarse control knob counter-clockwise. After a few minutes, the indicator light will slowly cycle on and off. At this point, check the temperature; if this is not the target temperature, adjust heat input with fine (central) control knob to obtain target temperature. When the indicator light cycles on and off, the sample cup is at target temperature.
3. Open the sample container in a draft-free location and withdraw a 2 mL sample using the present syringe. Discharge this sample to waste. Take a second 2 mL sample from the container and transfer it through the filling port orifice without losing any sample. Inject the sample into the cup by fully depressing the plunger of the syringe. Remove syringe from filling orifice.
4. Set 1 min timer by rotating its knob clockwise to its stop. Open the gas control valve and light the pilot and test flames, adjusting the test flame to a 4-mm diameter (the same size as the test flame gage inscribed on the cup lid). After 1 min, apply test flame by slowly and uniformly opening the shutter, then closing it over a period of approximately 2 s. Observe whether there is a flash at the cup opening. The sample has flashed if a large blue flame appears and spreads over the sample surface. A halo around the test flame is not a flash and should be ignored.
5. The result is recorded as a "flash at …temperature" or "no flash at …temperature."
6. After the test, turn off the gas supply, clean up instrument, and allow to cool off.

A.5.6 Method B Procedure—Actual Flash Point Determination

1. Same as Method A.
2. Same as Method A.
3. Same as Method A.
4. Same as Method A.
5. Turn off the pilot and test flame. When the temperature drops to a safe level, remove the sample and clean the instrument. If a flash occurred in the previous test, repeat the procedure with a new specimen at a temperature 9 °F (5 °C) below that at which the flash was observed. If necessary, repeat this procedure until no flash is observed. If no flash occurred in the previous test, repeat the procedure with a new specimen at a temperature 9 °F (5 °C) above that at which no flash was observed. If necessary, repeat this procedure until a flash is observed.
6. Having established a flash within two temperatures 9 °F (5 °C) apart, repeat the procedure, with a new specimen for each test, raising the temperature in 2 °F (1.1 °C) intervals from the lower of the two temperatures until a flash is observed. Record the temperature on the thermometer as the flash point at the time the test flame application causes a distinct flash in the fuel sample cup.
7. After the test, turn off the gas supply, clean up the instrument, and allow it to cool.
8. If it is desired to correct the observed flash point for the effect of barometric pressure, refer to ASTM D3828.

A.5.7 Cautions

The operator must take appropriate safety precautions during the preparation and initial application of the test flame to the sample. Samples containing low-flash material may give an abnormally strong flash when the test flame is first applied.

A.5.8 Interpretation of Test Results

The results indicate the possible presence of the following:

A flash point lower than expected may be caused by contamination by small quantities of light end contamination, for example, avgas (aviation gasoline), or mogas (motor gasoline) in Jet A or Jet A-1 that can arise from poor distribution practices [for example, 1 gal (3.8 L) of avgas in 1000 gal (3785 L) of Jet A may lower the flash point of the mix by 5 °F (2.75 °C) or more]. Off-specification product can be caused by from poor quality control in manufacture or transportation.

A.6 PRODUCT IDENTIFICATION

A.6.1 Introduction and Purpose

The purpose of this section is to describe general or field techniques used to identify aviation fuels and to determine if product mixing may have occurred.

A.6.2 References

ASTM D910—Specification for Aviation Gasolines.

ASTM D1655—Specification for Aviation Turbine Fuels.

API/EI Bulletin 1542—Airport Equipment Marking for Fuel Identification.

A.6.3 Description

Chart 1 lists tests that can be performed for determining product identity or contamination of aviation fuel. The only field tests on this chart that are commonly used for product identification are gravity and color, but some locations may be able to perform flash. Other tests are often done, such as membrane color, but for fuel quality, not product identification. In cases where there is still any doubt as to product identity, a product sample (1 gal, 3.8 L, minimum in an approved sample container) should be sent to a fuel testing laboratory for identification (Sec. A.9, shipment and handling procedures).

A.6.4 Equipment

Equipment (Chart 2) is described in Sec. A.2 for determining API gravity or metric density. Flash point equipment is described in Sec. A.5. A clear glass sample container is used for observing color (for example, a hydrometer cylinder).

A.6.5 Procedure

1. For Jet A and Jet A-1 fuels, run API gravity (or relative density) tests described in Sec. A.2 and flash point tests described in Sec. A.5.
2. For Jet B fuels, run API gravity (or relative density) tests described in Sec. A.2.
3. For avgas fuels, run API gravity (or relative density) tests described in Sec. A.2 and color test as described below.
    a. Obtain small sample (pint or quart) of avgas in a clear, glass sample container.
    b. Observe the color and appearance of the avgas. It should be clear and bright and the correct color for the specified grade (Chart 1) with no cloudiness or indication of contamination with another color (Sec. A.1).

A.6.6 Cautions

Be sure to properly dispose of aviation fuel samples. Safe handling procedures and regulating agency requirements must be followed.

A.6.7 Interpretation of Test Results

1. Refer to Sec. A.2 for interpretation of API gravity or metric density results.
2. 2. Refer to Sec. A.5 for interpretation of flash point results.
3. If jet fuel is not clear and bright, or avgas is not clear and bright as well as of the proper color, the fuel is suspect and a sample should be sent to a fuel testing laboratory for identification.

Field Test	Section Reference	Jet A or Jet A-1	Jet B	Avgas		
				Grade 80	Grade 100	Grade 100LL
Gravity °API (60°F)	A.4	37–51	45–57	64–75[b]		
Relative Density 60/60°F[a] (Specific Gravity)	A.4	.7753–.8398	.7507–.8017	.6852–.7238[b]		
Flash Point	A.7	100°F (37.8°C) (Min.)	Below 0°F (−18°C)	Below 0°F (−18°C)		
Fuel Color	A.8	Colorless to Light Amber		Red[c]	Green	Blue
Equipment Color Code[d]	A.8	Black-Jet A Gray-Jet A-1	Yellow	Red	Green	Blue

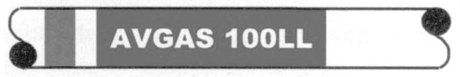
[a] There are hydrometers available for use in the field which give a direct reading of pounds per gallon.

[b] There are no ASTM specification limits, but these typical ranges are derived from the Energy Research and Development Administration.

[c] If agreed upon between purchaser and supplier, grade 80 may be free from lead. If so, the fuel may not contain any dye and then will be essentially colorless.

[d] Detailed recommendations for airport equipment marking for fuel identification are noted in Chart 2 (from API Bulletin 1542).

CHART 1—Field tests for determining product identity or contamination.

Product	Loading Valve, Joints, Valves, and Fittings (Colour Code)	Pump, Meter, Piping and Filters	Banding	Marking
Aviation Gasoline Grades				
Avgas 80	Red	White[a]	1–Red	
Avgas 82UL	Purple	White	1–Purple	
Avgas 91	Brown	White	1–Brown	
Avgas 100	Green	White[a]	1–Green	
Avgas 100LL	Blue	White[a]	1–Blue	
Aviation Turbine Fuels				
Jet A	Black	White[a]	1–Black	
Jet A–1	Black	White[a]	2–Black	
Jet B	Yellow	White[a]	3–Yellow	

[a] Aluminium is equally suitable - or, if piping is all the colour shown for the product loading valve, joints, and fittings, no banding is necessary.

CHART 2—Airport equipment marking for fuel identification, recommendations for airport installations. (Taken from API/EI Standard 1542, Identification Marking for Dedicated Aviation Fuel Manufacturing and Distribution Facilities, Airport Storage, and Mobile Fueling Equipment, Seventh Edition, August 2002. Reproduced courtesy of the American Petroleum Institute.)

A.7 ELECTROSTATIC HAZARDS IN MIXING AVIATION FUELS

A.7.1 Introduction and Purpose

Although nonmilitary turbine powered aircraft are usually fueled with Jet A or Jet A-1 fuels, it is sometimes necessary to refuel them with lower flash point fuels, such as JP-4 or Jet B, as approved by the airframe manufacturer or type certificate. (Note: Flash point is not an issue with JP-5 and JP-8 turbine fuels because they have flash points similar to or greater than Jet A and Jet A-1.) When lower flash point fuels are used the vapor space above the mixed fuels likely is flammable thus more easily ignited by electrostatic discharges. This use of lower flash point fuels is inherently more dangerous than fueling with jet fuel. Subsequent defueling or refueling operations are also more dangerous due to the vapors in the fuel tank, even after later dilution with Jet A or Jet A-1 fuel. It is important to notify ground fueling personnel and those responsible for their safety when an aircraft fuel system may contain fuel with flash point less than 100°F. Note that the use of lower flash point (wide cut) fuels (JP-4 and Jet B) is being phased out but they continue to be used particularly in areas with very low temperatures.

A.7.2 References

No official reference is known to exist for this, but some aircraft manufacturers may have individual aircraft fueling procedures.

A.7.3 Description

The vapor space in a turbine powered aircraft tank contains a mixture of air and fuel vapor. For kerosene type fuels, this mixture is seldom ignitable because the amount of fuel vapor from these fuels (Jet A and Jet A-1, as well as JP-5 and JP-8) is quite small, making the fuel-air mixture too lean to burn. However, when the tank is being (or has been) contaminated with or serviced with a more volatile fuel, such as avgas (or very rarely wide-cut turbine fuel still in use at some locations—Jet B or JP-4), the vapor space mixture can fall within the flammable range.

NOTE

Aviation gasoline is not recommended for turbine powered aircraft by any engine manufacturer.

Flammable conditions can also occur if tanks that previously had been serviced with a wide-cut (Jet B, JP-4 or similar fuel) product are fueled with kerosene type, or when the kerosene type product is serviced to aircraft at ambient temperatures above the flash point. The hazard associated with fueling and defueling under those conditions is the possibility of electrostatic induced ignition.

A.7.4 Caution

The aircraft flight crew must know the type of fuel introduced into the aircraft tanks in at least the last two fuelings so that the next fueling operator can be advised if a dissimilar fuel is to be loaded.

This section is included in this manual for the purpose of making fueling operators aware of the potential hazard of mixed fuels. ASTM neither endorses any procedure nor is prepared to write a recommended procedure that would eliminate hazards associated with electrostatic discharges.

A.8 PRESERVICE CLEANLINESS INSPECTION OF FUELING EQUIPMENT

A.8.1 Introduction and Purpose

The proper inspection of a new, refurbished, or repaired refueler or dispenser, prior to placing the unit into service, is of the utmost importance to ensure that only quality fuel is to be dispensed.

Refueler tanks and dispensing equipment may contain water, solid contaminants, or a mixture of fuels or off-specification fuel after being fabricated, repaired, or tested.

A.8.2 References

There is no known published standard for this inspection. There are, however, procedures established by some aircraft fueling companies or airlines.

A.8.3 Description of Inspection Procedures

The commissioning of equipment is basically a visual inspection of the equipment followed by a test of the first fuel to be dispensed by the unit. The fuel is tested for particulate matter and water before the equipment is put into service.

A.8.4 Equipment

The required equipment for this procedure includes a white bucket (Sec. A.1.2), field sampling kit (Secs. B.1–B.2), and water detection kit (Secs. C.1–C.5).

A.8.5 Procedure

1. Prior to filling the refueler, inspect all tank compartments for foreign matter and water. Clean tanks as required.

CAUTION

Tank cleaning must be accomplished in accordance with local, state, and national guidelines.

2. Drain all sumps and low points. Be sure to close all valves and reinstall plugs.
3. Ensure the filter elements and filter vessel accessories are properly installed and operating.
4. In the case of refuelers, fill unit approximately $\frac{3}{4}$ full with clean product. While filling, check that there are no leaks and verify tank vents and high level shut-off prechecks are functioning. Sample all tank and filter sumps (Sec. A.3).
5. Flush the refueler or dispenser piping system with clean fuel, taking care at first to ensure that all the air has been removed from the system. Flush twice the volume of the fueling circuit into a downgrade fuel receptacle or tank. Check for leaks while flushing.
6. Circulate clean product in the refueler or dispenser for approximately 30 min at maximum obtainable system flow rate (not to exceed the filter rated capacity).

CAUTION

Fuel flow in a refueler should be accomplished by means of a proper recirculation system. Recirculating the fuel through the bottom loading system may result in fuel circulation in the piping only. Flow should be established through the recirculation system (if so equipped) or through a drop tube designed to prevent the free fall or splashing of fuel. A test stand is preferable.

7. After circulation in step 6 is completed, take a sample of the fuel from each nozzle and filter sump. Also, take a sample from the tank of the refueler. Evaluate the samples for appearance, water, and particulate content (Sec. A.1). Continue circulating as necessary until samples are acceptable.
8. Check nozzle screens, clean as required, and reinstall.
9. New fuel hose must be properly prepared prior to use. The

process has been historically located in the API-1529, but has been relocated to Sec. A.15 of this publication.

10. If the product quality has deteriorated after the refueler or dispenser has been allowed to stand for a period of time, as mentioned above, continue fuel circulation and recheck fuel quality. Circulate until the fuel is of acceptable quality. If the fuel is not of acceptable quality, check filters and change if necessary. Repeat test starting with step 6. If fuel has been stored a long time, typically 6 months or more, the oil company or airline may require recertification to D1655 or D910.

11. Fuel soak and flushing procedures detailed in steps 9 and 10 may only be bypassed with approval by the appropriate authority as local operating conditions (equipment availability) dictate.

12. During the final recirculation step, perform a filter membrane test (Secs. B.1–B.2), check fuel for water (Secs. C.1–C.5), and record the differential pressure across the filter (Sec. D.5).

13. Additional serviceability checks that should be considered are:

a. primary and secondary pressure controls,
b. meter calibration,
c. brake and fueling interlocks, and
d. other safety features.

A.9 SHIPMENT OF AVIATION FUEL SAMPLES

A.9.1 Obtaining Samples and Flushing Sample Cans for Shipment to Laboratory

It is important that samples are taken carefully so the fuel tested at the laboratory is representative of the fuel in the system. In addition it is critical that the sample can does not contaminate or change any characteristic of the fuel sample.

A.9.1.1 Flushing Sample Cans

The sample can must be in compliance with any requirements for shipping, such as U.S. Department of Transportation (DOT), International Air Transportation Association (IATA), and International Civil Aviation Organization (IACO). The can must be epoxy lined and meet the requirements of ASTM D4306, Sec. 6 in regard to not having a negative effect on sample integrity.

It is strongly recommended to soak a full can overnight (known as "pickling") before flushing. Proper flushing requires at least three rinsings with the fuel being sampled. Fill the can about 10–20 % full (less than a quarter full) and shake vigorously for 1 min and drain completely. Discard each rinse.

Prior to filling the sample can, the sample connection and hardware must be flushed to make sure the sample is representative of the fuel in the system.

A.9.2 General

There are very restrictive rules and regulations that govern the shipment of hazardous materials. It should be clearly understood that all grades and types of jet fuels (both kerosene and naphtha-based), aviation gasolines (avgas), and used filter cartridges containing fuel residues are currently considered hazardous materials when shipped as cargo by air. Classification of product shipped, type of container used, labeling, and other factors greatly impact the shipping procedures that must be followed when selecting the method of transportation for fuel samples. It is important to note that the size and quantity of fuel samples for shipment on passenger carrying aircraft is closely regulated.

There may be different packaging and labeling requirements when shipments are on passenger versus dedicated freight hauling aircraft, either on domestic or international flight segments. Shipping regulations of hazardous goods on ground or marine transportation may also be significantly different than on aircraft.

In 1990, most major U.S. airlines adopted the ICAO, regulations as contained in the IATA resolutions governing shipments of hazardous material on passenger carrying aircraft. Some air transportation operators may still be following DOT shipping regulations.

Therefore, each prospective shipper of a hazardous material must contact the carrier of choice, either air, ground, or marine, for specific information necessary to meet their regulations. Sample containers should conform to the requirements of ASTM D4306.

A.9.3 References

ASTM D4306—Practice for Sampling Aviation Fuel for Tests Affected by Trace Contamination.

DOT (Department of Transportation) Code 49 of Federal Regulations, Parts 100–199.

IATA (International Air Transportation Association) Dangerous Goods Regulations.

ICAO (International Civil Aviation Organization) Technical Instructions for the Safe Transportation of Dangerous Goods by Air.

A.10 FIELD TEST FOR CONTAMINATION OF AVIATION GASOLINE WITH HEAVIER FUELS

A.10.1 Introduction and Purpose

Contamination of avgas by small amounts of heavier petroleum products, such as jet fuel, kerosene, and diesel fuel, may be difficult to detect in the field because the fuel dye masks color changes. When more sophisticated laboratory tests are unavailable, this test can provide an indication that a heavy petroleum contaminant is present in the fuel in significant quantity.

A.10.2 References

There is no published standard for this test. A similar procedure has been distributed by the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation, "Detecting Jet Fuel Contamination of Avgas," Safety Notice 1.

A.10.3 Description

Drops of the sample fuel and a known uncontaminated sample are each placed on a piece of paper. After the avgas evaporates, the spots are compared. The presence of a translucent (semitransparent) ring around the test fuel sample point, after a specified time interval, is a positive indication of contamination by heavier products.

A.10.4 Equipment

1. *Medicine Droppers and Clean Test Vials*. The specific type is not important but all droppers must be the same kind and size for each test.
2. *Test Paper*. The type of paper is not critical and any paper that will absorb the fuel drops should be satisfactory. Whatman No. 1 filter paper or standard note book paper is acceptable.
3. Stop watch or a watch with a second hand.
4. Sample of fuel from source known to be uncontaminated (base standard).

NOTE

Do not assume fuel upstream of the point of sampling is uncontaminated. It may be desirable to store a small sample of known good product for use when needed.

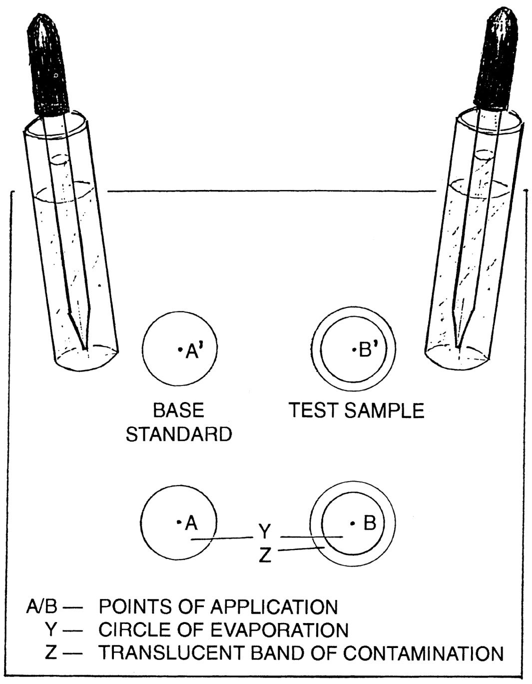


FIG. 5—Drop testing of a known good fuel (base standard) and fuel in question (test sample).

A.10.5 Procedure

1. Although the test can be performed under a variety of conditions, advantage should be taken of any available shade or shelter.
2. Make four pencil dots about 2 in. (5 cm) apart on a piece of test paper as shown in Fig. 5. Label two adjacent dots, A and A′ for the base standard, and two dots, B and B′ for the test sample.
3. Fill a clean medicine dropper with the base standard. Place the filled dropper in a small empty vial or bottle for support. In a like manner, fill a second dropper with the sample to be tested.
4. With one hand, hold the test paper horizontally and with the other hand, pick up the dropper containing the base standard. Holding the dropper immediately over point A, discharge *a single* drop of gasoline. Move the dropper to A′ and repeat the application. Replace the medicine dropper in its holder.
5. Immediately take the dropper containing the test sample and place single drops at points B and B′ and replace this dropper.
6. As soon as the fuel is evaporated from the base standard [about 10 s at 90°F (32°C) about 30 s at 50°F (10°C)], apply second drops of base standard to A and A′. Similarly, apply drops of the test sample at B and B′.
7. Repeat the application until five (5) drops have been added to each dot. After the last fuel drops have evaporated, pick up the paper and look through it towards an indirect light source and observe the four spots. If outside, hold it towards a portion of the sky away from the sun. Indoors, use a window or fluorescent or incandescent light. The inner circle (*Y* in Fig. 4) will dry rapidly. If there is contamination, the outer ring (*Z* in Fig. 4) will be translucent and remain visible for a longer period.

A.10.6 Cautions

When applying the drops to the test paper, try to add at the center of the spot each time and keep the drops about the same size. If more than one drop is added at a spot at the same time or if a spot is flooded in some other manner, discard and begin the test again on another piece of paper.

A.10.7 Interpretation and Limitations of Results

If no translucent outer ring (*Z*) appears or it disappears before 20 s after the base standard, report "no contamination by filter paper test." If the translucent band (*Z*) of the test sample remains longer than 20 s after that of the base standard, report "contamination by filter paper test." If contamination is indicated, the fuel should be immediately quarantined for more intensive testing.

If the type of contamination is not known, some information on the contaminating product may be obtained by examining the ring, as follows:

1. *Width of Ring*. The width varies with the boiling point of the contaminating fluid. Heavier products leave narrow distinct rings while lighter products, such as jet fuel, leave wider, fuzzier rings.
2. *Odor*. The contaminant may have a distinctive odor that may be detected after the inner ring dries.
3. *Color*. Heavy fuel oil will leave a brown deposit near the center of the spot.
4. *Effect of Temperature on Ring*. Jet fuel and kerosene

evaporate at room temperature; heating oil at slightly elevated temperatures; lubricants do not evaporate at all.

5. *Test Sensitivity*. If done properly, the test is capable of detecting as little as 1 % heavy product contamination.

A.11 FUEL SAMPLING TECHNIQUES

A.11.1 Introduction and Purpose

This section outlines techniques for choosing containers and sampling aviation fuels. Products are sampled for various reasons, such as: upon receipt, to ensure that the product is on specification; during storage, for custody transfer and pricing determination; or during storage and handling, to monitor aviation fuel quality and condition.

The quality of the fuel is determined by interpreting results of tests performed on samples of the fuel. Therefore, it is extremely important that samples accurately represent the fuel being tested or test results will be invalid.

These instructions for sampling and sample containers do not cover all cases. Therefore, judgment must be used to be sure that samples are representatives of the products to be tested. Also, if the purpose for taking the sample is not clear, additional information should be sought to be sure the sample is taken properly and in the right container.

A.11.2 References

ASTM D4057—Practice for Manual Sampling of Petroleum and Petroleum Products.

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

Section A.9—Shipment of Aviation Fuel Samples and Used Filter Elements.

A.11.3 Description

Table 1 contains a summary of the common types of samples taken for aviation fuel testing. Type and quantity of samples and sample containers must be chosen to ensure that the samples are representative of the aviation fuel in question and are satisfactory for the purpose intended, that is, testing, visual inspection, and so forth. Certain aviation fuel tests are known to be affected significantly by trace contaminants that can be introduced by an improper container. Table 2 contains a list of recommended sample containers for specific tests.

Liquid materials in tanks and other bulk containers should be sampled by the appropriate technique. The sample must be drawn through an opening that gives direct access to the bulk of liquid. This means that samples should not be drawn from nonslotted gage-tubes since nonrepresentative samples may result.

A.11.4 Equipment

1. Sample containers could be as follows: epoxy-coated metal containers; borosilicate (hard) glass bottles (Pyrex® is the popular brand name); polytetrafluoroethylene bottles (Teflon® is the popular brand name); polyethylene bottles; steel cans; and stainless steel beakers.
2. Closures, caps, lids, and so forth, as required.
3. Sample tags or labels.
4. Cleaning reagents, solvents, and reference fluids as required.

NOTE

See ASTM D4057 and D4306 for suggested materials and handling precautions for reagents, reference fluids, and solvents.

5. Sampling apparatus and hand tools, as required.

TABLE 1—Types of samples.

Type	Description
1. Spot sample	A sample taken at a specific location in a tank or other container or from a line at a specific time during a pumping operation.
2. Top sample	A spot sample obtained 6 in. (15.24 cm) below the top of the container's contents.
3. Upper sample	A spot sample obtained from the middle of the upper third of the container's contents.
4. Middle sample	A spot sample obtained from the middle of the container's contents.
5. Lower sample	A spot sample obtained from the middle of the lower third of the container's contents.
6. Bottom sample	A sample obtained at the bottom surface of the container at its lowest point.
7. Drain (sump) sample	A sample obtained from the water draw-off line or sump.
8. All levels sample	A sample obtained by submerging a closed sampler to a point as near as possible to the draw-off level, then opening the sampler and raising it at a rate such that it is 3/4 full as it emerges from the liquid.
9. Line sample	A sample drawn from a small sample connection on a line.
10. Drip sample	A "drip" or "continuous" sample is a line sample obtained by either of the following methods to produce a representative average: a. The product is allowed to drip or trickle into a container throughout the period of product transit. b. A pint sample may be drawn at regular intervals during a delivery to fill a gallon container.
11. Hose sample	A sample obtained from a refueling vehicle or dispensing cabinet delivery hose.
12. Composite sample	A sample consisting of a blend of equal portions of two or more of any of the other types of samples.
13. Multiple tank composite sample	A mixture of individual samples from several compartments of ships, barges, and so forth, which contain the same grade of fuel. The mixture is blended in proportion to the volume of material in each compartment.

TABLE 2—Summary of container recommendations.[a]

Type of analysis	MSEP	Electrical conductivity	Lubricity	Thermal stability	Trace metals
Hard borosilicate glass					
Immediate use	P	P	S	S	NR
Storage	P	P	S	NE	NR
Reuse	S	P	S	S	NR
Epoxy-lined steel					
Immediate use	P	P	S	P	NR
Storage	P	P	S	P	NR
Reuse	P	P	S	P	NR
Polytetrafluoroethylene					
Immediate use	S	NR	NR	P	P
Storage	NE	NR	NR	P	P
Reuse	NE	NR	NR	P	P
Tin-plate soldered steel (super clean only)					
Immediate Use	S	S	S	S	NR
Storage	NR	NR	NR	NR	NR
Reuse	NR	NR	NR	NR	NR
High-density linear Polyethylene					
Immediate	S	NR	NR	NR	P
Storage	NR	NR	NR	NR	P
Reuse	NR	NR	NR	NR	P

P=preferred.
S=suitable.
NR=not recommended.
NE=not evaluated but may be suitable.

[a]The containers listed in this summary should not be used without consulting the appropriate paragraphs of ASTM D4306.

A.11.5 Procedure

1. Determine for what purpose the sample is required and what tests are to be run on it. If not sure, get directions from the authority having jurisdiction.

2. Select sampling container of the appropriate size and type.

3. Inspect and clean the container according to the procedures listed in ASTM D4057 and D4306.

4. Rinse the container three times with the product to be sampled, if appropriate.

5. Inspect the sampling apparatus to be sure it is also clean. It is much simpler to keep the sampling apparatus clean if different apparatus is dedicated for different types of products, that is, aviation gasoline and jet fuel.

6. Use one of the following typical sampling methods to obtain the type of sample desired (Figs. 6–9).

- Lowering a weighted bottle assembly or a metal bomb sampling device into the product to the desired level.
- Drawing line samples from a sampling port on a pipeline or dock riser.

CAUTION

Do not disturb product flow while sampling, that is, by closing valves, and so forth.

7. In addition to the general information listed above, also include the following specific information on the sample label:

- Marine-vessel shipment—product, ship/barge, compartment, shipment or voyage number, and date;
- Tank samples—product and tank number, terminal, pipeline tender or marine vessel number, wheeled vehicle delivery number, if applicable, and date;
- Airport samples—shipping tank number, pipeline tender number, wheeled vehicle delivery number, product source, if known, and date;
- Filter vessel samples—date, name plate information, location, type of vessel, and vessel number.
- Aircraft samples—date, aircraft number, tank number, and flight number.

8. Clean sampling apparatus before storing it in an appropriate location. Samples should be transported to the testing laboratory as soon as possible or stored in an appropriate cool, dark (unless the container is metal), dry location.

A.11.6 Cautions

1. Fuel sampling involves hazardous materials, operations, and equipment. This section does not address all of the safety problems associated with fuel sampling. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

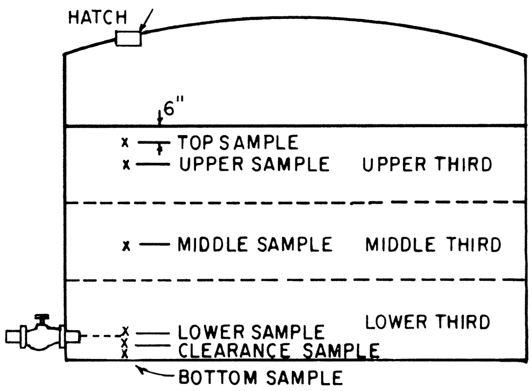
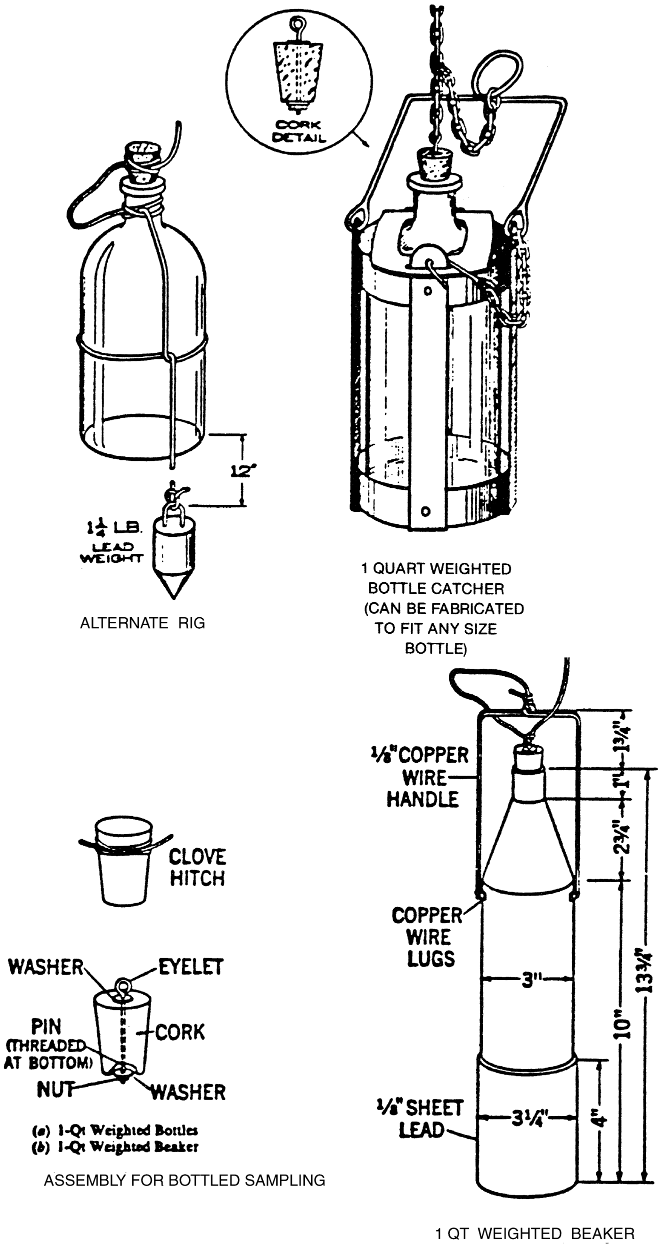


FIG. 6—Sampling depths. The outlet location shown applies only to tanks with side outlets. It does not apply when the outlet comes from the floor of the tank or turns down into a sump.



ALTERNATE RIG

1 QUART WEIGHTED BOTTLE CATCHER (CAN BE FABRICATED TO FIT ANY SIZE BOTTLE)

(*a*) 1-Qt Weighted Bottles
(*b*) 1-Qt Weighted Beaker

ASSEMBLY FOR BOTTLED SAMPLING

1 QT WEIGHTED BEAKER

FIG. 7—Bottle and beaker sampling apparatus.

2. Cleanliness is absolutely essential for proper sampling. The following techniques are recommended:

a. The sampler's hands (or gloves) must be clean.

b. The sampling apparatus and containers must be maintained in a clean condition (and environment) and *inspected* immediately prior to use.

NOTE

It is not acceptable to clean containers or sampling apparatus with common soaps and detergents since residual quantities of these materials may affect certain test results. Also, common plastics should not be used for sampling any petroleum fuel. Furthermore, if a hose sample is to be taken, the hose must be cleared before taking the sample.

c. Rinse the container (or intermediate containers) and sampling apparatus three times with the fuel to be sampled prior to taking the sample.

NOTE

If taking a sump sample, no flushing is required.

d. Seal containers immediately after filling, using the proper closures. (Review Sec. A.9 if sample is to be shipped to another location.)

e. Label container immediately after filling, using the proper label or waterproof marker.

f. The label should contain as much information as required to tell the person receiving it what is required from the sample. For example, the following information may be included on the label: name and grade of product; geographic location (terminal, airport, pipeline, and so forth); date and time sample taken; name of sampler; tank number, container or vehicle, including lot number where applicable, as well as point from which sample is taken; type of sample (composite, all level, bottom, and so forth); identification number of sample; and tests requested.

g. If the sample is sensitive to light (for example, leaded avgas) and the testing includes determination of color, tetraethyl lead, inhibitors, stability tests, and so forth, then the sample must be protected from light. Cans are preferred but brown bottles are sometimes used, or clear glass bottles may be used if wrapped in a material capable of keeping out the light (aluminum foil is commonly used).

NOTE

Any sample that is to be shipped to another location or will not be tested in a short time should be protected from light.

h. About 5 % of the sample container volume should be left empty to allow for expansion.

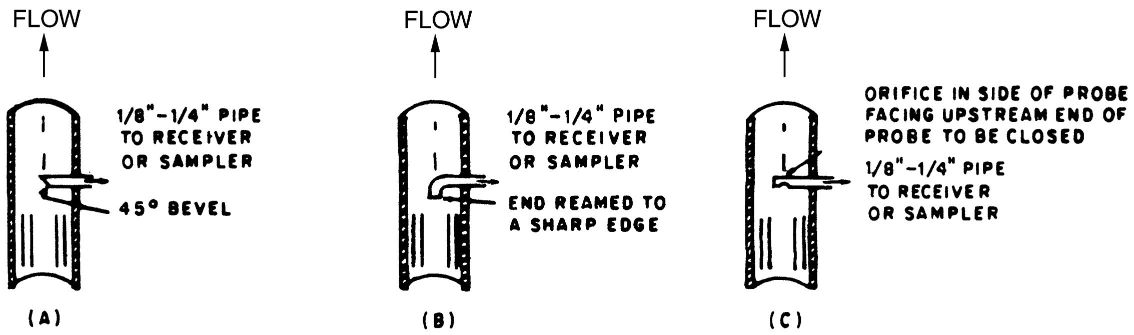
i. Add precautionary labels as required by local ordinance or if shipping sample to another location for testing (review Sec. A.9).

3. The following warning statements are applicable:

Flammable Liquid (General)

Warning—Flammable.

Keep away from heat, sparks, and open flame.



Note: Probes may be fitted with valve or plug cocks. Probes should be disposed horizontally.

FIG. 8—Probes for continuous sampling.

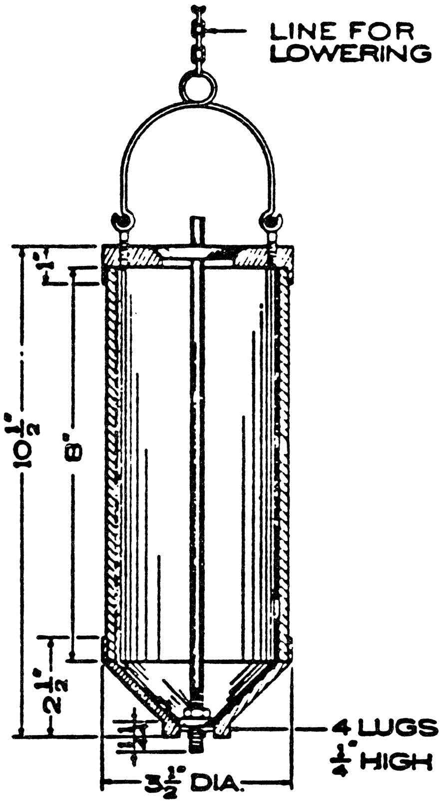


FIG. 9—Thief for sampling tank cars.

Keep container closed.
Use only with adequate ventilation.
Avoid prolonged breathing of vapor or spray mist.
Avoid prolonged or repeated contact with skin.
Aviation Gasoline (avgas)
Danger—Extremely Flammable. Vapors harmful if inhaled.
Vapors may cause flash fire.
Harmful if absorbed through skin.
Keep away from heat, sparks, and open flame.
Keep container closed. Use with adequate ventilation.

Avoid buildup of vapors and eliminate all sources of ignition, especially nonexplosion proof electrical apparatus and heaters.
Avoid prolonged breathing of vapor or spray mist.
Avoid prolonged or repeated contact with skin.
Aviation Turbine Fuels (Jet A or Jet A-1)
Caution—Combustible. Vapor harmful.
Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A.12 SURFACTANTS—SURFACE ACTIVE AGENTS

A.12.1 Introduction and Purpose

The purpose of this section is to provide basic information on surfactants and the need for the detection and prevention of these materials in aviation fuel systems.

A.12.2 References

ASTM D3948—Test Methods for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer.

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

A.12.3 Description

Surfactants are "surface active agents," which are materials that collect at liquid/liquid or liquid/solid interfaces and cause specific things to happen. One of the best known examples of surfactants might be dish detergent, which acts at the interface between oil and water to disperse the oil or grease into the water.

Surfactants in hydrocarbon fuels can be the result of naphthenate and/or sulfonate carry over from a refinery cross-contamination with other fuels, or can be in the form of additives such as corrosion inhibitors, dispersants, and static dissipaters. They can cause jet fuel handling problems because of their tendency to form fuel/water hazes and their ability to degrade the performance of filter/separators. For these reasons, fuel manufacturing procedures and handling practices are closely controlled and monitored.

Some additives are injected by the refineries for the protection of manufacturing and transportation facilities. Other approved additives may be introduced at intermediate distribution plants or at the point of aircraft fueling. Approved surfactant-type additives are tested and usually do not have adverse effects on properly designed filtration systems of ground storage and dispensing equipment. However, in high enough concentrations and especially when mixed with other components not usually present in jet fuel they can disarm the filter/separators of ground fueling equipment that could allow free water to be pumped into aircraft fuel systems.

A.12.4 Detection

Normally, evidence of surfactants is after-the-fact, that is, after gross contamination has occurred and a sudsy-like liquid appears in tank or filter sump drains.

Some symptoms of possible surfactant contamination are:

1. Excess dirt and/or free water detected downstream of the filtration system.
2. Hazy fuel samples.
3. Brownish colored water in tank and/or filter sump drainings.
4. A lace-like material at the fuel/water interface of tank or filter/separator sump drainings.
5. In aircraft, erratic operation of the fuel quantity gages is an indicator of possible surfactant or microbiological growth buildup on the fuel quantity gauge probes.
6. Single element test shows the coalescer to be disarmed (Sec. D.7).
7. Tests for water separation characteristics (MSEP) of the fuel yield unsatisfactory results (Sec. A.13).

A simple test that will alert an operator to the possibility of surfactant contamination is outlined below. Take a sample in an appropriate container. If it is hazy, allow the sample to settle for about 3 min. If the haze has disappeared and water does not accumulate at the sample container bottom, the haze was most likely caused by entrained air. Within 3 min, if water appears as the haze clears up, surfactant should not be suspected. If the haze fails to clear up in this time, the presence of surfactants should be suspected and further investigation should be made.

The White Bucket Test (Sec. A.1.4.3 and A.1.4.4) is particularly helpful in detecting the presence of surfactants in fuel systems. It should be noted here that microbiological growths have many of the visual characteristics of surfactants and only laboratory tests can determine the type of contamination found. Fuel samples taken for laboratory evaluation should include the fuel-water interface, and the sample should be obtained in a clean, epoxy coated sample can.

A.12.5 Prevention

The best methods for the prevention of surfactant contamination are proper manufacturing, transportation, filtration, and good housekeeping. If surfactants are a continuing problem, clay treatment should be considered to adsorb thus remove the surfactants.

A.13 MICROSEPAROMETER

A.13.1 Introduction and Purpose

The purpose of this test is to provide a rapid means to rate the ability of jet fuel to release entrained or emulsified water when passed through fiberglass coalescing material.

This test is commonly used to evaluate the performance of clay treating vessels (Secs. A.12 and D.8) that remove surfactants from jet fuel and to identify jet fuels that may contain significant levels of surfactant that would disarm coalescer cartridges.

A.13.2 References

ASTM D3948—Test Methods for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer.

ASTM D4306—Practice for Sampling Aviation Fuel for Tests Affected by Trace Contamination.

SAE Paper 851870—Development of the Portable Water Separometer for the WSIM Test.

A.13.3 Description

A fuel sample is processed semiautomatically through the microseparometer instrument. Using a portion of the fuel sample, a reference level of 100 is established. Another portion of the fuel sample is then mixed with water and forced through a fiberglass coalescing media using a sequence of timed events controlled by the instrument. This portion is then compared to the 100 reference level established by the first portion. The resultant numerical value, termed “MSEP rating,” indicates the relative ease of coalescing water from the fuel. The test takes about 5 min to run.

NOTE

The correct terminology for water separation characteristics obtained using the microseparometer is MSEP rating. In the field there is a tendency for people to refer to all water separation ratings as the WSIM number. Technically, the WSIM (water separation index modified) number should only be applied to ratings that were obtained from the water separometer, which was described in the now obsolete ASTM D2550 method superseded by the micro-separometer (D3948).

A.13.4 Equipment

Equipment is manufactured by EMCEE Electronics, Inc., 520 Cypress Ave., Venice, FL 34285.

The equipment consists of:

(1) Microseparometer instrument;
(2) reusable items that are initially furnished with the microseparometer and used for each test:
    (a) 50 μL pipette,
    (b) catch pan;
(3) consumable items are available in kit form from the manufacturer:
    (a) Alumicel® coalescer,

(b) syringe,
(c) syringe plug,
(d) plastic tip for the 50 μL pipette,
(e) double distilled water, and
(f) lint free wipes.

A.13.5 Procedure

Detailed instructions are contained in ASTM D3948 and in the manufacturer's operating instructions furnished with each microseparometer instrument. In very general terms, the procedure is as follows:

1. Condition the syringe and mixer shaft by adding a portion of fuel sample to the syringe and placing the syringe in the mixer. After mixing stops, discard the fuel but retain the syringe.

Note: This operation is performed twice.

2. Fill the syringe with 50 mL of fresh fuel sample, add 50 μL of distilled water, and place the syringe in the mixer.

3. Fill the vial half way with fuel sample and insert into the instrument well. Align the white mark on the vial to the black mark in front of the well.

4. Activate the mixer to create the water/fuel emulsion.

5. Adjust the meter to a 100 reference level using the fuel sample in the vial placed in the instrument well in step 3.

6. When the mixer stops, remove the syringe from the mixer, insert the plunger into the barrel to the 50 mL mark, replace the syringe plug with an Alumicel® coalescer, and place the syringe assembly in the syringe drive.

7. The meter will activate for 10 s during which time, if necessary, the meter can be adjusted to the 100 reference level.

8. Remove the vial from the instrument well and discard the fuel sample but retain the vial.

9. The syringe drive mechanism will activate forcing the water/fuel emulsion through the Alumicel® coalescer. Using the retained vial, collect the last 15 mL of processed fuel sample from the Alumicel® coalescer and place the vial in the instrument well, aligning the marks.

10. After 56 s, preceded by a steady tone, the display will activate. After an additional 5 s or when another 1 s tone sounds, read and record the displayed value as the MSEP Rating.

A.13.6 Cautions

1. DO NOT reuse the consumable items. Subsequent tests using these items could cause erroneous results.

2. The outside of the vials must be kept clean and free of external surface contamination (such as fingerprints) by wiping with a lint-free material. Since the clarity of the fuel sample determines the MSEP rating, any surface contamination would result in a lower reading.

3. The fuel sample temperature should be kept between 65 and 85°F (18 and 29°C) and should not vary more than 5°F (2.75°C) during the entire test cycle.

4. If the fuel sample is not clear and bright between these temperatures, do not run the test.

5. The alignment of the fuel sample vial in the instrument well must be the same during the adjustment period when the 100 reference level is attained in step 5 and when the final MSEP Rating is read in step 10. This is easily accomplished by orienting the label on the vial in the same direction during both steps.

A.13.7 Cleanliness Guidelines for Downstream MSEP Testing

A.13.7.1 Introduction

The cleanliness of aviation turbine fuel is an essential performance requirement. A key element in preventing dirt and water contamination is to minimize or eliminate surfactants. The D 1655 Aviation Turbine Fuel specification contains in Table 1 a D 3948 MSEP requirement to prevent surfactant contamination at the point of manufacture, and in Appendix X2 downstream D 3948 MSEP guidelines for the prevention of downstream surfactant contamination.

A.13.7.2 General Surfactant Cleanliness Guidelines

1. Cleanliness requires the relative absence of free water and solid particulates. Water and/or dirt contamination in fuel onboard an aircraft represents a potential threat to flight safety and can cause longer term problems in areas such as wear, corrosion, and plugging of filters and other narrow tolerance parts. The cleanliness of aviation turbine fuel is protected in part by allowing time for dirt and water to settle during fuel distribution and by the routine use of effective filtration that removes both dirt and water. Generally the fuel handling system filters the fuel several times between manufacture and use with the final filtration occurring as the fuel is loaded onto an aircraft.

2. A key element in aviation turbine fuel quality is to minimize surfactant contamination; which can compromise the ability of fuel handling systems to remove dirt and water. Surfactants tend to increase the settling time of suspended solids and water droplets, decrease particulate filter effectiveness, and adsorb on the surfaces of filter/coalescers thereby interfering with water removal. Surfactants can also lift rust and dirt from surfaces increasing the solids level in the fuel.

3. Unlike most other fuel properties, fuel cleanliness is dynamic; constantly changing during transportation and distribution. Jet fuel should be transported in a manner that minimizes contamination from water, dirt, and surfactants as much as possible while in the distribution system. Fuel cleanliness reduces filtration costs and reduces the potential failure of filtration components that could lead to an unsafe condition. Filtration systems and airport quality control programs should be designed to ensure that solid particulates, surfactants, and free water are adequately removed prior to loading the fuel into aircraft. To determine the level of surfactant contamination in the fuel ASTM D3948 MSEP testing should be used at appropriate points through the distribution system and as part of the airport quality control program.

4. Results of D3948 testing are not to be used as the sole

reason for rejection of fuel; but can indicate a mandatory need for further diligent investigation and/or remedial action such as passing the fuel through a clay adsorption unit to remove surfactants. However, the fuel may be rejected in the absence of satisfactory D3948 testing results if no documented evidence is presented that a detailed investigation was carried out which demonstrated that the fuel was free of excess water and dirt and can be delivered into aircraft in a clean condition.

5. Because distribution systems can be complex and employ a variety of methods of transporting the fuel, sampling points and methodologies should be established as a result of a technical assessment designed to ensure that fuel cleanliness is maintained throughout the system to the point of delivery into aircraft. Since transport systems vary in their basic nature, e.g., water-borne transport versus a multiproduct pipeline versus a dedicated pipeline, and also in their detailed operating conditions, the parties assuming custody of the fuel should evaluate their particular systems and establish suitable testing requirements.

A.14 AVIATION FUEL ADDITIVES

A.14.1 Introduction and Purpose

There are a number of additives that may be present in aviation fuels for various reasons. The purpose of the section is to briefly acquaint the reader with the different additives and why they may be present. Additives and their uses must meet the requirements of the appropriate ASTM aviation fuel specification.

The purpose of using an additive is to either add a feature (such as identifying specific avgas grades) or to improve a specific quality or performance parameter or fuel characteristic over that achieved by refining and blending (such as fuel anti-icing or static conductivity).

A.14.1.1 Storage and Handling

Additives should be stored and handled appropriately as indicated by the applicable material safety data Sheet. Premixing of additives together into a “cocktail” is not recommended since reactions can take place between the additives, reducing their effectiveness or causing other problems.

A.14.2 References

ASTM D910—Specification for Aviation Gasolines.

ASTM D6615—Specification for Jet B Aviation Turbine Fuel.

ASTM D1655—Specification for Aviation Turbine Fuels.

ASTM Manual 1—Significance of tests for Petroleum Products.

ASTM D6227—Specification for 82UL Aviation Gasoline.

Note: 82UL Avgas is not a direct replacement for Avgas 80.

IATA Guidelines on Microbiological Contamination in Aircraft Fuel Tanks

Issue 1, November 2003.

ASTM D6469 Microbiological Contamination Guidance Material.

Additives that are Typically Injected into the Fuel at or Downstream of the Refinery

A.14.3 Tetraethyl Lead (TEL)

A.14.3.1 Purpose

TEL is an antiknock compound used in most aviation gasolines (avgas) to improve the antiknock characteristics of the avgas, resulting in higher octane and performance numbers. The newest grade, 82UL, does not contain lead and some other grades of avgas may not contain TEL.

A.14.3.2 Precautions

a. Tetraethyl lead antiknock compound is classified as very toxic and careful controls are required during its storage, handling, and use, which are available in the TEL Suppliers MSDS documentation.

b. The concentration of TEL in aviation gasoline is controlled by the specifications (ASTM D910). At these levels, the hazardous classification of the gasoline is unaffected by the presence of TEL. Tanks used for the storage of leaded aviation gasoline may, however, after extended use, pose risks related to the presence of TEL or derivatives (chemicals formed by degradation of these compounds) in deposits. Precautions should therefore be taken when entering, cleaning, repairing or disposing of leaded gasoline tanks or piping. Details are available from TEL suppliers.

A.14.4 Color Dyes

A.14.4.1 Purpose

Dyes are added to avgas for two reasons; to differentiate between avgas grades (see Sec. A.6) and because dye is required in any fuel containing lead.

Dyes are not allowed in jet fuel.

A.14.4.2 Precautions

If jet fuel or avgas appears to be different in color than the normal color seen (see Sec. A.6), there may have been an inadvertent mixing with another product. For example, jet fuel with a reddish appearance may have been contaminated with some amount of red-dyed diesel fuel. (U.S. off-road untaxed diesel is dyed red.) Avgas with a color different from the usual may have been mixed with a different grade of avgas or another product.

a. Refer to the manufacturers’ MSDS information for safety precautions.

A.14.5 Antioxidant

A.14.5.1 Purpose

Antioxidant is added to some aviation gasolines and some jet fuels. In aviation gasolines, antioxidant prevents the formation of gum and the precipitation of lead compounds. In some jet fuels, antioxidant is added to prevent the formation of peroxides, which can adversely affect thermal stability and storage stability and degrade elastomers (seals).

a. Refer to the manufacturers' MSDS information for safety precautions.

A.14.6 Metal Deactivator

A.14.6.1 Purpose

Metal deactivator may be used in jet fuels to prevent certain metallic materials (such as copper) from accelerating the degradation of thermal stability.

a. Refer to the manufacturers' MSDS information for safety precautions.

A.14.7 Corrosion Inhibitor

A.14.7.1 Purpose

Corrosion inhibitor/lubricity improver (CI/LI) additive is used to minimize corrosion of pipelines and tanks, etc. in contact with fuels in which trace amounts of water are sometimes present. CI/LI additive also provides improvements in the lubricating properties ("lubricity") of jet fuels. In general, military fuels require the addition of an approved CI/LI additive. Civilian jet fuels normally do not contain CI/LI additive but the use of specific additives is permitted by both D 1655 and D 910.

a. Refer to the manufacturers' MSDS information for safety precautions.

Additives that are Typically Injected into the Fuel Downstream of the Refinery

A.14.8 Static Dissipater Additive (SDA)

Also known as: Antistatic Additive, Stadis 450, Conductivity Improver Additive.

Note: Static electrical charges can cause dangerous sparks, which can lead to ignition of fuel vapors. The important action is to bond all components in the system so that no *difference* in electrical charge potential exists. For example, the overwing nozzle must be mechanically and electrically bonded to the aircraft. Static conductive hose is not used to accomplish overwing nozzle bonding because it does not constitute a reliable and auditable means of ensuring that there is no difference in electrical potential between the nozzle and the aircraft.

A.14.8.1 Purpose

Because static electrical charges can buildup in fuels moving through fuel systems, particularly through filters, SDA can be added to jet fuels to increase the electrical conductivity of the fuel to reduce the time that it takes for electrical charge to dissipate.

A.14.8.2 Precautions

If the fuel is treated with static dissipater additive, the additive level and /or the effectiveness of the additive in the fuel can be reduced as the additive moves through the distribution system. The electrical conductivity level of the additized fuel is measured at various locations, with a hand-held meter, or with an in-line conductivity meter. If the conductivity level drops below the customer's prescribed limits, re-additizing within approved specification limits is necessary.

a. Refer to the manufacturers' MSDS information for safety precautions.

A.14.9 Fuel System Icing inhibitor (FSII)

A.14.9.1 Purpose

In cold climate operations, or as aircraft ascend to altitude even in tropical climates, the temperature of fuel in wing and other tanks can drop well below freezing (0 °C, 32 °F). As fuel cools, roughly one part per million of dissolved water comes out of solution as free water for every °F of temperature drop. Certain aircraft without fuel system heaters require that FSII be properly blended into the fuel to prevent the free water from freezing in the fuel system, which could cause blockage of filters and fine passages by the formation of ice crystals.

Note: The following information on basic care in the handling and injection of FSII applies to both DiEGME (diethylene glycol monomethyl ether) additive and Isopropanol (alcohol type) additive, as they are both chemically aggressive and sensitive to water. This applies whether the additive is injected at the airport or at an off-airport fuel terminal.

Note: DiEGME is the only anti-icing additive permitted in jet fuels. DiEGME and isopropanol are both permitted in avgas.

A.14.9.2 Precautions

a. DiEGME dissolves into fuel, but with difficulty. It must be finely dispersed into the fuel flow proportionally as fine droplets in order to get sufficient surface area to promote rapid dissolving of the additive into the fuel before droplets settle to the bottom. Injection should not be immediately upstream of any filter vessel. To prevent additive loss and/or filter damage, it is best to inject DiEGME upstream of some form of high shear device (such as a control valve) or through an atomizing nozzle. FSII additive does not fully dissolve into fuel containing free water because part of it dissolves in the free water, so it is best to additize downstream of a filter separator or water absorbing filter.

b. As stated above, DiEGME does not fully dissolve in "wet fuel," (fuel containing free water) even with proper additive injection equipment. In fuel containing free water, the DiEGME will preferentially dissolve in the water, resulting in a lower than expected concentration of DiEGME in the fuel, and water bottoms containing high DiEGME concentrations. Free water should be minimized upstream of DiEGME injection in the fuel system.

Note: The following instruction in basic care of handling FSII applies to both the DiEGME additive used in turbine fuel and the alcohol type additives used in Avgas fuels, as they are both chemically aggressive and sensitive to water.

c. As free water drops out of FSII treated fuels FSII concentrates in the water (up to about 60% FSII/40 % water). This mixture has the solvency of paint remover and can damage filter separators, tank linings and accelerate pipe and tank corrosion. (The use of FSII is incompatible with water absorbing elements because FSII/ water mixtures can dissolve water absorbing media forming a viscous material known in the aviation industry as "APPL" jelly.) The resulting FSII concentration in the fuel is decreased. Concentration of DiEGME type FSII can be determined by ASTM D5006, but no simple field test has been developed for measuring Isopropanol type FSII concentration in avgas.

d. It is important to prevent water and moist air from entering the FSII additive tank because water dissolves readily into the additive, which becomes FSII saturated free water in the FSII additized fuel with the same issues described above. A desiccator should be used in the air vent to prevent entrance of moist air to the FSII additive storage tank.

e. FSII, either by itself or mixed with water, can be corrosive to aluminum and degrade fiberglass tanks and epoxy-type tank linings. It should not be allowed to remain in tank bottoms, low points or filter/separator sumps. In FSII treated fuel, the water in the tank bottoms and sumps should be drained daily.

f. FSII should be stored in stainless steel or Teflon coated tanks due to its corrosive nature. Because laboratory testing shows that long term stability of DiEGME is questionable even in sealed containers, it is recommended that DiEGME stocks be rotated as frequently as possible. DiEGME should be fully retested for quality conformance at least annually.

g. Refer to the manufacturers' MSDS information for safety precautions.

A.14.10 Biocide

A.14.10.1 Purpose

A biocide may be added to jet fuel with purchaser-supplier agreement on an as-needed basis to treat microbiological growth (commonly referred to as "bugs" or microbial growth). Biocides are typically used on a one-time "shock treatment" basis where storage tanks or aircraft tanks have been infested with microbiological growth. The only biocidal additives presently approved for use in aviation fuels are Biobor JF and Kathon FP 1.5.

A.14.10.2 Precautions

a. Refer to the manufacturers' MSDS information for safety precautions.

b. Where such an additive is used in the fuel, the approval status of the biocide and associated conditions must be checked for the specific aircraft and engine to be operated.

c. After treatment with a biocide, debris or "slime" may be released into the fuel system, possibly plugging filter elements.

d. Biocides can partition between fuel and water. Appropriate care should be taken in disposing of any water drains from a biocide-treated system.

A.14.11 +100 Additive (JP-8+100)

Also known as: GE Betz SPEC-AID 8Q462, AeroShell Performance Additive 101 and Turboline FS100C.

A.14.11.1 Purpose

The "+100 additive" is added to JP-8 fuel to produce the JP-8+100 grade jet fuel (NATO F-37 jet fuel). The +100 additive increases the high temperature performance of the jet fuel with the result that some high performance engines run much cleaner requiring significantly less maintenance than with JP-8. Benefits with +100 additive are also being found with Jet A in certain helicopters in civilian application.

This additive is not yet fully approved for general usage in commercial aircraft. The additive is not compatible with some filtration because it can impact water coalescence.

A.14.11.2 Precautions

Fuel containing the "+100" additive must be segregated from filtration systems designed to handle untreated fuel.

A.14.12 Leak Detection Additive (Tracer "A")

A.14.12.1 Purpose

Leak detection additive is added on a one-time basis to fuel pipelines, storage, distribution and aircraft refueling hydrant systems to check for possible fuel leaks. Tracer "A" is a gaseous compound that rapidly dissolves into the fuel and vapor space of the tank. It has no effect on aviation fuel characteristics.

a. Refer to the manufacturer's MSDS information for safety precautions, as well as environmental regulations regarding use of the additive.

A.15 FLUSHING NEW AVIATION FUELING HOSES

When placing a new hose in service, or putting a hose back in service after a period of time out of service, it is important to properly clean and flush the hose to prevent contamination and manufacturing materials from reaching the aircraft.

A.15.1 Procedure

Hose should be completely filled and then soaked in fuel for a minimum of 1 h, then fully drained. This fuel should be inspected visually for any color change or visible contamination. This procedure should be conducted at least two times, and at least until a clean, clear sample is obtained. Dispose of soak fuel. Do not return soak fuel to the fuel system.

After a successful soak, 500 gallons of fuel should be recirculated back to storage through the hose and the nozzle strainer should be checked for signs of contamination or hose deterioration prior to fueling.

B

Particulate Detection

B.1 FILTER MEMBRANE TEST—COLORIMETRIC

B.1.1 Introduction and Purpose

Particulate contamination of aviation fuels may be indicated by passing a measured volume of fuel through a standard white filter membrane and evaluating the color of the membrane against a standardized color chart with numbers ranging from 0 for the lightest through 10 for the darkest. At the same time, the color can be evaluated for change with respect to previous tests. This test provides a standard means for communicating filter membrane colors.

B.1.2 References

ASTM D2276/API/IP-216—Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling.

B.1.3 Description

The test is performed by withdrawing a fuel sample at a pressurized sampling point on a flowing system. The fuel sample is drawn through a filter membrane (and paper support pad) having a pore size of 0.8 μm. Fuel contaminate is indicated by comparing the color and the intensity of the color of the filter membrane after fuel passage. It is sometimes desirable to simultaneously perform filter membrane tests on the inlet and outlet sampling points of various filtration equipment, storage tanks, or pipeline segments.

B.1.4 Equipment

Equipment is available from several commercial sources that are on file with ASTM. In the United States, known suppliers of kits and field monitors are: Gammon Technical Products, Inc., Manasquan, NJ; and Millipore Corp., Bedford, MA.

The following equipment is required: field sampling kit (Fig. 1); field monitors each containing one 37-mm diameter, 0.8-micrometer (micron) membrane backed by a 34-mm diameter support pad; electrically bondable receiving container (graduated or known/proven capacity); and a color rating booklet (ASTM D2276, Appendix X, and Fig. 2). Optional equipment: SGTP-3940 Color and Particle Assessment Rating Guide, available from Gammon Technical Products, Inc.

B.1.5 Cautions

The sampling unit must be properly bonded to both the sampling connection and the measuring container to minimize the hazards of static charged fuel in the container and static buildup on the apparatus. The test requires extreme care in sampling.

1. Failure to properly flush the field sampling kit and the sample tap prior to testing can lead to erroneous results.
2. DO NOT operate valves in the system during the test.
3. Avoid starting and stopping pumps during the test.
4. Do not open the field monitor on-site after the test.
5. Be sure to measure the sample volume through the membrane accurately.
6. Removal of fuel remaining in the field monitor must be done with care to avoid damage to the test membranes. Damaged membranes are not acceptable for analysis.
7. Do not exceed 689 kPa (100 psi) unless you are using a special high pressure housing.
8. Line flow rate in the main system should not be below 50 % of rated capacity.
9. When drying the membrane, locate it away from potential ignition sources.

B.1.6 Equipment Preparation

1. A permanently installed connection is strongly recommended at the sampling point and will include a quick disconnect that will accept the fitting on the inlet of the field sampling kit. Components should be made of aluminum

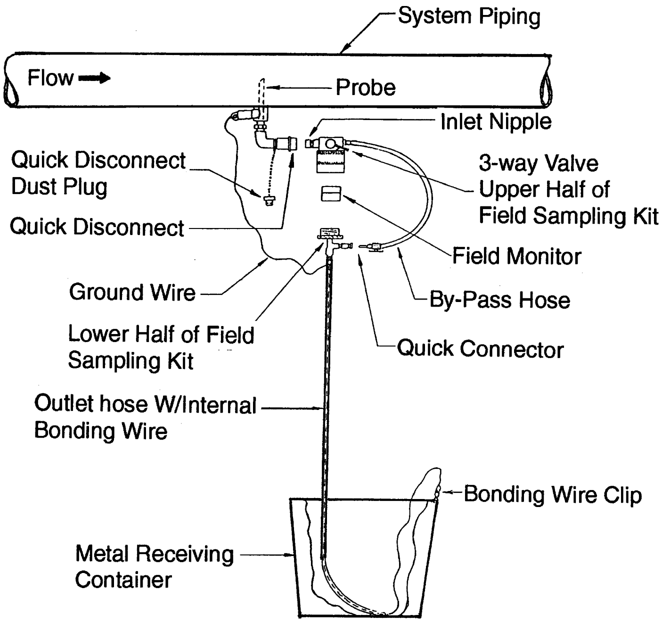


FIG. 1—Typical test setup of a field sampling kit.

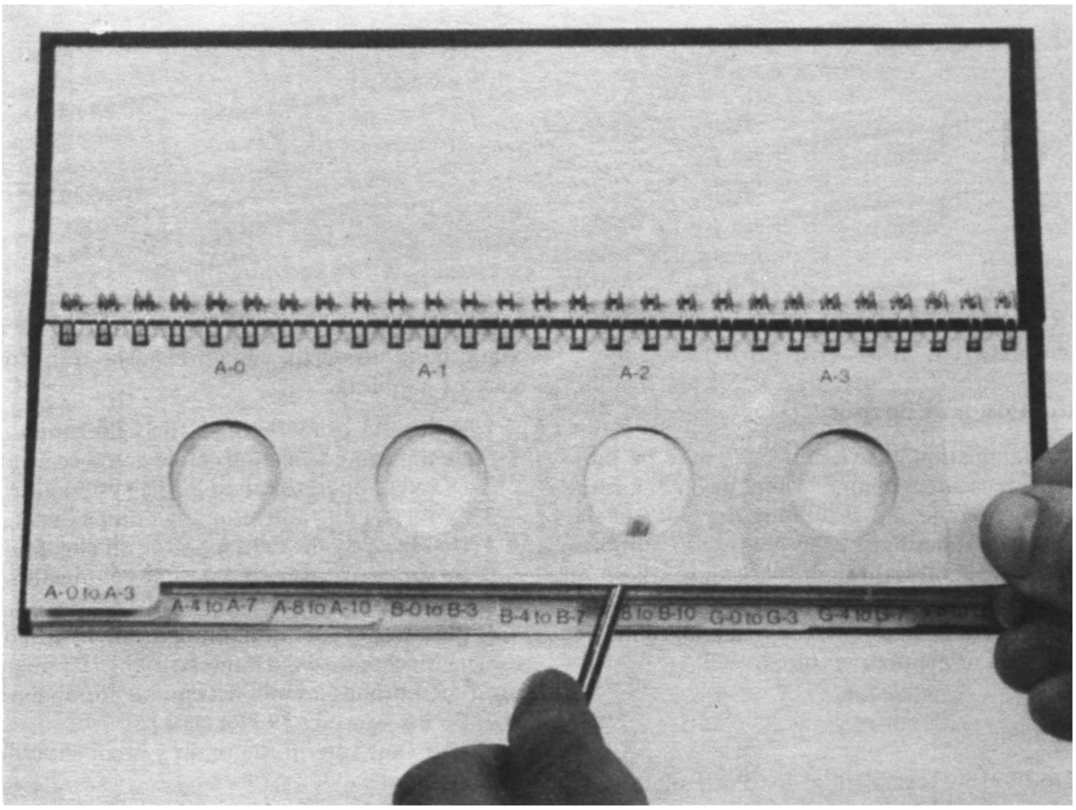


FIG. 2—Color rating booklet.

or stainless steel and the threaded connections sealed with Teflon® tape. A sampling probe projecting into the fuel stream will aid in preventing trapped particles in the pipe from influencing results. A dust plug should be installed in the quick disconnect between tests.

2. Check all equipment for contamination and clean as necessary.
3. Prepare the field monitor by installing a new support pad (with the rounded edge upwards) in the recess having the molded spokes. Place an approved membrane on the support pad. Be sure to use tweezers when handling the pads to avoid contamination. Press the top half of the monitor into position to clamp the outer edge of the membrane. Install a blue dust plug at the inlet port and a red plug at the outlet port of the monitor until it is to be used.

B.1.7 Test Procedure

1. Separate the halves of the field sampling kit housing.
2. Remove the dust plugs from the field monitor. Retain plugs in a clean area for reinstallation after test.
3. Place the field monitor in the lower section of the field sampling kit with the inlet side up and the outlet (spoked side) down.
4. Reassemble the halves of the field sampling kit housing. Make certain the connection is hand tight; extreme force is not necessary and is not desirable.
5. Place the three-way valve selector in the "Off" position and connect the bypass hose and the outlet hose.
6. Place the outlet hose in the receiving container. Connect the grounding wire from the field sampling kit to the system piping and to the receiving container.
7. Remove dust plug from the sampling quick disconnect on the main piping and connect the field sampling kit.
8. Fuel should be flowing past the sampling point at a steady rate not less than 50 % of the highest normal flow rate of the system.
9. Slowly turn the valve to the "Flush" position.
10. Flush a minimum of 2 L (0.5 gal) of fuel through the field sampling kit. If the sampling connection is remote from the main system piping (for example, smaller sampling line extended some distance from main line), the quantity flushed should be a minimum of ten times the sampling line volume.
11. Turn the valve to the Off position.
12. Remove field sampling kit outlet hose from receiving container and empty the contents in an approved manner if the container is not large enough to hold the discharged fuel from the following steps in the test procedure.
13. Place the field sampling kit outlet hose into the empty receiving container.
14. Turn the valve to the "Test" position.
15. Measure and record the exact volume of fuel collected. Unit of measure is the operator's choice. When possible, collect a minimum of 3.8 L (1 gal) but to facilitate comparison from earlier and repetitive tests, the volume should be approximately equal.

16. Turn the valve to the Off position.
17. To protect against electrostatic discharge, allow all equipment, including the receiving container and contents, to stand for a minimum of 1 min.
18. Disconnect the field sampling kit inlet hose from the sampling quick disconnect and disconnect the bonding wire and bypass hose. Replace dust plug in the sampling quick disconnect.
19. Turn the valve to the Flush position and drain residual fuel from the field sampling kit into the receiving container.
20. Remove the outlet hose from the receiving container and empty contents in an approved manner.
21. Separate the halves of the field sampling kit and remove the plastic monitor.
22. Remove remaining fuel from the plastic monitor using the suction device supplied with the field sampling kit. Make certain that suction is applied gently and only to the outlet (spoked) side of the monitor to prevent damage to the filter membranes. **Do not open the plastic field monitor**.
23. Reinstall colored dust plugs in the field monitor.
24. Wipe the outside of the field monitor dry of fuel.
25. Wipe field sampling kit dry and store all components.
26. Open the monitor in a clean environment, remove the membrane and dry it before rating its color. To raise the membrane from its cavity in the outlet half of the field monitor, gently push upward through the outlet hole against the support pad using a toothpick or other small diameter probe, enabling the membrane to be grasped with tweezers.
27. To dry the membrane for rating, proceed as follows. Remove the membrane from the monitor with tweezers. Dry the membrane by placing it carefully on an absorbent paper on a nonflammable heat source such as a radiator or by letting it air dry for 3 h in a clean environment. Dryness can be estimated by comparing the white color of the outer portion of the test membrane with a new membrane.

CAUTION

Keep the drying membrane away from ignition sources.

28. If it is desired to rate the membrane while it is wet, immediately rate the membrane after removing it from the monitor.
29. Select the color that most closely matches the sample. In matching, be careful that the viewing angle is nearly perpendicular, and that shadows are not cast unevenly on the surfaces being compared. Ratings should be done in a location shielded from direct sunlight.

B.1.8 Test Report

1. Report the match by scale letter and rating number, such as B-1, G-3, A-4. If the shade is between two rating numbers, report the lower number. If the membrane color does not conform to any of the standard scales (A, B, or G), establish the shade to the nearest rating number and report the color.
2. Report the sample volume used.
3. If the sample was not taken under rated flow conditions, report the flow conditions and sampling pressures.
4. Report whether the membrane was rated wet or dry.
5. Report the test location and position in the system.

B.1.9 Interpretation of Test Results

There is no technical significance to color ratings obtained in this test; it is a comparative test. The most valuable use of this test is in comparison, based either on long-term experience at a location or on previous test results obtained on the same fuel by the supplier. Specifically, a darker color membrane, or a membrane having a color that compares with a different color scale (A, B, or G) than usual, are both indicators that contamination may have occurred in the fuel. Comparing these unusual test results with the supplier's test results may indicate that this batch of fuel is simply different from previous batches but is acceptable, or that the fuel has been contaminated somewhere in the transfer. Depending on the amount of difference, this could warrant additional testing to determine if other fuel characteristics have been affected, such as MSEP and thermal stability.

In addition, if little or no improvement in dark membrane color is seen in tests conducted before and after a filter, it indicates that the filter element is being bypassed, or the dirt is too small for the filter to remove, or the color arises from color bodies, which are fuel soluble dye-like components.

When color bodies are suspected of causing the membrane color, this can be tested by placing two membranes "piggyback" in the same plastic monitor and performing the test in the standard manner. If both membranes have the same color after the test, this indicates there are color bodies in the fuel. A darker top membrane indicates that filterable contaminant is trapped by the top membrane. When the bottom membrane is dark, but not as dark as the top membrane, this indicates that both filterable contaminant and color bodies are present.

Wet color ratings may be of value to a trained observer familiar with local conditions. However, only dry ratings should be reported when color ratings are employed as a communications tool. Dry membranes appear lighter in color and have a lower color rating.

In evaluating a membrane for color, the reading reverts to the lower number of color. For example, a membrane color between an A2 and an A3 is reported as an A2.

B.2 MEMBRANE FILTRATION—GRAVIMETRIC

B.2.1 Introduction and Purpose

The purpose of this test is to determine the weight of particulate matter in jet fuel.

B.2.2 References

ASTM D2276/API/EI-216—Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling.

ASTM D5452—Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration.

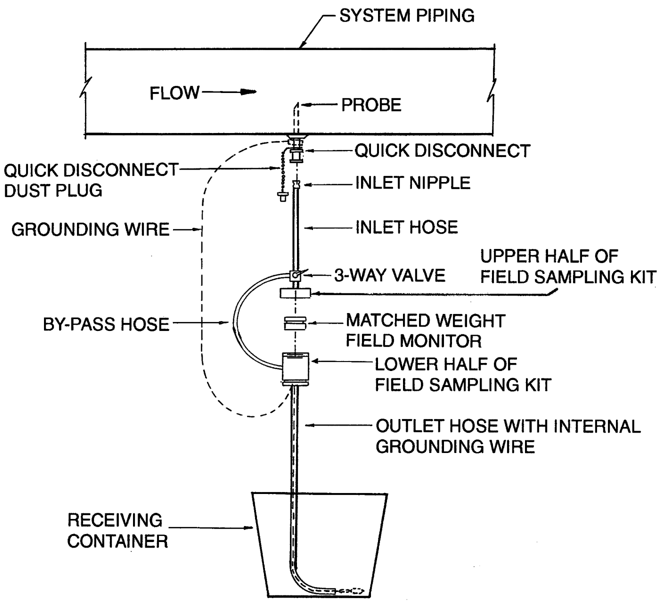


FIG. 3—Typical test setup of a field sampling kit.

B.2.3 Description

Using a field sampling kit, a measured volume of fuel is passed through a pair of matched weight filter membranes in a field monitor. The field monitor is then removed from the field sampling kit and forwarded to a qualified laboratory for weighing.

B.2.4 Equipment

Equipment is available from a number of commercial sources that are on file with ASTM. In the United States, known suppliers are: Gammon Technical Products, Inc., Manasquan, NJ; and Millipore Corp., Bedford, MA.

1. Field sampling kit (Fig. 3).
2. Field monitor containing two matched weight filter membranes (37-mm diameter, 0.8 μm) plus support pad or backup pad. (Fig. 4).
3. Receiving container (graduated or known/proven capacity, unless fuel is metered through the field sampling kit).

B.2.5 Equipment Preparation

1. Check condition of the field sampling kit for any contaminants, especially the inlet nipple and inside housing. If required, connect the sampling kit to a fuel source and thoroughly flush.
2. Check the sampling connection in the system piping where the sample is to be taken. If any visible contamination is present, wipe thoroughly with a clean cloth or paper towel.
3. Be sure the field monitor is the correct type and that protective dust plugs are in place. Do not use if plugs are missing.
4. If the field sampling kit is not equipped with a three-way valve with Off, Flush, and Test positions, connect to the sampling point in the system piping and perform the pretest flushing operation (item 10 in Sec. B.2.6).

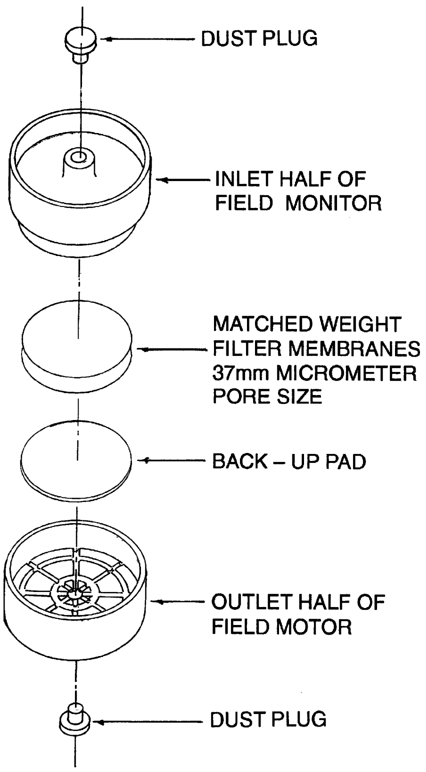


FIG. 4—Matched weight field monitor (shown disassembled).

B.2.6 Procedure

CAUTION

The operating pressure for this test must NOT exceed 689 kPa (100 psi), unless the high-pressure housing is used, in which case the pressure should not exceed 3103 kPa (450 psi). The selector valve should always be turned SLOWLY from one position to another. If the valve were turned rapidly, this could rupture the filter membrane.

1. Separate the halves of the field sampling kit housing.
2. Remove dust plugs from the matched weight field monitor. Retain in a clean area for reinstallation after the test.
3. Place the matched weight field monitor in the lower section of the field sampling kit housing with the inlet side up and the spoked side down.
4. Reassemble the halves of the field sampling kit housing. Make certain connection is hand tight; extreme force is not necessary and is not desirable.
5. Place the three-way valve selector in the Off position and connect the bypass hose and the outlet hose.
6. Place the outlet hose in the receiving container. Connect the bonding wire from the field sampling kit to the system piping and to the receiving container.
7. Remove dust plug from the sampling quick disconnect and connect the field sampling kit.
8. Fuel should be flowing past the sampling point at a steady rate not less than 50 % of the highest normal flow rate of the system.
9. Slowly turn the valve to the Flush position.
10. Flush a minimum of 2 L (0.5 gal) of fuel through the

field sampling kit. If the sampling connection is remote from the main system piping (for example, smaller sampling line extended some distance from main line), the quantity flushed should be a minimum of ten times the sampling line volume.

11. Turn the valve to the Off position.

12. Remove field sampling kit outlet hose from receiving container and empty the contents in an approved manner if the container is not large enough to hold the discharged fuel from the following steps in the test procedure.

13. Place the field sampling kit outlet hose into the empty receiving container.

14. Turn the valve to the Test position.

15. Measure and record the exact volume of fuel collected. Unit of measure is the operator's choice. When possible, collect a minimum of 3.8 L (1 gal).

16. Turn the valve to the Off position.

17. To protect against electrostatic discharge, allow all equipment, including the receiving container and contents, to stand for a minimum of 1 min.

18. Disconnect the field sampling kit inlet hose from the sampling quick disconnect and disconnect the bonding wire and bypass hose. Replace dust plug in the sampling quick disconnect.

19. Turn the valve to the Flush position and drain residual fuel from the field sampling kit into the receiving container.

20. Remove the outlet hose from the receiving container and empty contents in an approved manner.

21. Separate the halves of the field sampling kit and remove the plastic monitor.

22. Remove remaining fuel from the plastic monitor using the suction device supplied with the field sampling kit. Make certain that suction is applied gently and only to the outlet (spoked) side of the monitor to prevent damage to the filter membranes. **Do not open the plastic field monitor**.

23. Reinstall colored dust plugs in the field monitor.

24. Wipe the outside of the field monitor dry of fuel.

25. Wipe field sampling kit dry and store all components.

26. Prepare an identification label or data sheet containing the following information: date, organization, facility, location, sampling point, and volume collected.

	Example
Date	7/1/93
Organization	ABC Fueling Company
Facility	XYZ Airport
Location	Tank Farm
Sampling point	Incoming receipt, tank 1
Volume collected	1 U.S. gal

27. Forward the field monitor with the above information to a qualified laboratory for weighing according to ASTM Method D2276/IP/EI-216.

B.2.7 Cautions

The test requires extreme care in sampling. Erroneous interpretations can result from failure to properly flush the field sampling kit and the sample tap prior to sampling, operation of valves during the test, starting and/or stopping pumps during the test, opening the field monitor on-site, failure to promptly replace dust plugs in field monitor, or failure to accurately measure sample throughput. Removal of residual fuel from the field monitor must be done with care to avoid damage to the test membranes. Damaged membranes are not acceptable for analysis.

B.2.8 Evaluating Test Results

Results in terms of mg/gal or mg/L will be reported by the qualified laboratory. Significance of the results reported is dependent upon where the sample was taken. Some guidance material is offered as follows:

1. Test results from sampling points in airport storage systems may vary depending on facility features. For example, if storage tanks and piping are internally coated (for example, epoxy) lower readings can be expected than those obtained from an uncoated system. In either case, test results should be compared with previous readings obtained from the same sampling point. A significant increase over previous readings requires investigation.

2. The test can be used to check the effectiveness of filtration equipment. In this case, samples are taken upstream and downstream of the filter at the same time and the results compared. If the upstream sample result shows a substantial amount of contaminant, the downstream sample result should be significantly lower. In this case, no reduction in contaminant level indicates possible failure of the filtration equipment. If the upstream sample results show little or no contaminant, no valid conclusions regarding the effectiveness of the filtration equipment can be reached.

Records of test results should be maintained for comparison with those of past and future tests performed at the same sampling point. Those records are vital to the operator in observing trends in contaminant level (Sec. B.3)

B.3 MEMBRANE FILTRATION RECORDS

B.3.1 Introduction and Purpose

Establishing and maintaining a record of membrane filtration tests provides a history of normal and abnormal filter and/or fuel conditions.

B.3.2 References

ASTM D2276/IP/EI-216—Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling.

B.3.3 Description

Filter membranes used for color ratings or records of membrane weights should be retained in local files for at least one year. Membrane records should indicate, as a minimum: (1) sampling point, (2) date of test, (3) sample volume, and (4) dry color rating (or weight).

The membrane records may also include the following fuel system information, as applicable: (1) wet color rating, (2) length of sampling time, (3) line pressure, (4) differential pressure across the filter and the type of filter, (5) flow rate, (6) throughput, and (7) element change date.

Filing membrane records may be by individual sampling points or any other convenient, orderly method.

B.3.4 Cautions

Filter membranes should be filed in protective transparent plastic bags or sheets to prevent color changes due to dust or mishandling. Prolonged exposure to strong light can cause color fading.

C

Water Detection

C.1 SHELL® WATER DETECTOR

C.1.1 Introduction and Use

The Shell® water detector determines low levels of suspended (undissolved) water in jet fuels.

C.1.2 References

There is no known published test standard on this subject.

C.1.3 Description

A sample of jet fuel is drawn by syringe through a capsule fitted with a disk of water-sensitive paper. The paper changes color if suspended water is present.

C.1.4 Equipment

1. A standard calibrated polyethylene or nylon syringe of 5 mL capacity, with a record type (thin blunt tube) end fitting. A 10 mL sample may be taken to obtain a more sensitive reading.
2. A disposable Shell water detector capsule containing a disk of filter paper treated with water-sensitive chemicals. The detector capsules are available from: in the U.S., Gammon Technical Products, Inc., PO Box 400, Manasquan, NJ 08736 (Telephone: 908-223-4600) and their distributors; elsewhere, A. Searle & Company, 24 Bourne Industrial Park, Bourne Rd., Crayford UK, DA1 4B2 Tel 44 (6) 1322591 (9).
3. Clean dry sample container, for example, 100 mL beaker.

C.1.5 Procedure (Fig. 1)

1. Collect a fuel sample in the sample container.
2. Examine the detector capsule to confirm that the paper is a uniform yellow color. If not, the capsule should be replaced from a fresh supply.
3. Fit the capsule to a clean syringe and immerse it into the fuel sample.
4. Slowly withdraw the syringe plunger until the fuel sample reaches the 5 mL mark.
5. Examine the paper disk in the capsule for any difference in color between the inner wetted portion and the outer portion that is protected by the plastic molding.

C.1.6 Cautions

1. The response of Shell water detector capsules to suspended water tends to deteriorate after approximately 9 months. Thus, allowing for shipping time, it is suggested that only a 6-month supply be ordered at any time. The expiration date (month/year) is marked on the bottom of each tube of capsules and also on one end of each box of ten tubes.
2. It is important that the capsule container be closed and sealed immediately after removal of the test capsule to prevent discoloration of the remaining capsules by moisture in the air. Unused capsules should not be carried outside of the container.
3. Capsules shall be used only once.

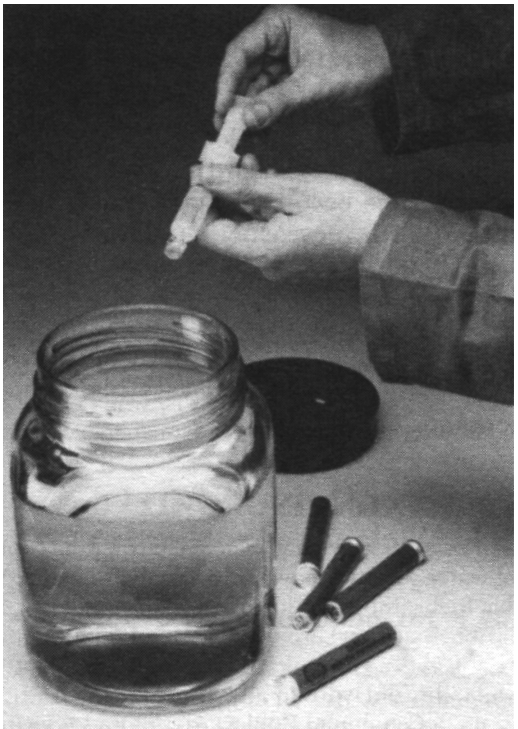


FIG. 1—5 mL syringe and detector capsule. (Reprinted courtesy of Shell International Trading Co., London, England.)

C.1.7 Interpretation of Test Results

The presence of suspended water is indicated by a change in color of the inner wetted portion of the paper disk. The resulting color change becomes progressively more evident with increasing suspended water content until at approximately 30 ppm (or 20 ppm for a 10 mL sample) a distinct green color is obtained. At low water contamination levels, a yellow/green color is obtained, changing to blue/green and finally blue/black at very high water contamination levels.

C.2 VELCON HYDROKIT®

C.2.1 Introduction and Purpose

The Velcon Hydrokit® is a simple test for suspended water in commercial jet fuel. It indicates the presence of more than 15 or 30 ppm by volume of suspended water (two sensitivity levels are available) by a change in color of water sensitive powder in a sample tube. It is principally used as a final water check at the aircraft refueling point. However, it may be used for quick checks of suspended water anywhere in the delivery system.

C.2.2 References

There is no known published standard for this test.

C.2.3 Description

The sample of jet fuel is drawn by vacuum into a stoppered test tube where the fuel contacts the Hydrokit powder. The color change of the powder is compared to a standard color card for a pass or fail decision; that is, whether the sample contains more or less than 15/30 ppm of suspended water.

C.2.4 Equipment

Hydrokit consists of a small evacuated test tube containing sufficient water sensitive powder to react with 10 mL of fuel. Both a reusable fuel sample bottle and needle assembly (to puncture the rubber stopper) is included to obtain the fuel sample.

For availability of Hydrokit address inquiries to Velcon Filters, Inc., 1210 Garden of the Gods Rd., Colorado Springs, CO 80907 (Telephone: 719-531-5855) or its distributors.

C.2.5 Procedure (Fig. 2)

1. Inspect the sample bottle to ensure that it is clean and dry.
2. Fill the bottle about 1/2 full with fuel directly from the fueling unit (downstream of filter/separator or at fueling nozzle). Make sure no moisture gets into the bottle.
3. Insert the plastic needle holder into the sample bottle immediately.
4. Insert the glass Hydrokit tube with stopper down into the needle holder assembly. Press the tube firmly onto needle, forcing the needle through the stopper. Hold until fuel flow stops. When the tube is held vertically with the stopper on top, fuel should reach a point above the black line on the tube.
5. Remove the tube from needle assembly. Shake vigorously for 15 s. Allow to settle 2 min and compare powder color to color standard.

C.2.6 Cautions

If the fuel does not enter the tube or if the fuel level in the tube does not reach the level noted in procedures, the tube has leaked (lost vacuum) and should be discarded. Repeat the test on a new fuel sample with a new Hydrokit tube.

Do not use tubes beyond the expiration time stamped on the box.

C.2.7 Interpretation and Limitations of Results

Compare the Hydrokit powder with the color standard immediately after the 2 min settling time. A pink color as dark or darker than the "fail" standard indicates more than 15/30 ppm suspended water in the fuel. Delivery of fuel should be stopped to determine the source of the excess suspended water. If the Hydrokit powder is lighter than the 'fail' color standard, the fuel has less than 15/30 ppm suspended water. The results showing less than 15 or less than 30 ppm of water depend on which Hydrokit is being used

It is important that the comparison with the color standard should be made at 2 min after shaking the sample. Powder in the fuel will gradually darken with time; color comparison after extended time is not valid. If the result is doubtful, repeat with a new tube and fuel sample.

C.3 GAMMON AQUA-GLO® WATER DETECTION KIT

C.3.1 Introduction and Purpose

The undissolved water content (in ppm) of turbine fuel can be measured accurately using this apparatus. One of its primary uses is to monitor the performance of devices designed to remove water from turbine fuels, for example, filter/separators. It may also be used to measure the undissolved water content of fuel anywhere in the distribution system.

C.3.2 References

ASTM D3240—Standard Test Method for Undissolved Water in Aviation Turbine Fuels.

C.3.3 Description

1. A 500 mL sample of fuel from a flowing fuel line is drawn directly through the detector pad at a quick-disconnect fitting.
2. Undissolved (free) water in the fuel will react with the chemical on the test pad. When the pad is subsequently illuminated by ultraviolet light, the coating will glow a bright yellow-green if any water was in the fuel sample. The brightness increases with larger amounts of free water in the fuel. The ultraviolet light illuminated pad is compared to a known standard, called the fluorescing standard, using a photocell comparator. The free water in the fuel sample is indicated in ppm by volume. The test covers a range from 0 to 12 ppm of water. The upper limit can be increased to 60 ppm by decreasing the sample size to 100 mL.

C.3.4 Cautions

1. The fuel sample must be drawn from the flowing fuel system directly through the test pad. Large errors may result if fuel is first collected in a sample container and then tested.
2. Sample lines should be as short as possible. Sampling

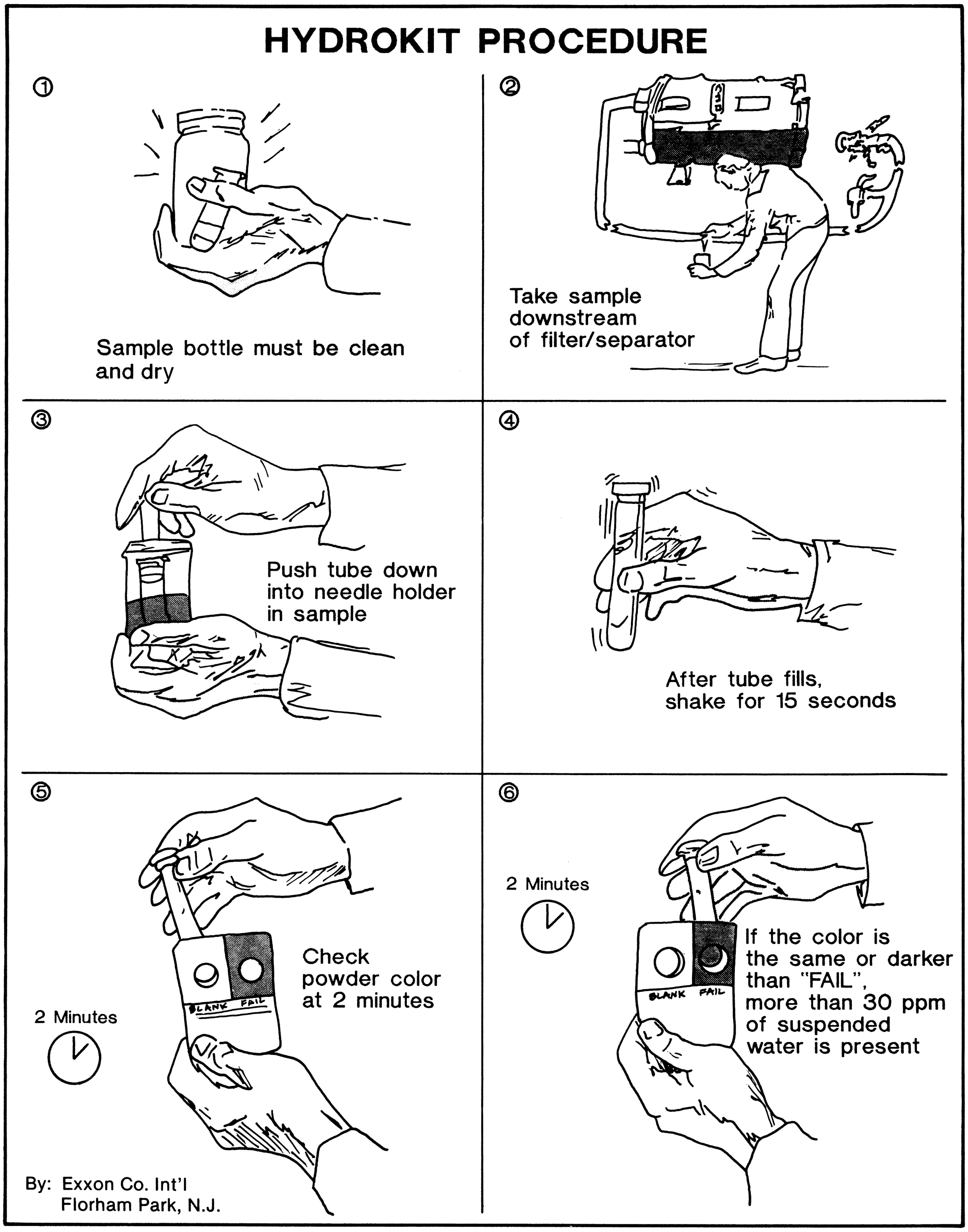


FIG. 2—Hydrokit procedure. (Reprinted courtesy of Exxon Mobil.)

connections that are so long that temperature differences exist between collected fuel and fuel in the system will cause errors. Temperature has a substantial influence on dissolved water in jet fuel. As a rule, 1 ppm of water will come out of solution for every 1 °F (0.55 °C) reduction in temperature. Typical jet fuel can hold about 70 ppm of water in solution at 70 °F (21 °C). If the sample of this fuel is cooled to 60 °F (15.5 °C), the dissolved water content is decreased to 60 ppm and the free water content is increased by 10 ppm.

3. Do not expose the water detector pad to the atmosphere until just before use. Humidity or water droplets on the pad will cause errors.

4. Never touch the pad, use tweezers.

5. Never use the fluorescing standard or calibrating standard

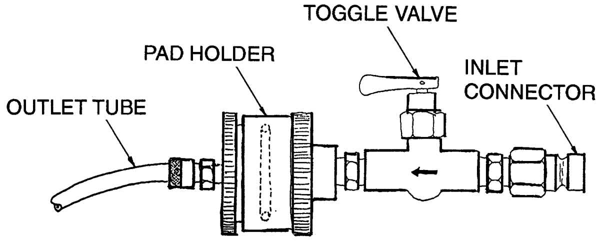


FIG. 3—Test setup for a water detector pad holder.

from one instrument in another instrument because they must be matched at the factory.

C.3.5 Equipment

1. Aqua-Glo Series II, III, or V Water Detector Kit, Model GTP-322 (or GTP-323) is required for this procedure. There is no difference in the water measuring components of Series II, Series III, or Series V kits. The Series III has an improved ultraviolet light source and the Series V has an improved power supply and is more field repairable.

2. Water Detector Pad (25-mm diameter), Model GTP-25.

Apparatus is available from: Gammon Technical Products, Inc., PO Box 400, Manasquan, NJ 08736.

C.3.6 Equipment Preparation

1. Check condition of the water detector pad holder, especially the inlet nipple and inside of holder for any dirt or water. If required, connect the assembly to a fuel source and thoroughly flush (Fig. 3).

2. Check the sampling connection in the system piping where the sample is to be taken. If any visible dirt or water is present, wipe thoroughly with a clean cloth or paper towel.

3. Calibrate the Aqua-Glo instrument. The calibrating standard that corresponds to a given undissolved water content is placed in the test pad window. Turn on the lamp. The ultraviolet light can be checked by moving the light adjusting lever from one extreme to another. The photocell comparator meter needle should swing widely when this is done. Null the photocell comparator by slowly moving the light adjusting lever until there is a steady reading at zero. *Always move the light adjusting lever in the same direction when zeroing the photocell comparator during calibration or testing to eliminate errors caused by play in the lever mechanism.* If the reading obtained does not agree with the calibrating standard rating, adjust the photocell comparator. Remove the plug screw on the side of the comparator at the 45° bend. Insert a small screwdriver and adjust as necessary. Repeat the above procedure until the reading obtained agrees with the calibrating standard rating. The instrument calibration should be checked frequently enough to ensure accuracy (see manufacturer's instructions). When the calibration check is completed, turn off the lamp. The calibrating standard is matched to each specific Aqua-Glo instrument and should not be used on a different instrument.

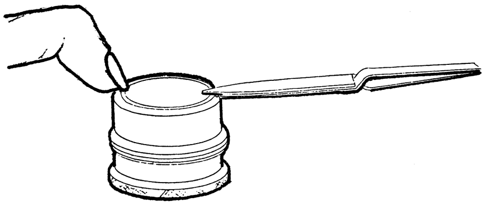


FIG. 4—Proper placement of the water detector pad in the pad holder.

4. If the meter is slow to respond, remove the four screws on the battery cover plate located on the instrument pack and replace the 9 V transistor battery.

C.3.7 Procedure

1. Connect the empty pad holder assembly to the sampling quick-disconnect and flush at least 1 gal (3.78 L) through the assembly.

2. Disconnect and separate the halves of the pad holder.

3. Carefully tear open the protective envelope and remove the water detector pad with the tweezers supplied in the kit. *Do not touch the pad with your finger.* If the pad is orange, it is suitable for the test. If it is yellow, it has spoiled and should not be used because an excessively high water content will be indicated.

NOTE

Do not remove the test pad from the hermetically sealed package until ready for use. Do not allow any water droplets to come into contact with the pad (from rain, sneezing, coughing, and so forth). Exposure of the test pad to the atmosphere, especially on humid days, will ruin the pad in a matter of minutes.

4. Place the water detector pad (orange side up) in the recess of the outlet half of the pad holder. Use the thumb nail of the other hand to hold it in place as the tweezers are released (Fig. 4).

5. Reassemble the pad holder; hand tighten to prevent bypassing.

6. Turn the toggle valve to the closed position.

7. Connect the pad holder assembly to the sampling quick-disconnect.

8. Place outlet hose in the calibrated bottle that is provided in the kit.

9. Open the toggle valve.

10. Collect 500 mL of fuel in the calibrated bottle and close the toggle valve. Dispose of this fuel in an approved manner.

NOTE

A flow rate of 600–800 mL/min is recommended for greatest accuracy (about 45 s for 500 mL). To prevent higher flow rates, a throttling valve should be installed in the sampling connection.

11. Disconnect the pad holder assembly from the sampling quick-disconnect and separate the two halves of the pad holder. If the toggle valve is opened and the two halves are then separated, the water detector pad is less likely to stay in the inlet half.

12. Remove the water detector pad with tweezers and press between clean dry paper towels to remove excess fuel. A suit-

able procedure is to press firmly three or four times using the heel of the hand, moving the pad with tweezers each time.

NOTE

For maximum accuracy, the test pad should be read within 3 min.

13. Using tweezers, place the pad under the test pad flap of the comparator chamber. The coated side must face the hole in the chamber. Turn on the lamp. While pressing the photocell button, null the photocell comparator by slowly moving the light adjusting lever until there is a steady reading at zero. Always move the light adjusting lever in the same direction when zeroing the photocell comparator to eliminate errors caused by play in the lever mechanism. Turn off the instrument light immediately after use to conserve battery power.

14. Record the ppm as indicated by the lever position on the scale. Also record the sample volume.

15. Wipe the test pad holder dry of fuel and replace it in the carrying case.

B.3.8 Evaluation of Test Results

If conditions do not permit collecting 500 mL, or if readings higher than 12 ppm are expected, accurate results can be obtained for any volume of fuel between 100 and 500 mL by correcting the reading using the following equation:

Free water, ppm=[(scale reading in ppm) × 500 sample volume in mL]/reduced test volume size in mL.

For example, if it was impossible to "zero" the meter using a 500 mL sample, repeat the test with a new water detector pad and a smaller sample volume, such as 100 mL. This results in a range of 60 ppm. If the sample volume is 250 mL, the range is 2–24 ppm, etc.

If the water content exceeds 12 ppm, it will be impossible to zero the meter. To measure up to 60 ppm, repeat the complete test using a new water detector pad, but take a sample volume of only 100 mL, and use the above equation.

C.4 WATER DETECTION PASTE

C.4.1 Introduction and Purpose

Water detection pastes are used to determine the depth of water at the bottom of a storage tank. Water detection pastes do not respond to suspended or dissolved water in fuels. Many pastes do not detect water-alcohol mixtures.

Standard water paste does not detect water if a significant amount of DiEGME (anti-icing additive), e.g., FSII or "Prist ®" is present. Special "modified" water finding paste is available for use in fuels containing this type of additive.

*Prist is a registered trademark of Prist Aerospace Products, Inc., Division of CSD Inc.

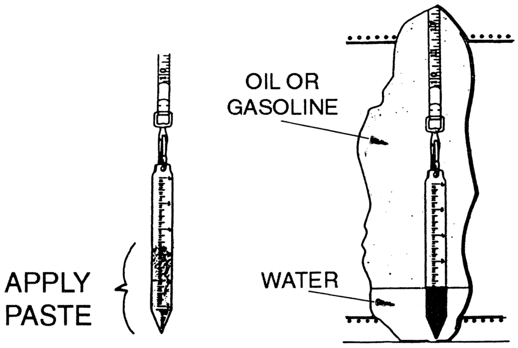


FIG. 5—Application of water detection paste.

C.4.2 References

ASTM D1085/API Standard 2545—Standard Practice for Gaging Petroleum and Petroleum Products.

C.4.3 Description

A water reactive paste is applied to a gage tape or stick to determine the fuel/water interface. The paste will change color if it contacts water.

C.4.4 Equipment

A calibrated stick or gauge tape of sufficient length to reach from the gauge hatch to the tank bottom, along with water detection paste is required for this procedure.

C.4.5 Procedure

1. Apply a thin coating of water detection paste to the gauge several inches above and below the suspected interface level (Fig. 5).

2. Carefully lower the gauge or stick through the fuel (in a vertical plane) until it lightly touches the tank bottom. Hold in this position for several seconds.

3. Remove the gauge and observe the color difference in the paste. The water level will be clearly indicated by a definite color change where the water contacts the paste.

C.4.6 Cautions

1. Avoid rapid lowering of the gauge tape through the product to prevent tilting of the plumb-bob that could result in inaccurate readings.

2. Maintain tape contact with the gauge hatch to prevent static charges.

3. Periodically check the reactivity of the paste.

C.4.7 Interpretation of Test Results

The water depth is indicated by a color change of the paste. The volume can be calculated using tank or vessel tables.

D

Filtration Equipment

D.1 FILTRATION EQUIPMENT—GENERAL

D.1.1 Introduction and Purpose

This section describes filter vessels and filter element media that may be used at aviation fuel handling facilities. This topic is sufficiently complex that only the highlights can be considered herein. Taking inspiration from this ASTM Manual 5, the API and Energy Institute have recently published a new guidance document (API/IP 1550) to communicate to the typical user many of the issues that should be appreciated in using fuel filters for the supply of aviationfuel.

D.1.2 References

API/IP/EI 1550 Handbook on equipment used for the maintenance and delivery of clean aviation fuel.

API/IP/EI Specification 1581—Specifications and Qualification Procedures for Aviation Jet Fuel Filter Separators.

API/IP/EI Specification 1582—Specification for Similarity for API/IP/EI 1581

Aviation Jet Fuel Filter Separators.

IP Specification 1583—Specifications and Qualification Procedures for

Aviation Fuel Filter Monitors with Absorbent Type Elements.

API/IP/EI Specification 1590—Specifications and Qualification Procedures for

Aviation Fuel Microfilters.

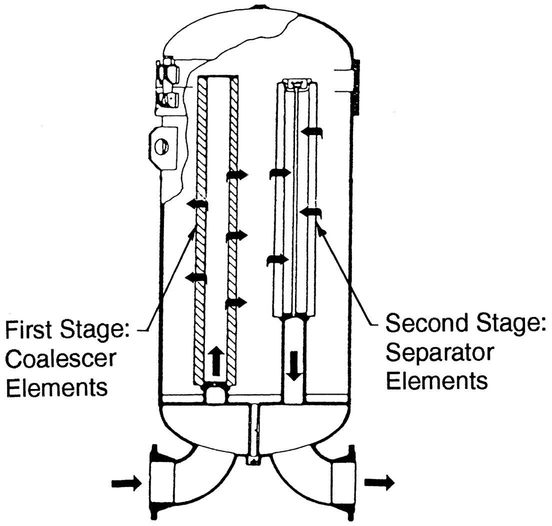


FIG. 1—Vertical filter/separator vessel.

MIL-PRF-81380 Filter/Monitor, Contamination, Aviation Fuel.

Dispensing System.

D.1.3 Description

1. Filter/Separator Vessels

Filter/separators are used to remove solids and water from the fuel. In the simplest case they contain two types of elements: coalescers (first stage) and separators (second stage). Flow is normally from inside to outside through the coalescers, and outside to inside through the separators. Figure 1 shows a typical vertical filter/separator vessel. The arrows show the direction of fuel movement through the elements.

a. *Coalescers*. Coalescer elements combine extremely small water droplets into large drops that fall by gravity into the vessel sump. On the outside of each coalescer is a “sock” (knitted cotton or synthetic material) that assists in coalescing the water drops. Solid particles are also filtered from the fuel by the coalescer. Coalescer elements are usually either all fiberglass, or a combination of pleated paper and fiberglass. The all-fiberglass type is usually constructed so that coarser fibers are placed in the center of the element and finer fibers are wrapped on the outside. In the combination fiberglass and pleated paper coalescers, the pleated paper on the inside of the element filters solids before the fuel reaches the fiberglass. The paper protects the fiberglass so that it can coalesce water better, since solids entrapment will eventually degrade fiberglass coalescing performance.

b. *Separators*. Separator elements are made from water repellent (hydrophobic) media that allow fuel to pass but block the passage of previously coalesced water drops. Separators are normally made with a Teflon-coated screen (TCS), a synthetic screen or silicone-treated paper in pleated or cylindrical form The types of separators are described below.

- *TCS Separators*. The element is typically 100 or 200 mesh stainless steel or monel wire screen that is coated with Teflon material. These separators, with proper handling and cleaning, can be reused (Sec. D.4).
- *Synthetic Separators*. The media in these elements is synthetic mesh material with chemically bonded hydrophobic treatment. These separators, with proper handling and cleaning like the TCS separators, can be reused (Sec. D.4).

2. Particulate Filter Vessels

Particulate filters (sometimes called micronic filters or prefilters) remove solid particles from the fuel. These vessels are not designed to remove water. Typical elements for these units

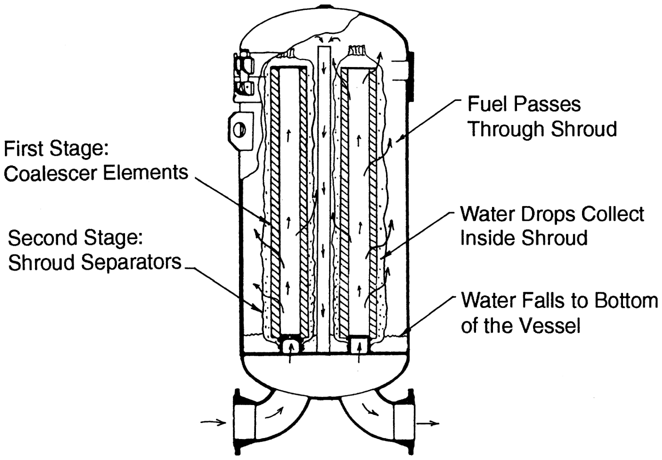


FIG. 2—Filter/separator vessel with shrouds.

are the pleated paper type and are designated in terms of micron rating. The micron ratings indicate that a vast majority of particles larger than the rating will be removed. Micron ratings of filter elements are not determined by all manufacturers based on the same criteria. For this reason, API/IP 1590 was developed to provide a consistent basis for measuring and specifying the micron ratings of aviation fuel particulate filters. Several micron ratings are available but the typical elements used for aviation fuel are 5 μm or less. Pleated paper provides more surface area in the elements for longer service life.

3. Clay Treatment Vessels

Clay treaters are used to remove surfactants from the fuel, which could otherwise "disarm" filter/separator elements located downstream of the clay vessel. The clay (Fullers's earth or attapulgus clay) can be either in bulk or packed in elements (bags or canisters). The clay is usually 50–90 mesh grain sized and is designated as "LVM" (low volatile material). LVM treatment of the clay makes it more resistant to "disarming" by water.

4. Dehydrator Vessels

Dehydrators (commonly referred to as hay packs) remove large particulate matter and bulk water from the fuel prior to all other filtration. They are effective in protecting clay elements from water. The media used in dehydrators is a special excelsior or other combination of media that promotes coalescence and dirt removal. The media is packed into the vessel and held in place by special containment devices.

5. Monitor Vessels

NOTE: Due to the changing nature of the standards of the EI/IP in regard to this form of filtration, refer to the latest standard IP-1583, which may be more up-to-date than this document.

NOTE: Water absorbing elements **should not** be used in fuel containing anti-icing additive, also known as DiEGME, FSII or Prist. ®

*Prist is a registered trademark of Prist Aerospace Products, division of CSD, Inc.

A filter monitor is a vessel containing absorbent filter elements. A filter monitor is intended to continuously remove dirt and water from aviation fuel to a level acceptable for fueling modern aircraft. It is also intended to restrict the flow of fuel if the level of dirt or water is unacceptable.

Filter monitor elements have short service life with wet fuel so they are usually used downstream of coalescer/separator systems. They often comprise the last filtration of jet fuel before it is placed on an aircraft.

Filter monitors are generally effective for removing dirt and water contamination from aviation fuel but must not, by themselves, be viewed as fail-safe devices. Because the water absorption performance of filter monitor elements can degrade in service, a filter monitor must be regarded as no more than one component in a comprehensive system to control aviation fuel contamination.

Monitors, usually located downstream of filter or filter/separator vessels, are "insurance" vessels. These elements are changed out when the differential pressure reaches a certain level; the manufacturer normally recommend 15–25 psi differential, 103–167 kPa.

6. Strainers

Strainers are screens installed prior to nozzles, valves, pumps, and other mechanical equipment to remove coarse particulate matter. They do not provide the filtration and water removal functions of the other equipment of this section.

7. Suggested Vessel Sequence

There have been numerous questions about the proper sequence of the various filter-type vessels. At a jet-fuel receiving station downstream of a pipeline where relatively large amounts of water, particulate matter, and surfactants might be present in jet fuel, the suggested sequence of vessels is as follows, but this sequence may be altered to suit local conditions. For example, in high dirt/low water locations, reversing the order of the prefilter and dehydrator and using an oversized prefilter may be advantageous. If water is not considered to be a likely problem, the dehydrator may be eliminated.

First—Coarse coalescer, or dehydrator (hay pack) vessel to remove most of the bulk water, thereby protecting the downstream clay (water blocks flow through clay where it makes contact, increasing the fuel velocity in the remaining clay and greatly reducing the ability of the clay to remove surfactants). Dehydrators (hay packs) are used primarily at locations where severe water contamination may be expected.

Second—Particulate filter (micronic or prefilter) vessel to remove dirt, and so forth and protect the clay vessel from becoming plugged with particulate matter.

NOTE

Oversizing the dehydrator and particulate filter vessels is recommended in order to improve efficiencies of water and particulate removal and to increase the time between media change outs, and clay vessels may also be oversized if advisable due to the level of surfactants expected.

Third—Clay treatment vessel to remove surfactants, thereby protecting the downstream filter/separator vessel.

Fourth—Filter/separator vessel with acceptable water defense protection to remove any remaining water and particulate matter, getting the fuel to the cleanliness level required at the airport. The F/S vessel will remove any clay fines that might migrate from the clay vessel.

NOTE

If local conditions indicate that a monitor vessel should be included in this sequence, it should be positioned last.

API/IP/EI 1550 is available to provide more detail concerning the various options typically used for aviation fuel filtration.

D.2 FILTER ELEMENT INSTALLATION PROCEDURE

D.2.1 Introduction and Purpose

The purpose of this procedure is to ensure that filter elements (that include coalescer, separator, micronic, and clay treatment elements) are installed correctly to prevent bypassing or malfunctioning of the elements.

D.2.2 References

There is no known published test standard on this subject. Most manufacturers include element installation instructions in their equipment operating manuals and instruction sheets are usually included in the element shipping cartons.

D.2.3 Description

New filter elements are installed in filter vessels just before start-up. Elements are replaced when: the differential pressure reaches the recommended change-out point, the recommended service life has been reached, the elements become disarmed (Sec. D.7), or there is reason to suspect that the elements need changing (possible rupture, bypass, unacceptable filter membrane rating, and so forth).

D.2.4 Equipment

A new set of the correct elements and a new cover gasket should be available before the vessel is opened. A supply of clean cloth is needed for wiping foreign matter from the vessel interior.

D.2.5 Procedure

General steps for replacing micronic filter elements, clay elements, and coalescer and separator elements are listed below. Specific comments on coalescer and separator elements follow the general steps.

1. Shut off the pump.

2. Turn off power to the electric sump and/or drain heater if vessel is so equipped.

3. Close the inlet and outlet valves.

4. Open drain valve and remove product from vessel.

CAUTION

Due to differing vessel designs, it is important to identify and open the proper drain valves.

5. Open the manual air eliminator valve. This permits the vessel to drain faster.

6. When drained completely, open the cover, and before disturbing elements, allow 10 min for relaxation of accumulated static electricity charges.

7. Inspect the interior of the dome cover for evidence of soot and/or contamination (Sec. D.3).

8. Remove spiders if installed and then remove the elements.

9. Wipe off or wash down any foreign matter from the vessel interior and the cover with clean cloth soaked in product or clean water.

CAUTION

Do not use soap or detergents to clean the inside of the vessel.

Remove all cleaning material.

10. Before installing the new elements, the vessel should be inspected and/or tested in accordance with Sec. D.3.

11. Install elements with clean hardware (spacers, end caps, and so forth) as per manufacturer's or conversion kit instructions. Five types of element instructions are listed below.

CAUTION

Do not touch the outer surface of an element with your bare hands or any greasy materials. When installing elements, open the plastic bags at the open ends of the elements and slide the bags back a few inches. Leave the bags on the elements for handling purposes during installation.

After the elements have been installed, remove the plastic bags *SLOWLY* to prevent static discharge.

- *Threaded Base Coalescers*. Thread the coalescers by hand onto the adapters, which are installed in the vessel, until you feel the gaskets seal on the adapter knife edges. Turn each element with both hands, gripping the end cap only, until it is hand tight and then remove the plastic bag. If there is a square fitting on the end of the coalescer, use the proper adapter and wrench to tighten it to the manufacturer's recommended torque value.
- *Open End Coalescers*. Install elements carefully so they seal around the pilot guides on the inlet holes. Remove plastic bags and install cover plates or spacers as needed on the tie rods. Install rubber gasket, flat washer, lock washer, and nut on the tie rod. Hand tighten the nut and then use a wrench to tighten it to manufacturer's recommended torque value, or until the lock washer is flattened and the rubber washer begins to curl up around the outer edge. *DO NOT OVER TORQUE*.
- *Separator Elements*. Separator elements are normally TCS type or synthetic screen. TCS or synthetic separators may be removed, inspected, cleaned (and repaired as required), and tested each time the coalescer elements are changed, depending on manufacturer's instructions. Synthetic separators may need to be discarded. Also see Sec. D.4 for maintenance procedures. Elements that do not test satisfactorily should be replaced.

CAUTION

DO NOT TOUCH the separator media with bare hands. It is recommended that separators be handled only at the end caps.

If fabric shroud separators are used, follow the manufacturer's instructions for tying them. Be careful that the fabric at the threaded end does not interfere with the threads. Also, ensure that the fabric at the top end is not tied so loosely that it will enter the outlet pipe.

- *Clay Canisters and Micronic Elements*. Tighten nuts on tie rods to manufacturer's recommended torque value. *DO NOT OVER TORQUE.*

CAUTION

A careful inspection of the hardware that supports and seals the elements is recommended. If a small portion of the fuel can bypass the clay, the overall effectiveness of the treatment is reduced substantially.

Some hardware that is designed to hold bag elements is only marginally effective in sealing canister elements. If the hardware was designed to hold canisters, it is probably totally ineffective for bag type elements.

- *Bag Type Clay Elements*. The I.D. liner of a bag element is a fabric that may be permanently supported by a porous plastic tube (type A element) or temporarily by a heavy fiber tube (type B element). Install elements in stacks with as many layers as required using special care to keep the fabric end discs flat to avoid bypassing through creases. Do not drop the elements in place, but use a firm downward motion to promote settling and stabilization of the clay. If the stack is too high to install the cap, raise and then firmly lower the elements a few inches to promote further settling. Type A elements must be installed with the porous tube in place. Type B elements are installed by lowering the element over the perforated support tube. The fiber tube will be forced upward out of the element. Install the spring loaded top cap in accordance with the manufacturer's instruction.

CAUTION

Never remove the fiber tube from the type B element before installing it. Do not remove type B elements from the vessel and expect to reinstall them, because the fiber tubes cannot be reinserted in the bags.

Never attempt to install bag-type elements in a vessel that was designed for canister elements unless special bag-holding hardware is used.

Spring cap "hang up" is a common problem. This is caused by the I.D. liner fabric catching on the top end of the porous tube of type B elements. The I.D. of the spring loaded cap then wedges against this fabric, resulting in the entire cap being "hung up" so that it cannot follow the clay downward as it settles. The same problem can occur with type A elements with the fabric catching on the top of the perforated support tube assembly. To avoid this problem, the fabric of the top element must be pushed downward by hand until it is clear of the edge of the support tube before the spring cap is installed.

12. Install the spider over the tie rods or end bolts. Then tighten nuts on the tie rods (end bolts) to help hold the elements securely in place.

13. Install a new cover gasket.

14. Check cover gasket for proper alignment. Replace cover and secure tightly. Stencil or otherwise mark the date of the element change on the outside of the vessel.

15. Close the manual drain valve.

16. Open the manual air eliminator valve if so equipped.

17. Leave the inlet and outlet valves closed.

18. Preferably, gravity fill the vessel; if not feasible, start the system pump.

19. *SLIGHTLY* open the inlet valve allowing the vessel to *SLOWLY* fill with fuel (the slower the better) to avoid static electricity charging of the fuel and/or fuel misting, either of which could lead to an internal fire or explosion.

20. If the vessel has a manual air eliminator valve, leave the valve open until the fuel flows from the opening; then close it quickly. If the vessel has an automatic air eliminator, the vessel is full when the eliminator stops discharging air. Check for fuel leaks.

21. When the vessel is filled with fuel, fully open the inlet valve and *SLOWLY* open the outlet valve. Then turn power on to the sump and/or drain heater of the filter separator (if so equipped).

22. If the vessel is the final stage of filtration before refueling aircraft, then fuel should be recirculated through the vessel at normal flow for at least 15 min to help clear the system of possible contaminants.

23. When flow has been established, record a differential pressure reading. If there is no differential pressure or it is lower than expected, the system should be shut down and the vessel inspected for broken seals, ruptured or charred elements, elements left out, or improperly installed elements. If the differential pressure is higher than expected, contact the element manufacturer or representative.

24. A good practice is to perform a filter membrane test downstream of the vessel in accordance with Sec. B.1.

D.3 FILTER ACCESSORY MAINTENANCE

D.3.1 Introduction and Purpose

The proper operation of the accessory equipment on a filter vessel is a key factor in obtaining reliable performance from the filter. This section outlines the periodic normal maintenance requirements and procedures for filter vessel accessories. Among these accessories are differential pressure gages, sump floats and probes, shutoff valves, air eliminators, pressure relief valves, drain and sample valves, sump heaters, and sight gauge glasses (Fig. 3).

D.3.2 References

There is no known standard method for performing this maintenance. This section should be read in conjunction with Secs. D.5, D.2, and D.6 that detail procedures for checking fil-

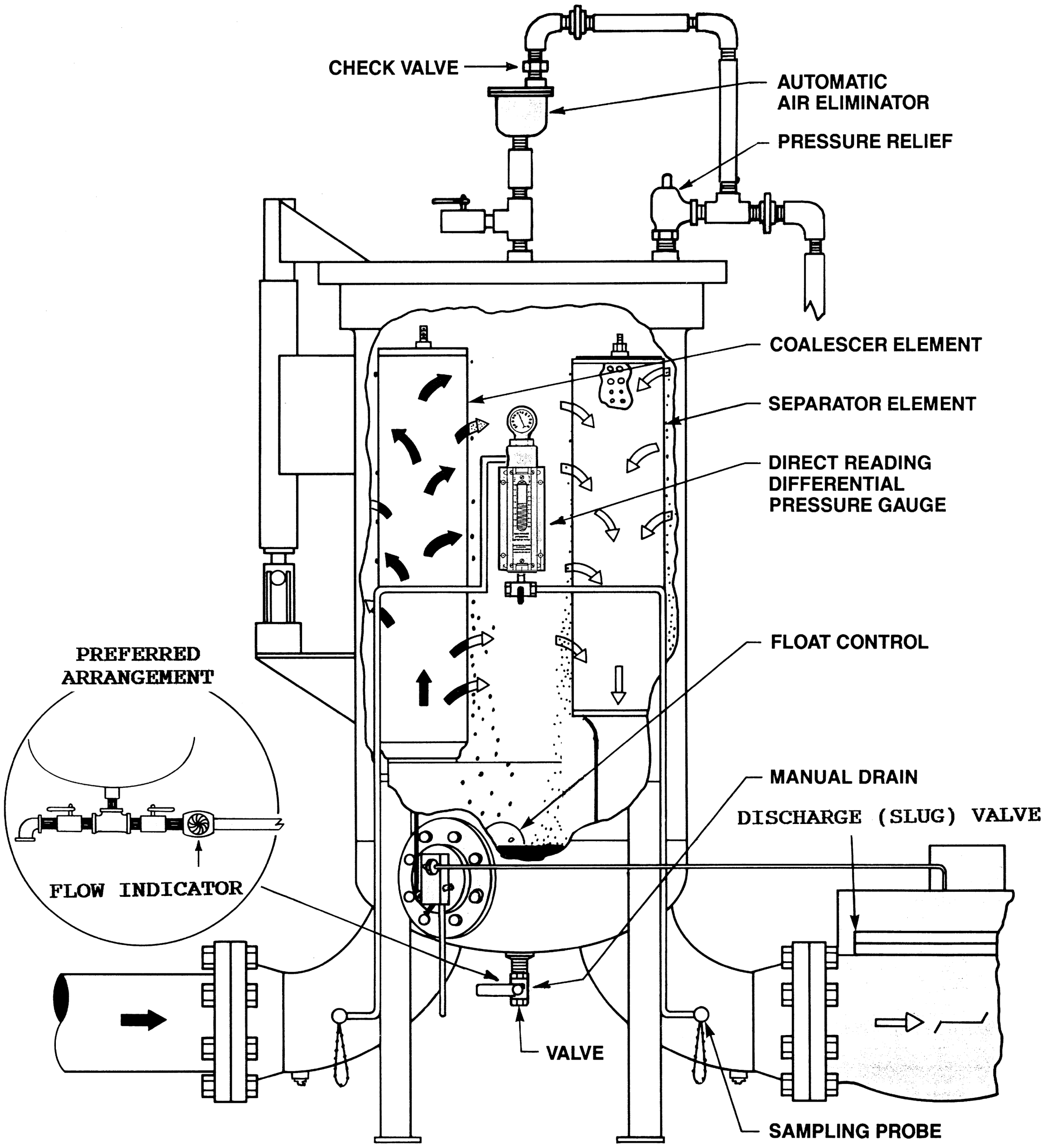


FIG. 3—Typical vertical two-stage filter/separator, per API-1581, showing some accessory equipment.

ter differential pressure, filter element replacement, and flow control (slug) valve.

D.3.3 Accessory Maintenance

1. Differential Pressure Gauge

a. Periodically check that gage lines and valves in lines are not air-bound, plugged, or restricted.

b. Some direct reading gages have small filters in their inlets. They must be clean to ensure proper gage operation and avoid sluggish response. Replace as necessary.

c. Where three way valves are used, be sure that the various positions are correctly marked and verify that the valve handle shows the correct valve position.

d. Periodically, or if gauge readings are suspect, remove the gauge and test it against a known reference; replace or repair as required.

e. If a piston-type direct reading gauge shows evidence of internal contamination or sluggish operation, the gauge should be disassembled and cleaned. Be sure that the manufacturer's repair instructions are followed.

Note: The API/IP/EI 1581 requires that a three-way test valve be present on the outlet (lower) fitting of piston-type differential pressure gauges. This allows the incoming (filter outlet) pressure to be shut off and the area under the piston to be vented to atmospheric pressure by way of a proper catch system to prevent a spill of the fuel. The piston then will be driven down by system pressure to the bottom of its travel, and this can be observed to ensure that no damage or debris inhibits the smooth operation of the piston/spring assembly. If the piston does not move smoothly, the piston and glass tube can be cleaned in accordance with the manufacturer's recommendation.

The next test is to return the valve to the operating position and stop all flow in the system. The piston should return to the "zero" position. If not, either cleaning, as above, or replacement of the spring may be required.

2. Sump Float or Probe

See Sec. D.6 for instructions on the periodic testing of this equipment.

A float or probe is installed in the sump of the vessel to detect a buildup of water in the sump. At a predetermined water level, the float/probe will actuate (close) the flow control (slug) valve and/or shutdown the flow.

3. Flow Control (Slug) Valve

See Sec. D.6 for instructions on the periodic testing of this equipment.

The flow control valve at the outlet of the filter vessel will automatically shut down the system if the float/probe signals that an excessive amount of water has accumulated in the sump.

4. Air Eliminator

The ability to remove air can be checked when a filter vessel is being filled after maintenance, or in some cases when the pump is first started up, by noting that air is being expelled from the air eliminator outlet piping. Only a relatively small amount of liquid should be expelled with the air and there should be no leakage of liquid after the air is out. Where the air eliminator is piped to a closed system, a sight gage should be installed in the line to determine whether liquid product is leaking through the air eliminator.

The air eliminator could also be removed, the unit inspected, and the float action checked according to the manufacturer's instructions.

CAUTION

It is recommended that a check valve be installed on the *outlet side* of the eliminator to prevent air from reentering the vessel.

When the vessel is opened, note whether a stain ring or soot shows on the internal upper wall or top cover. This could indicate the air eliminator is not working properly. Air is being trapped in the vessel or bleeding back through the air eliminator and its outlet check valve if the vessel happens to be the high point in the system. Air trapped in the vessel can lead to an explosion if sufficient static charge is generated to cause an internal spark.

5. Pressure Relief Valve

The valve should be removed periodically and tested to see that it operates at the set pressure.

CAUTION

The set pressure must never be higher than the filter's design or maximum working pressure.

6. Drain and Sample Valves

These valves should be repaired or replaced when leakage or operation difficulty is noted. The use of ball valves is desirable, since they permit rapid opening to full flow, rapid closing, and have less tendency to trap rust and dirt.

7. Sump Heaters

In areas where the temperature goes below freezing, electrical jacketing or immersion heaters may be necessary to prevent water from freezing in the sump and water drain off lines. Heaters should be activated and checked according to the manufacturer's instructions prior to the onset of cold weather, and periodically during the winter.

CAUTION

Prior to the vessel being taken out of service for maintenance, be sure to turn off and lock out electrical power.

8. Sight Glasses

Sight glasses are sometimes installed on filters to show when water is building up in the bottom of the vessel. They must be periodically flushed or disassembled to clean the glass so that the water/fuel interface can be readily seen.

D.4 TEFLON® COATED SCREEN (TCS) AND SYNTHETIC SEPARATORS

D.4.1 Introduction and Purpose

The purpose of this procedure is to evaluate TCS and synthetic material separators for serviceability. Procedures are described for cleaning and repairing.

D.4.2 References

There is no known published test standard on this subject. Cleaning procedures are published by some filter element manufacturers.

D.4.3 Description

When coalescer elements are changed in accordance with Procedure D.2, and at other times when the performance of TCS or synthetic elements is in question, it is desirable to verify the proper condition of the separator elements. This is done by visually inspecting, testing with running water, and if necessary, cleaning and repairing the elements.

D.4.4 Equipment

The following equipment is required for this procedure: container of clean jet fuel, clean cloth or *soft* fiber brush, tap water, and two part epoxy if necessary.

D.4.5 Procedure

General

1. If the filter/separator vessel is not open, follow the procedure outlined in Sec. D.2.5, items 1–7.

2. Remove spiders, if installed, and carefully remove the separator elements.

CAUTION

In removing the separator elements, care must be taken not to touch the surface of the screen. Skin oils may disarm the separator elements. A clean cloth or cotton gloves should be used while holding the elements to facilitate their removal.

3. Visually examine each element. It should appear clean, without any collection of dirt, particulate matter, "slime" or "foam." No cuts, tears, or abrasions should be visible.

4. If any dirt or other matter is present, the cleaning procedure should be followed.

5. If any cuts, tears, and so forth are present, the repairing procedure should be followed after cleaning.

Cleaning Procedure

1. Submerge the element in a container of clean jet fuel and gently scrub the entire surface with a soft fiber brush.

2. If foreign material is present, it may be necessary to change the fuel to ensure that clean, uncontaminated fuel is used as a final rinse.

3. Inspect the element to ensure that it is clean. If any foreign matter is noted, repeat steps 1 and 2. If any cuts, tears, nicks, and so forth are noted on the surface, proceed with the repairing procedure below; otherwise, proceed with the water testing procedure.

Repairing Procedure

NOTE

If the screen surface shows a cut, nick, tear, and so forth, larger than $\frac{1}{8}$ in. size, the element should not be repaired.

1. If the hole in the separator is small, coating the damaged area with two part epoxy may repair it. Epoxy will not stick to Teflon, so the epoxy must be worked into the screen, to provide a mechanical lock. A tool must be used to force the epoxy into the hole and the immediate surrounding mesh.

2. After the repair has been made, the element must be tested in accordance with the water testing procedure.

Water Testing Procedure

1. Be sure that the separator is fuel-wetted before performing this test by completely immersing the separator in clean fuel. Hold the element by the end cap at an approximate 45° angle and gradually pour water over the entire screen surface while slowly rotating the element.

CAUTION

Do not spray the water and do not let it fall more than 3 in. (7.62 cm) before contacting the separator, since the splashing will make interpretation of the results difficult.

2. Examine the screen as the water flows over it. It should bead and roll off the surface without wetting the surface. This beading is similar to water drops on a waxed automobile finish. If the water "wets" the surface and penetrates into the screen, the surface must be cleaned again.

3. If the element successfully passes this test, it may be reinstalled in the filter vessel after a final rinse in clean fuel to remove any water traces. Care should again be exercised to prevent touching the screen with anything other than a clean cloth or cotton gloves.

4. If the element fails the water testing procedure, washing with hot water may be attempted. Using pressurized hot water, *not steam*, spray the area that has not passed the water test. It may be necessary to also rescrub the area with a clean cloth or soft fiber brush. Allow the element to dry thoroughly and then repeat the water testing procedure, after fuel-wetting the separator.

5. If the element cannot pass this test, it must be discarded and replaced with an acceptable element.

D.5 DIFFERENTIAL PRESSURE—DELTA P OR ΔP

D.5.1 Introduction and Use

The purpose of observing differential pressure across a filter vessel is to monitor the changing condition of the elements. Establishing and maintaining a record of differential pressure readings across filters provides a history, so that element change times can be anticipated and abnormal conditions detected.

D.5.2 References

API/IP/EI Publication 1581—Paragraphs 3.1.4.2 and 3.2.4.2.

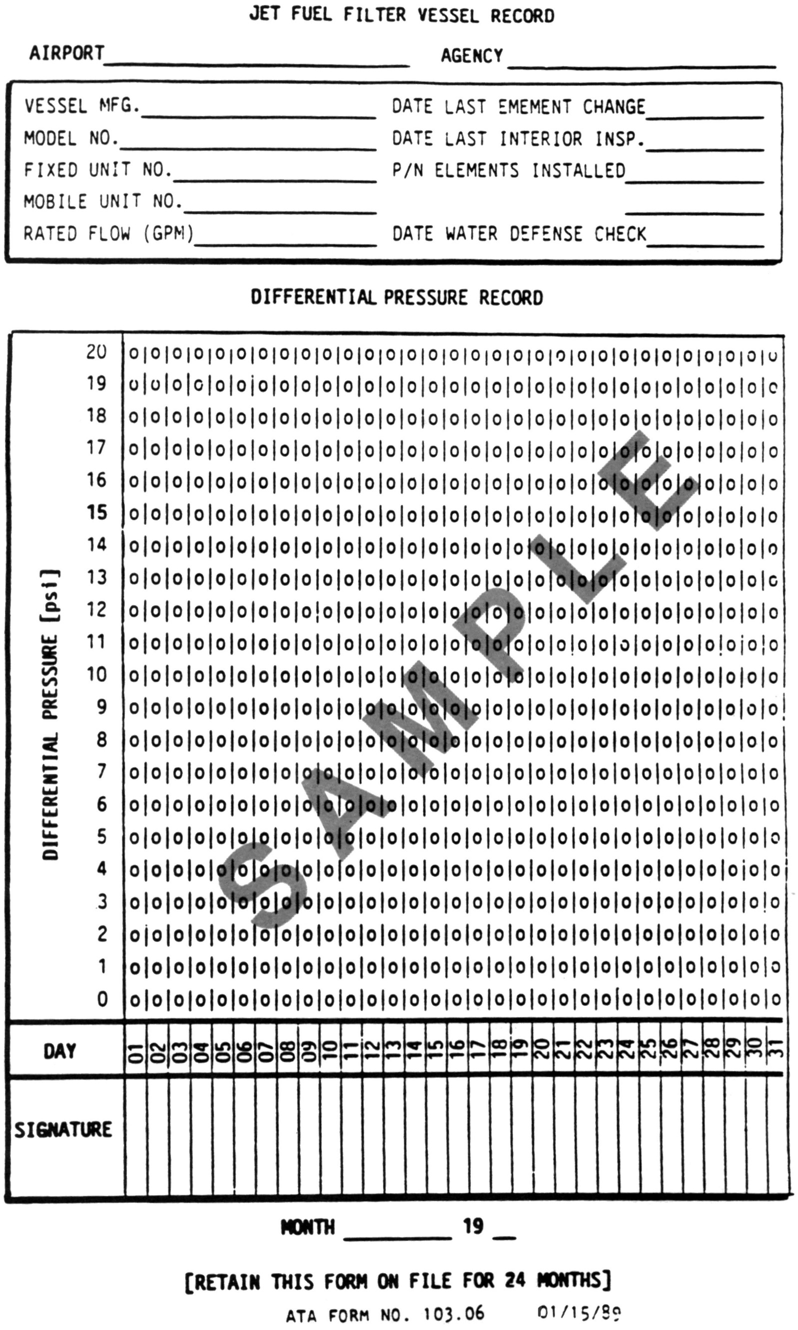
Air Transport Association of America (ATA) Specification 103—Sections 2-4.3, 2–7.2, and 2–8.3.3 and Form 103.06.

D.5.3 Description

1. Whenever fuel passes through a filter, a drop in pressure occurs across the element. (At any fixed flow rate the absolute pressure upstream of the element is higher than the absolute pressure downstream of the element.) This may be quite minimal with new filter elements, normally ranging from less than 1 to 7 psi (7 to 48 kPa) at rated flow. As the elements collect solids or contaminant from the fuel, the drop in pressure across them gradually increases. The difference in pressure between inlet and outlet of the filter vessel should be monitored daily, and recorded no less than weekly (more often on filters in critical applications). This differential pressure is one of the more apparent indications of filter element plugging. If the differential pressure increases suddenly, it could indicate plugging of the elements. If the differential pressure decreases suddenly, it could indicate element rupture or bypassing, which is cause for immediate investigation. Maximum allowable differential pressure is specified by the element manufacturer, usually 15 psi (103 kPa) to 25 psi (172 kPa), at which point the filter elements should be replaced in accordance with Sec. D.2 above.

2. Differential pressure readings across filters should be recorded, either as a column of figures or, preferably, as a line graph with information on fuel source, batch tank, and so forth. This record provides an immediate indication of abnormal filter differential pressure. It may also help to identify shipments or receipts of contaminated fuel or storage tank contamination. It alerts fuel handlers to impending element failure, thereby allowing corrective action to be scheduled prior to actual failure.

3. Throughput should be recorded at the time of any filter inspection or element change (may also be recorded as a run-



JET FUEL FILTER VESSEL RECORD

AIRPORT__________ AGENCY__________

VESSEL MFG.__________ DATE LAST EMEMENT CHANGE__________
MODEL NO.__________ DATE LAST INTERIOR INSP.__________
FIXED UNIT NO.__________ P/N ELEMENTS INSTALLED__________
MOBILE UNIT NO.__________ __________
RATED FLOW (GPM)__________ DATE WATER DEFENSE CHECK__________

DIFFERENTIAL PRESSURE RECORD

DIFFERENTIAL PRESSURE [psi]

20	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
19	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
18	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
17	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
16	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
15	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
14	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
13	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
12	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
11	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
10	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
9	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
8	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
7	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
6	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
5	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
4	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
3	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
2	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
1	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
0	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
DAY	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SIGNATURE																															

MONTH ________ 19 __

[RETAIN THIS FORM ON FILE FOR 24 MONTHS]

ATA FORM NO. 103.06 01/15/89

FIG. 4—Filter/water separator record sheet.

FIG. 4—Filter/water separator record sheet. (Courtesy of ATA, Washington, DC.)

ning usage) to establish normal and abnormal filter element life.

4. Figure 4 is a suggested form for recording differential pressure, throughput, and filter element data. Some users may additionally plot volume throughput on the horizontal axis.

D.5.4 Equipment

Each filter vessel should be equipped with pressure taps on the inlet and outlet sides of the filter. These taps may supply pressure sensing to a common gage by means of a three-way valve (off-inlet-outlet), or to a direct reading differential pressure gauge accurate to ±1 psi (±7 kPa). Some operators prefer two separate pressure gauges for reading inlet and outlet pressure, but it is not recommended.

D.5.5 Procedure

Establish steady flow through the filter vessel at the normally used flow rate. If a valve arrangement to a common gauge is used, read the inlet pressure. Next, read the outlet pressure. Subtract the outlet pressure from the inlet pressure.

This is the differential pressure that should be recorded. If a direct reading gauge is used, read the differential pressure directly from the gauge and record it. Observed differential pressure at other than normal flow rates should be converted to the normal flow rate differential pressure by means of a graph supplied by the filter manufacturer.

D.5.6 Cautions

1. Differential pressure varies with flow rate. It is important to always record differential pressure at a common flow rate close to the maximum normally used.

2. Differential pressure across some filter elements will remain fairly constant until they begin to become plugged and will then rise at a fast rate. When an abnormal rise in differential pressure occurs, that filter should be monitored on a more frequent basis until the elements are changed and/or the situation has been rectified. Zero differential pressure or a sudden decrease in ΔP is not normal and should always be investigated because it may indicate that a filter element has burst, collapsed or come loose from its mounting.

3. Differential pressure readings that remain at a constant level over an abnormal period of time may indicate improper element installation, a faulty gage, blocked or restricted pressure sensing lines, blocked or dirty internal gauge filter element, and so forth.

4. The handles on some three-way valves do not accurately indicate the actual operating position of the valve. Care must be taken to ensure that readings made are dynamic pressure and not blocked pressure in the lines.

5. Operation of filter vessels above the manufacturer's recommended maximum differential pressure, usually 15 psi (103 kPa) to 25 psi (172 kPa), can result in element rupture, collapse, or bypass.

D.6 AUTOMATIC WATER SLUG SYSTEMS

D.6.1 Introduction and Purpose

This section describes the equipment, operation, and testing procedures for automatic water slug systems.

D.6.2 Reference

There is no known published standard on this procedure.

D.6.3 Description

A fuel discharge valve (or slug valve) is installed in a system to stop fuel flow when water reaches a predetermined level in the filter/separator.

CAUTION

On some older systems, an additional function was provided that would automatically open a drain on the filtration unit to drain any accumulated water. For many reasons, including environmental concerns, this additional function is **NOT RECOMMENDED** and should be removed.

1. Float-Operated System

This system is actuated by a signal from a float with a sealed air and fluid chamber, which, when properly balanced, will sink in fuel and float in water. The float remains in the downward position, permitting fuel flow until enough water accumulates in the sump to raise the float. As the float rises, it repositions a pilot valve that closes the fuel discharge (slug) valve and/or operates an electrical switch to stop fuel flow. To restart fuel flow, the operator must manually drain the accumulated water from the sump, allowing the float to return to the downward position.

2. Electric Exposed or Sealed-Probe-Operated System

This system consists of an electric probe installed in the filter/separator sump that actuates a relay system to stop fuel flow when sufficient water accumulates. Water must be drained off manually before fuel flow can resume. The internal contacts of these units may also be used to activate audio or visual alarms in addition to or instead of the above action.

The different applications and uses of these Automatic Water Slug Systems are summarized in Table 1.

D.6.4 Testing Equipment

Equipment required may vary depending on the type of water slug system being tested but may include:

1. a special pump with sufficient output pressure to overcome static head pressure to inject water into the water sump of the filter/separator through the water drain valve,

TABLE 1—Control system summary.

Type	Power signal	Usual application	Action
A. Float	Compressed air	Mobile	Closes fuel discharge (slug) valve
B. Float	Electrical	Mobile/stationary	Closes fuel discharge (slug) valve and/or stops pump and/or provides alarm signals.
C. Float	Hydraulic	Stationary	Closes fuel discharge (slug) valve
D. Probe	Electrical control of air deadman	Mobile	Closes fuel discharge (slug)/valve and/or provides alarm signals.
E. Probe	Electrical control of electric deadman	Mobile	Closes fuel discharge (slug) valve and/or provides alarm signals
F. Probe	Electrical	Stationary	Closes fuel discharge (slug) valve and/or stops pump and/or provides alarm signals

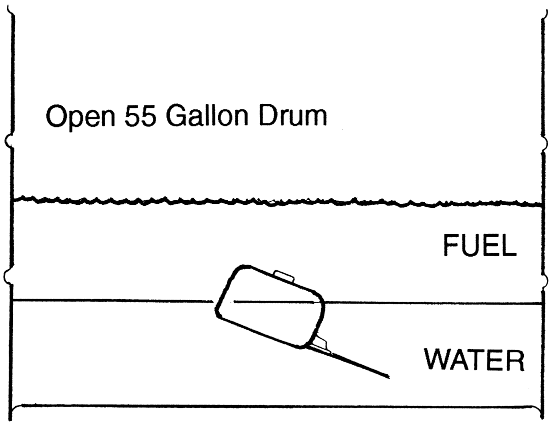


FIG. 5—Example of a float buoyancy test.

2. a hose of sufficient pressure rating to connect the above pump to the water drain valve,

3. a container of approximately 3 gal (11.4 L) volume, calibrated to show at least gallon markings, to hold water used for injection into the filter/separator water sump,

4. a test bulb to inject water into the test cavity of an electrical water detection probe,

5. an ohmmeter or multimeter to measure electrical continuity, and/or

6. a test container for checking the proper buoyancy of float mechanism (Fig. 5).

D.6.5 General Precautions

1. Good housekeeping procedures prescribe complete removal of sump water to prevent microbiological growth. The unit should be drained through the manual water drain valve at least daily. It should be emphasized that the automatic systems described above **DO NOT** operate until there is a substantial quantity of water in the sump of the unit. Therefore, they do not replace the requirement for manually draining all the water from these sumps.

2. Ensure that the pilot valve (float control valve) is installed with the correct side facing up. If it is mounted upside down, the fuel discharge (slug) valve will operate improperly.

3. Proper actions must be taken to ensure any fuel or fuel/water mixture is properly collected and disposed of in accordance with applicable federal, state, and local environmental regulations.

D.6.6 Procedures

A. Mobile Units

All mobile systems should be tested while the fuel system is pressurized and flowing on a test stand (not while fueling an aircraft) using the following procedures:

1. Float Operated Systems

Table 1, types A and B.

CAUTION

When performing these, or similar, float system tests **NEVER** connect the test equipment directly to any city, public, or other domestic water supply system. The fuel pressure can be greater than the water system pressure, and fuel could be forced into the water supply, contaminating it. Additionally, there is no positive means to verify how much water has actually been put into the sump, and therefore no way to be sure to remove the same amount.

2. Water Injection Procedure

i. Flush product through the manual drain line and valve from the filter/separator to ensure all dirt and foreign material has been removed.

ii. Connect equipment noted in Secs. D.6.4.1 and D.6.4.2 above to the manual drain valve to inject a measured amount of clean fresh water.

iii. The following assumes that the sump volume of a filter/coalescer and separator system is less than 1 gal (4 L). Testing of systems with significantly different sump volume should be scaled as appropriate. While maintaining system pressure, slowly inject 3 qt. (3 L) of water through the manual drain valve. Close the drain valve and depress the deadman control to test system operation. If the system activates, stop flow at once. Inject a 4th qt. (1 L) of water and attempt to restart flow. The system should not operate. **DO NOT** inject more than 1 gal (4 L) of water. The system is considered unacceptable if fuel flow resumes after injecting 1 gal (4 L) of water. Further investigation is required by qualified repair personnel and the system retested and accepted before returning the unit to service.

iv. If flow does not restart after the injection of the water, then this portion of the operation is considered acceptable.

v. Drain, collect and measure (by volume) all the water injected. Depress the deadman control to test that the system flow activates. The system is considered unacceptable if fuel flow does not resume when test water is removed. Further investigation is required by qualified repair personnel and the system should be retested and accepted before returning the unit to service.

vi. Remove the specialized test equipment. Drain an additional 1 gal (4 L) of product to ensure that all water is removed, then stop the flow of product and return the system to normal operation. Dispose of the water and any fuel collected in accordance with applicable environmental regulations.

CAUTIONS

After testing the float and pilot assembly, ensure that all ports are free of water before reassembly. NOTE: Some floats are carefully weighted (to have the correct bouyancy), when manufactured, with an internal liquid, oil or water. Do not remove the oil or water from the inside of these floats.

When testing mobile float systems, always inject a measured amount of water, and never more than 1 gal (4 L). The **same** amount of water should be recovered after test completion.

3. Mechanical Test Procedure

i. Recirculate fuel within the system or, if a hydrant servicer, through a test connection or into a refueler at the desired flow rate.

ii. Operate the mechanical override device (test mechanism) in accordance with manufacturer's instructions until the product flow control system operates to stop the recirculating flow. (This may be through means of pneumatic or electrical solenoids or a combination of such solenoids or operators.)

iii. If the recirculating flow through the system does not stop when the test mechanism is operated, the automatic system is malfunctioning and further checking must be made by qualified repair personnel.

iv. If the recirculating flow has stopped, slowly return the test mechanism to its original position. The fuel flow should resume. If flow does not resume, the system is malfunctioning and further investigation is required by qualified repair personnel before the system can be returned to service.

v. Stop the pump or release the deadman control as required to stop all flow through the system and return all system valves to normal operational positions.

CAUTION

The manual test mechanism on the float pilot valve only checks the operation of the pilot valve assembly. It does not check if the float is buoyant in water. (Ballast types of float valves **do** check the bouyancy the float. The manual override device on this type of unit lifts the ballast from the float which allows it to float in fuel. Releasing the ballast back to the float causes it to sink in fuel but float in water.)

vi. The next time the filter/separator is opened, the float assembly should be removed and its buoyancy checked by verifying that it will rise in water and sink in jet fuel. This may be accomplished by removing the float assembly from the filter/separator and testing in a container, as shown in Fig. 5.

Note: As an alternative to the above, when the unit is out of service and open, the sump may be filled with jet fuel until the float is covered with jet fuel, and then water slowly added to the sump. The float should sink in fuel but float on water. If the float does not float on water, the float and/or its mechanism is malfunctioning and further investigation is required by qualified repair personnel before the system can be returned to service.

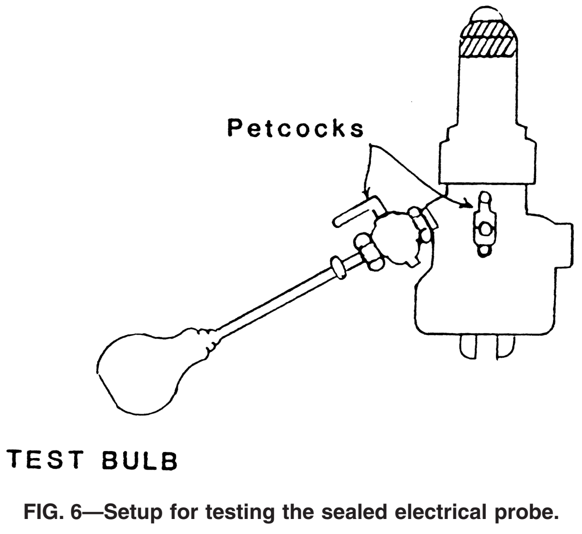


FIG. 6—Setup for testing the sealed electrical probe.

3. Electrical Probe System

There are several types of water probes available and different test procedures are used for each one. Basically, they constitute three types: Units where water is injected into a nonpressurized internal chamber to simulate water contact, units with a built-in water pump which displaces a small amount of water into the actual fuel wetted surfaces under pressure, and units which are mounted into a drain line assembly to allow the probe to be isolated from the pressurized system while water is added (not under pressure) to test the actual fuel wetted surfaces.

1. Water Injection Procedure—Units With Sealed Internal Nonpressurized Test Chambers

Sealed electrical probe systems are normally fitted with 0.25 in. (6.3 mm) petcocks through which water may be injected inside the probe (Fig. 6). The process to test them is:

a. Fill a test bulb noted in Sec. D.6.4.3 above with about $\frac{1}{2}$ cup of water.

b. Attach the discharge end of the test bulb to the inlet petcock.

c. While recirculating fuel at the desired flow rate, open the inlet and outlet petcocks and slowly squeeze water into the probe through the lower petcock. When the water reaches the internal surface of the probe, the fuel flow should stop.

The system is malfunctioning if the flow of fuel has not stopped prior to water exiting from the upper petcock. Drain all water injected and stop the flow of fuel in the system. Further investigation is required by qualified repair personnel before the system can be returned to service.

d. If the system has stopped the fuel flow, remove the test bulb and completely drain the probe of all water. The system fuel flow should resume. Stop the flow of product and return the system to normal operation, removing all test equipment connected and closing both petcocks.

CAUTIONS

The electrical power circuits to the probe must be shut off and tagged out by qualified personnel to ensure they are not energized during the removal and cleaning of the probe.

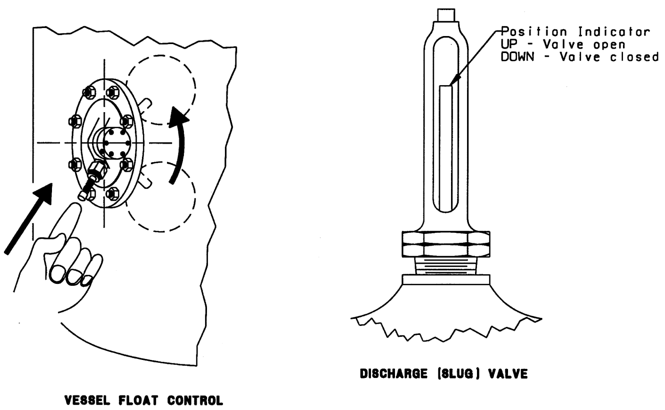
After reinstallation of the probe, the electrical continuity between the probe and the case of the filter/separator should be verified with an ohmmeter.

e. The next time the filter/separator is drained or opened, the probe assembly should be removed and cleaned with fine steel wool or abrasive cloth (e.g., "Scotchbrite" TM 3M) to ensure all electrical surfaces are conductive.

2. Water Injection Procedure—Units With Built-in Test Pump

i. Remove the cover and remove the test pump by rotating the pump $\frac{1}{4}$ turn and pulling out. Handle the test pump on only the large diameter when removing.

ii. Unscrew the plunger from the pump and fill with clean fresh water, holding and using a finger to cover the small hole on the outlet on the end. Replace the plunger and turn the pump in two full turns. Never unscrew the plunger while installed.



VESSEL FLOAT CONTROL

DISCHARGE (SLUG) VALVE

FIG. 7—Operating the float control manual test mechanism. (Observe the fuel discharge valve position indicator.)

iii. Reinstall the pump and turn the plunger inward to inject the water.

After testing, it may be necessary to flush the water from the pump in cold climates. To do so, simply repeat the process with fuel instead of water.

3. Water Injection Procedure—Units in Drain Lines With Isolation Valves

i. Turn off the isolation valve. This valve isolates the drain assembly from the filter vessel.

ii. Open the drain valve and the upper filling valve and drain all fuel. Close the drain valve

iii. Pour water into the upper fill valve.

iv. After testing, drain all water, close open valves and reopen the isolation valve.

B. Stationary Units

Due to the volume of water required, as well as flow rates and pressures encountered, stationary units should **NOT** be tested by injecting water into the filter vessel sump. Most float operated systems of type C (Table 1) are equipped with an external test mechanism. This test mechanism will physically raise the float (or ballast in newer type floats) inside the unit to enable verification of the correct operation of the automatic system. The following procedure should be followed in testing this type system.

1. Normal Procedure

a. Start the pump to pressurize the system and establish normal flow rate.

CAUTION

Be sure the vent port from the pilot valve (float control valve) is unobstructed. Sometimes this vent is plugged during shipment to prevent dirt or debris from getting into the pilot valve assembly. If the vent is plugged for any reason, improper operation of the fuel discharge valve will occur.

b. Operate the test mechanism, observing the valve position indicator, if installed, on the fuel discharge (slug) valve. The discharge valve should close, stopping all flow (Fig. 7), as the test mechanism raises the float to its raised position.

NOTE

If no position indicator is installed, pressure on the downstream system will drop. In addition, the cessation of flow can frequently be heard, especially as the fuel discharge (slug) valve closes.

c. If flow is not stopped when the test mechanism is operated, the system is malfunctioning and further checking will be required by qualified repair personnel.

d. While slowly returning the test mechanism to its original position, the fuel discharge (slug) valve should open, thus restoring flow. If flow is not restored, the system is malfunctioning and further investigation is required by qualified repair personnel before the system can be returned to service.

e. Turn off the pump to stop all flow through the system and return all system valves to normal operational positions.

CAUTION

The manual test mechanism on the float pilot valve only checks the operation of the pilot valve assembly. It does not check whether or not the float will rise in water. (Newer types of float valves, ballast type, **will** check the capability of the float to rise. The manual override device on this type of unit lifts the ballast from the float which then allows the float to rise in fuel. Releasing the ballast back to the float will allow the float to only rise in water.)

f. The next time the filter/separator is opened, the float assembly should be removed and its buoyancy checked in accordance with the procedures of Sec. D.6.6.A.2

2. Procedure for Systems with Probes

If the stationary system is equipped with a probe, the procedure used under electrical probes on mobile equipment as per Sec. D.6.6.A.2 may be used. This type of electrical probe may be connected to perform various operations, such as activating an alarm or a warning light, stopping the pump and/or closing the discharge (slug) valve. The testing of this type of unit is performed in the same manner as that specified under mobile equipment.

CAUTIONS

It must be ensured that the electrical power circuits to the probe are shut off and tagged to ensure they are not energized during the removal and cleaning of the probe. It may be necessary for an electrician to disconnect the probe from the power source.

After reinstallation of the probe, the electrical continuity between the probe and the case of the filter/separator shall be verified with an ohmmeter.

a. The next time the filter/separator is drained or opened, the probe assembly should be removed and cleaned with fine steel wool to ensure all electrical surfaces are conductive.

D.7 SINGLE ELEMENT TEST FOR COALESCER ELEMENTS

D.7.1 Introduction and Purpose

Coalescer elements in filter/coalescer and separator system coalesce undissolved water into large droplets that fall into the sump of a filter vessel by gravity. Coalescer elements can become "disarmed" (lose their ability to coalesce water) by the

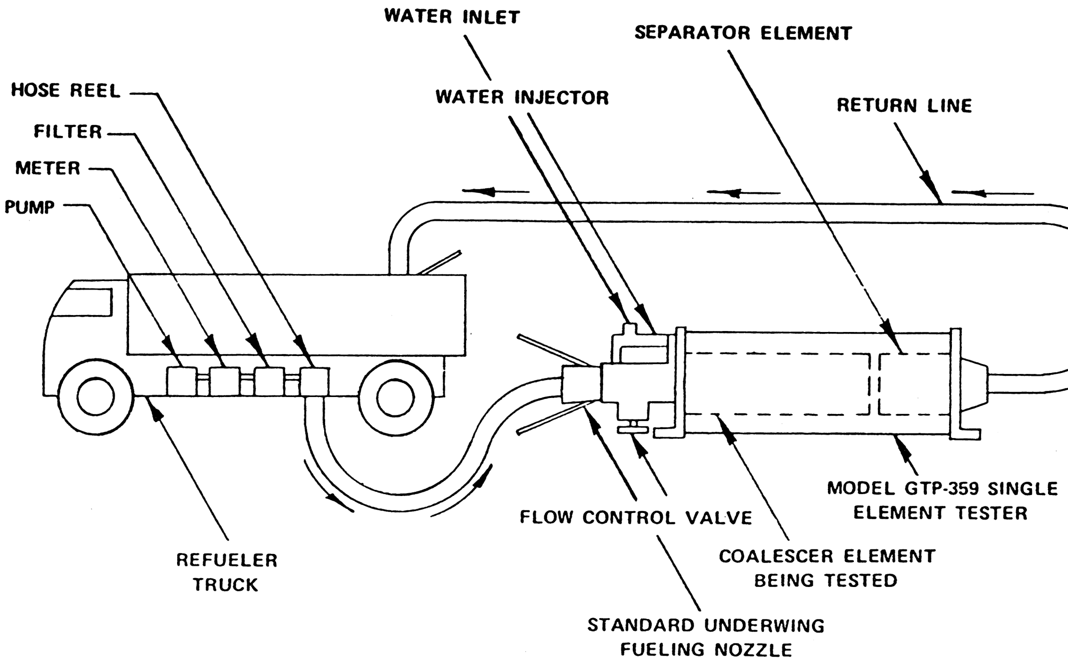


FIG. 8—Single element tester connected to a refueler truck.

adsorption of trace fuel components or contaminants even when the differential pressure across the element is low. The single element test was developed to observe the coalescing capability of a set of elements in a filter/separator system by testing the water coalescence of one of the elements.. The continued use of the remaining elements can be judged by the results of this test.

D.7.2 References

There is no known published test standard on this subject.

D.7.3 Description

A coalescer element is removed from a filter/coalescer and separator vessel that was in field service. The element is removed using extreme care to avoid damage or contamination (such as bare hand contact with the outer white sock). The element is installed in the single element test apparatus, where its performance is evaluated when challenged with a controlled emulsion of fuel and water.

D.7.4 Test Equipment

Test equipment, supplies, and other requirments include:

1. Gammon Model GTP-359 Single Element Tester, available from Gammon Technical Products, Inc., PO Box 400, Manasquan, NJ 08736 (Telephone: 732-223-4600).

NOTE

This procedure is based on the only known commercially available tester: the Gammon Single Element Tester. It should be possible to substitute an equivalent tester if available.

2. A source of flowing jet fuel. This may be supplied by a refueling truck or any other dedicated source that can deliver fuel for at least 10 min at 50 psi (344 kPa) and at the rated flow rate of the element to be tested. Ideally, the fuel used for this test should be the same fuel as the element handled in service.

3. 1 gal (4 L) or more of clean water, such as drinking (potable) water contained in a suitable container such as a bucket that is free of particulates and surfactants.

4. A safe and secure site isolated from ignition sources.

D.7.5 Equipment Preparation

1. Arrange the tester in the manner shown in Fig. 8. A dedicated refueling truck is shown as the source of jet fuel in Fig. 8 although other arrangements may be made. The pump, meter, hose, and refueling nozzle on the truck are required to supply fuel at the required flow rate.

NOTE

The pressure control valve on a refueler is normally set so that the pressure at the refueling nozzle will not exceed 50 psi (344 kPa). This pressure control feature is required to protect the single element tester.

2. Attach a bonding wire between the tester and the fuel source.

3. The fuel flowing from the tester may be recirculated back into the truck tank as shown, or it may be directed to some other receiver, depending upon local policy and facilities.

4. Install a coalescer element in the tester, being careful to avoid skin contact with the element. Torque it to the manufacturer's specifications. Elements that have mechanical damage are not suitable for testing.

NOTE

Adaptors are available from the tester manufacturer to mount any coalescer element that flows from inside to outside in the single element tester.

5. Place the water supply in a bucket or other suitable container and secure the water suction tube in the bucket.

6. Close the water supply valve and the tester chamber drain valve. Open the chamber air vent valve.

7. Close the flow control valve by turning the knob in the direction stamped onto the valve body.

8. When fuel pressure has been established, slowly open the valve on the refueling nozzle. The flow rate is very slow during filling of the test chamber, because, with the flow control valve (item 7) closed, the only flow is through a $\frac{1}{4}$ in. (6.3 mm) port in the eductor. This slow fill rate is required to prevent the development of excessive electrostatic charges.

9. Close the air vent valve when the chamber is full.

NOTE

For reasons of safety, it is important that all air be vented from the chamber.

10. Check the fuel flow rate by timing the truck (or other) meter, as appropriate. Adjust the flow control valve until the flow rate is correct for the coalescer being tested.

NOTE

The correct flow rate is the maximum flow rate that the element can experience in the particular operation where it is used. If the maximum flow rate of the system is 600 gal per min (gpm) (2300 L/min) and there are ten coalescer elements in the system, then the single element test should be run at 60 gpm (230 L/min). However, if the filter/separator is rated at 600 gpm (2300 L/min) but the pumping system is incapable of exceeding 400 gpm (1500 L/min), the test should be run at 40 gpm (150 L/min).

11. Before initiating water injection, be sure any preexisting water has stopped coming from the element media.

D.7.6 Cautions

1. Water can wash surfactants out of a coalescer causing it to recover its ability to coalesce water. Therefore, the visual evaluation of coalescence must be made immediately upon the introduction of test water.

2. The test chamber must be filled slowly to avoid electrostatic charge buildup. A fill rate of no more than 5 % of element rated flow is recommended.

3. When water drops are viewed through the wall of a curved chamber, the true sizes are distorted. A scale located inside of the chamber near the droplets permits their true size to be assessed.

D.7.7 Test Procedure

1. Observe the outside of the element in the transparent chamber and report evidence of water drops and their color. Also refer to Paragraph 4.c, which follows. Do not proceed with water injection until fuel flowing through the coalescer element is clear and free of any signs of water.

2. Record the differential pressure across the element.

3. Adjust the valve on the water flow meter until the required injection rate is established.

NOTE

Figure 9 has a set of curves that show the water meter reading that is necessary to obtain various injection rates for various fuel flow rates.

4. Closely observe the test coalescer as water is being injected to look for the following indications of element failure:

a. Haze or from any part of the element means that fine water droplets are not coalescing indicating that surfactant is present and causing a water/fuel emulsion to form. Haze often has the appearance of smoke and the word "smoke" is generally used to describe a failed condition.

b. Clusters of water drops that look like a bunch of grapes

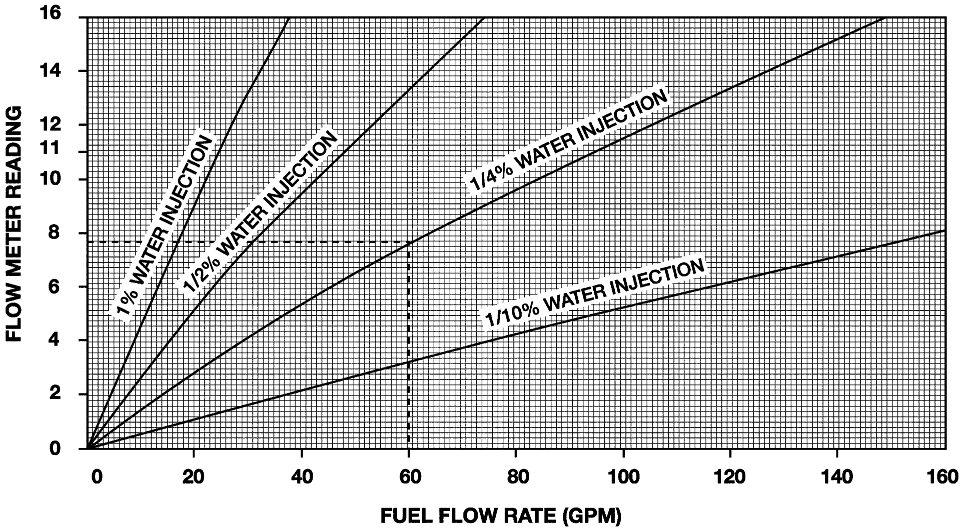


FIG. 9—Water flow injection chart for single element tester Model GTP-359. (Reprinted courtesy of Gammon Technical Products, Inc., Manasquan, NJ.)

(“graping”) are really water films surrounding fuel. A coalescer that performs this way has failed: the water film ruptures to form fine droplets that are not removed by the separator.

c. Slimes are evidence of surfactant contamination or of microorganism debris. Even if the element coalesces properly, it must be considered unsatisfactory.

d. If element performs well except that haze or smoke appears to come from the end gaskets, recheck the seating and torque (to manufacturer’s recommendations) and repeat the test. If the smoke cannot be eliminated then the element should be discarded and a different element tested.

e. If haze appears at the bond between the coalescing media and the end cap, the entire set should be rejected. Note that droplets are often somewhat smaller very near the ends of elements than elsewhere. This is not generally a cause for concern as long as the droplets appear as discrete droplets not haze or smoke.

5. In addition to the visual assessment, measure the effluent free water content 15 s after seeing the first water droplets coming from the coalescer. If the reading is greater than 15 ppm, the elements should be replaced.

6. In the case of failing results it can be useful to drain a water and fuel sample from the single element tester as soon as there is enough water available. A low interfacial tension measurement on this sample proves that surfactants are present.

7. Report the results of all observations.

8. Close the nozzle valve, stop the pump, open the test chamber drain valve to dispense water and fuel to a suitable container, and open the vent valve. Dispose of the water/fuel mixture in an appropriate manner.

9. When the fuel level falls below the coalescer, remove it from the chamber.

D.7.8 Interpretation of Results

1. Generally speaking, if the water droplets average at least one half the size of the droplets from a new element, the remaining elements in the filter/separator may be continued in service. Different models of coalescing elements produce different sizes of water drops when they are working properly so it is not possible to set absolute droplet size limits.

2. If any slime flushes out of the test element, the entire set of elements should be removed from service because this indicates that they are grossly contaminated by surfactants or microbial growth. Such elements may coalesce water at the time of the single element test, but are no longer reliable.

3. Any evidence of haze or smoke from the coalescing media is reason to immediately stop the test and replace all of the coalescers in the filter/separator.

4. Occasionally, coalescers create clusters of droplets that look like a bunch of grapes. This is called graping. The droplets are actually water films with fuel inside. Elements that have this problem (all coalescers in the vessel can be assumed to have the same condition) should be discarded because the water films (droplets) break on contact with the separator elements, generating very fine droplets that pass onward through the separators.

D.8 CLAY TREATMENT

D.8.1 Introduction and Purpose

This section describes the reason for using clay media in certain aviation fuel handling facilities and recommends the procedure for determining when the clay media should be changed out.

D.8.2 References

There is no known published test standard on this subject.

D.8.3 Description

Clay treatment vessels, where used, are located upstream of filter/separators. The clay removes surfactants from the fuel, thereby protecting the filter/separators. The clay treatment vessels are usually the element-type vessels, containing either clay bags or clay canister elements.

Surface active agents (surfactants, see Sec. A.12) can disarm elements in filter/separator vessels, thereby preventing the filter/separator from efficiently removing water from aviation fuels. The more common surfactants come from the following sources:

1. Naphthenic and sulfonic acids arise from natural components of crude oil.

2. Pipelines, transport trucks, ships, and barges can generate residuals from motor gasoline and heating oil additives that adsorb on pipe or tank walls. Pipeline corrosion inhibitors, some of which are approved additives for aviation fuel, are also weak surfactants.

3. Maintenance materials produce soaps, detergents, and steam cleaning residues. Rust preventatives and descaling chemicals usually are surfactants or combine to form surfactants.

Clay particles are normally 50–90 mesh in size (about 300–170 μm). Each particle is made up of hundreds of microscopic attapulgite crystals that are bound together in a porous cluster by kiln treating under carefully controlled temperature conditions.

The clay crystals remove surfactants from the fuel by adsorption (adhesion of the surfactant material to the surface of the clay crystal). The longer the fuel is in contact with the clay (residence time) the more efficient the clay is in removing surfactants. Normally the bags and canisters are flow rated at about 5–7 gpm (19 to 27 L/min) per element.

D.8.4 Procedure

Various methods are used to predict when clay elements should be changed. Among these are throughput, time, and differential pressure increase across the clay vessel, comparison of filter membrane tests taken upstream and downstream of the clay vessel and the preferred method discussed below.

Since clay media is used to remove surfactants, the most reliable indicator for determining when to change the clay media is a reduction in its surfactant removal efficiency. This efficiency is best obtained by periodically taking simultaneous upstream and downstream fuel samples from the clay treatment vessel, and then analyzing the two samples for an indication that the surfactant level is less downstream of the clay than upstream. Most find MSEP (Sec. A.13) to be the most practical method to test these samples.

D.8.5 Interpretations

The downstream MSEP rating is compared to the upstream rating. For example, interpretations of the results might be as follows:

1. If both ratings are high (90 or above), draw no conclusions. This indicates relatively surfactant-free fuel entering and leaving the clay treatment vessel.
2. If the upstream rating is low (80 or below) and the downstream rating is high (90 or above) the clay media is still effectively removing surfactants and need not be changed.
3. If the upstream rating is low (80 or below) and the downstream rating is also low (80 or below), the clay media is not removing surfactants and should be changed. Clay media would ideally be changed before this condition occurs.
4. If an unusual condition occurs, such as high upstream ratings but lower downstream ratings, this can also indicate a possible upset condition. For example, entrained water in the influent fuel may be "flushing out" adsorbed surfactants from the clay media. In such cases, further investigation is required.

D.8.6 Cautions

1. The interpretations are guidelines for helping to predict when clay media should be changed. The number ratings listed are for illustrative purposes only and are not to be interpreted as either good, surfactant-free fuel or, conversely, as surfactant-laden fuel.
2. In addition to using the difference in MSEP ratings as guidelines for changing clay, the performance of the downstream filter/separator should also be monitored. If indications are that the coalescer elements are disarmed, it would be wise to assume that the clay elements upstream are in need of changing.
3. Clay elements can be disarmed by large amounts of water. Where this situation could occur, it is a common practice to place a coarse water separator such as a dehydrator (hay-pak) upstream of the clay treatment vessel.

E

Microbial Contamination Detection

E.1 LABORATORY METHODS & FIELD KITS

E.1.1 Introduction and Purpose

This section describes accepted laboratory test methods as well as field test kits than can be used to detect microbial contamination in fuel facilities.

Microorganisms can enter the fuel system in many ways, and cause a variety of problems. These problems can occur anywhere in the world. The purpose of this section is to explain the nature of the problem, and to define accepted means of detection.

The tests listed herein were chosen due to wide use in the industry. All possible tests are not shown. Inclusion of a test in this section does not mean to imply that is an accepted test by any airline, aircraft manufacturer, or oil company.

Treatment of contaminated systems must be done in accordance with environmental law and the aircraft manufacturer's requirements, airline, and oil company standards. These vary.

E.1.2 References

"Manual on Fuel and Fuel System Microbiology: Fundamentals, Diagnosis, and Contamination Control," MNL 47. Copyright ASTM International, West Conshohocken, PA. Published in 2003.

ASTM D6469. Copyright ASTM International, West Conshohocken, PA. Published in 2004.

"Guidance Material on Microbiological Contamination in Aircraft Fuel Tanks," 2nd Edition. Copyright 2004 International Air Transport Association, Montreal-Geneva. Published February 2005.

E.1.3 Description

Opportunities for bacteria and fungi (also referred to as "microorganisms" or "microbes") to enter the aviation fuel supply, storage, and distribution system as well as aircraft generally occur after the refining process. Although microorganisms may have entered a fuel system, water and fuel are necessary for the microbes to become viable and grow. Without meeting the minimum water requirement, microbes will become dormant (inactive) and move with the flow of fuel until a source of water is located or the fuel is consumed. In addition to water, microorganisms require a source of energy and carbon for growth and development. Aviation fuel is well suited for this because the hydrocarbon fuel becomes the source of energy and the carbon from the fuel is used for cellular growth and development. As long as water and aviation fuel are available in sufficient quantities, microbes will settle in a safe low flow area, secrete a biosurfactant to form an emulsion at the fuel–water interface for metabolic activities that support the growth and development of the microorganisms and biofilm.

Once established, the impact microbes can have on fuel storage tanks, delivery systems, and aircraft can vary depending upon the severity of the contamination. Problems associated with microbial contamination include: dark spots, growth on surfaces (spotting), clogging and disarming of coalescing filters, dark colored water bottoms or smelly "black water," and extreme cases, fuel tank corrosion. Uplifting microbially contaminated fuel from a fuel farm, refueling truck or hydrant system, can lead to the aircraft becoming contaminated. Once established in aircraft fuel system, microorganisms can cause a variety of issues including clog engine fuel filters, erratic fuel quantity readings in the flight deck, corrosion of fuel tank structures and plumbing.

Microbes that are found in fuel systems are microscopic in size (typically several microns in length) and can be bacteria, yeasts or molds; yeasts and molds are collectively referred to as fungi. These microbes are found in nature, but can form viable colonies in fuel tanks and distribution systems. Bacteria are single cell organisms. Some species of bacteria can only survive in the presence of oxygen (i.e., aerobic bacteria), whereas other species of bacteria can only live in the absence of oxygen (i.e., anaerobic bacteria). During conditions where water or energy are inadequate, bacteria have the ability to become inactive (dormant) as a natural form of preservation until environmental conditions are adequate to resume metabolic activity. Fungus (sing.)/fungi (pl.) are terms used to describe single celled microorganisms—yeast—or filamentous microorganisms—mold—that are larger than bacteria and will grow to form fungal mats. Fungi and some bacteria produce spores that are equivalent to immature and inactive reproductive cells (seeds) seeds that germinate and grow in the presence of water. Once a spore germinates in water, a fungi grow by using fuel for food, along with trace materials in the water and dissolve oxygen.

Severe microbial contamination can generally be detected without the aid of special test equipment. Characteristics such as odor or discoloration of water samples or "leopard" spotting of the water monitors and coalescers are an indication of a microbial contamination problem. However, field test kits can be used to detect microbial contamination long before microbial levels become operationally and economically severe. These test kits can be useful in a routine monitoring program that can serve as an early warning sign for fuel systems where contamination from microorganisms is likely. Once microbial contamination has been detected, some test kit(s) can be used to detect the source of contamination, which is often upstream of the detection point although this may prove elusive. Some of the test kits listed below are useful for trend monitoring. Microbial contamination is traditionally measured and reported as colony forming units (cfu) where a sample is added to a growth medium, which is incubated for a period over of several days and visible colonies of growth develop and are counted. Today, in addition to the more traditional methods, rapid techniques have been developed which measure other indicators of microbial contamination.

Microbes are always present in fuel, however, if water is low or minimized the level of contamination should be low that it does not cause operational problems. Aviation fuel systems should be well designed to facilitate the draining of all free water. Regular water draining and good housekeeping in conjunction with a well-designed scavenge system are the most practical means to minimize microbial contamination. However, in systems where water is present microbial contamination is likely.

Laboratory test methods and field test kits described in the remainder of this section may assist in the detection of active microbes. A brief description of each test is given below. Refer to the suppliers for more detailed information.

E.1.4 Equipment and Procedures

E.1.4.1 Laboratory Test Methods

ASTM D6974 Standard Practice for Enumeration of Viable Bacteria and Fungi in Liquid Fuels—Filtration and Culture Procedures.

IP 385 Viable Aerobic Microbial Content of Fuels and Fuel Components Boiling Below 90°C—Filtration and Culture Method.

ASTM D6974 and IP 385 are used to determine the viable microbial content in fuel. A fuel sample is filtered through membrane filters. Viable microbes collected on the membranes are then incubated on a growth medium. After the incubation period, the colonies are then counted and given in terms of colony forming units per liter of fuel.

E.1.4.2 Field Test Kits

a) Product: Microbe Lab
   Manufacturer: ECHA Microbiology, UK
   Distributor: Warner Lewis JR, Industrie-Filter GmbH
   Tel UK: +44 (0) 1256 768811
   Fax UK: +44 (0) 1256 768818
   email: sales@warnerlewis.co.uk
   website: www.warnerlewis.de
For Global Sales Inquiries Contact:
   Warner Lewis JR, Industrie-Filter GmbH
   Tel UK: +44 (0) 1256 768811
   Fax UK: +44 (0) 1256 768818
   email: sales@warnerlewis.co.uk
   website: www.warnerlewis.de

b) Product: MicrobMonitor2
   Manufacturer: ECHA Microbiology, UK
   Distributor: Air BP
   Tel UK: +44 (0) 1442 223966
   Fax UK: +44 (0) 1442 223960
   email: microbmonitor2@bp.com
   website: www.microbmonitor.com
For Global Sales Inquiries Contact:
   Air BP
   Tel UK: +44 (0) 1442 223966
   Fax UK: +44 (0) 1442 223960
   email: microbmonitor2@bp.com
   website: www.microbmonitor.com

c) Product: Easicult Combi
   Manufacturer: Orion Diagnostica Finland
   Distributor: LifeSign, LLC
   Tel USA: 800-526-2125
   Fax USA: 732-246-0570
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d) Product: Fuelstat™ Resinae
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e) Product: HY-LiTE® Jet A-1 Fuel Test
   Manufacturer: Merck KGaA, Germany
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f) Product: Hum Bug Detector® Kit
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1) The Microbe Lab is a portable microbial testing laboratory that contains a series of four (4) tests, sterile sample bottles, training information and literature to test fuel and water samples in the field. Contact the manufacturer or your local sale representative for more detailed product information. The tests include in the Microbe Lab are:
   a. The MicrobMonitor2® can be used to test fuels and water associated with fuel. A description of the product is provided in paragraph 2) below.
   b. The dip slide is a semiquantitative test used only for water samples to determine the level of microbial contamination from aerobic bacteria and fungi. The test consists of a rectangular plastic slide that has a nutrient agar affixed on each side specific to the growth of bacteria and fungi. The test is performed by inoculating the dip slide with a water sample, incubating the dip slide in the clear sterile tube provided and examined regularly during the recommended incubation period for microbial colonies. The numbers of colonies are estimated by comparing the dip slide to a chart.
   c. The Sig® Sulphide is a semiquantitative test used to detect anaerobic microorganisms, such as sulfate reducing bacteria (SRB), which can cause sulphide corrosion or sulphide spoilage of fuel. The test method consists of a glass tube containing a measured volume of nutrient growth gel selective for specific anaerobic microorganisms. The test is performed by adding a measured volume of sample to the glass tube and incubating the glass tube. The speed and extent of the gel turning black indicates the severity of SRB contamination.
   d. The Sig® Rapid WB is a semiquantitative test used to detect the presence of moderate to heavy microbial contamination from aerobic and anaerobic bacteria, yeast and mold in fuel tank water bottoms. The test method consists of a glass tube containing a reagent tablet specific for a microbial enzyme. The test is performed by adding a known volume of sample to the glass tube and incubating the tube for 1 h. At the end of the 1 h incubation period a color developer is added to the glass tube and a color reading is obtained by comparison to a calibration chart.
2) The MicrobMonitor2® is a quantitative test used to detect aerobic microorganisms in fuel and water associated with fuel. The test consists of a clear nutrient gel in a rectangular glass bottle that contains an indicator wich enhances the development of microbial colonies and makes them easier to count. The test is performed by adding a known volume of sample to the test bottle, shaking the bottle to liquefy the gel, and incubating the sample. The test bottle is then examined regularly during the recommended incubation period for microbial colonies. The number of colonies are counted or estimated by comparison to a chart. Contact the manufacturer or your local sale representative for more detailed product information.
3) The EasiCult Combi® dip slide is a semiquantitative test used only for water samples to determine the level of microbial contamination from aerobic bacteria and fungi; any fuel that comes in contact with the growth media will invalidate the test. The test consists of a rectangular plastic slide that has a nutrient agar affixed on each side specific to the growth of bacteria and fungi. The test is performed by inoculating the dip slide with a water sample, incubating the dip slide in the clear sterile tube provided and examined regularly during the recommended incubation period for microbial colonies. The numbers of colonies are determined by comparing the growth on the agar to a Colony Density Chart provided. Contact the manufacturer or your local sale representative for more detailed product information.
4) The FuelStat® resinae is a semiquantitative immunoassay test that is specifically designed to detect the presence of Hormoconis resinae (H resinae) a fungus that commonly contaminates aviation fuel and water associated with aviation fuel. The test consists of a test paddle holding two lateral flow devices (LFD) which produce a combination of lines when in contact with H. resinae metabolites. The test is performed by preparing the fuel or water sample as directed, introducing the prepared sample onto the “low” and “high” LFDs, allowing the test to undergo a reaction for 10 min and then reading the results within 30 min. The combination of lines indicates a negative result, low positive result, or high positive result. Contact the manufacturer or your local sales representative for more detailed product information.
5) The HY-LiTE® Jet A-1 Fuel Test is a quantitative bioluminescence test that indicates the presence of aerobic and anaerobic microorganisms in fuel and water associated with fuel by quantifying the amount of adenosine triphosphate (ATP) present in the test sample. ATP is a unique biochemical that is responsible for energy metabolism and is present in all living organisms. The test is performed by preparing the sample as directed and then transferring a small volume of the sample to a test pen which combines the microbial ATP with other chemicals associated with the pen to activate the test pen to produce light. The acti-

vated test pen is then inserted into an analyzer which quantifies and reports the light produced by the sample. The test is completed in less than 10 min and the results are directly proportional to the quantity of microbial ATP present in the sample. Contact the manufacturer or your local sales representative for more detailed product information.

6) The Hum Bug Detector® Kit is a qualitative test designed to indicate the presence or absence of microorganisms that directly utilize hydrocarbons in fuels. The test consists of a sterile sampling syringe and bottle containing a hydrocarbon phase, growth nutrient and an indicator dye. The test is performed by injecting a sample by sterile hypodermic syringe through the rubber septum into the test bottle. The test bottle is incubated and monitored for a recommended period. If microorganisms are present, the indicator dye will turn the solution in the test bottle pink. If microorganisms are absent the solution in the test bottle will remain clear. Contact the manufacturer or your local sale representative for more detailed product information.

E.1.5 Cautions

1) Section A.11 should be consulted to ensure that representative samples are obtained. Water drain samples may give an indication of microbial growth. However, sump samples that do not contain free water may not show contamination since microorganisms live in the water later. Samples taken from the fuel/water interface should contain the highest level of microbes.

2) Accidental contamination from outside sources during sampling and testing may give a false positive indication for the presence of microbial contamination. To ensure against accidental contamination, sampling and testing conditions should be as close to sterile as possible and sample containers should be new and preferably sterile. Glass or high density polyethylene containers are satisfactory for this purpose. For further information, please refer to ASTM D6469 “Standard Guide for Microbial Contamination in Fuels and Fuel Systems,” or ASTM Manual 47 “Manual on Fuel and Fuel System Microbiology: Fundamentals, Diagnosis, and Contamination Control.”

3) Each test method discussed above has performance advantages and limitations which should be taken into consideration by discussion with the test manufacturer, review of product technical literature, or by discussion with a qualified microbiologist. It must also be appreciated that results obtained using different test methods are not directly comparable. For example, a rapid assay method may not correlate directly with a colony forming unit test.

E.1.6 Interpretation of Test Results

1) the ASTM D6974 and IP 385 test methods and the field test kits listed above use different technologies to detect microbial contamination. Always refer to the test instructions to interpret the results. A positive result does not necessarily indicate that microbial contamination will cause operational problems. A “single” positive test result should always be confirmed by a “second” test before any corrective actions are initiated. A second test will validate the test results and will indicate the risk of microbial contamination to equipment and downstream users.

2) Microorganisms are always present in an aviation fuel system. This generally does not pose an operational problem unless gross contamination is present. Many tests will indicate the presence of microorganisms at levels that can be considered normal. It is important to establish a baseline and track the changes in microbial contamination. The value of detecting early stages of growth is that remedial measures can be taken before an operational problem occurs. A sudden increase in microbial contamination can indicate a problem and a risk to the downstream users.

3) Trend monitoring of test data will always provide more useful information than the occasional spot checks. By regularly monitoring fuel systems and trending the test results, the user can proactively observe an increase in contamination that deviate from normal baseline data indicating the potential for increasing operational problems. A trend monitoring program can also provide valuable information regarding storage tanks and hydrant fuel systems.

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