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An American National Standard

Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer[1]

This standard is issued under the fixed designation D3948; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers a rapid portable means for field and laboratory use to rate the ability of aviation turbine fuels to release entrained or emulsified water when passed through fiberglass coalescing material.

1.2 The procedure section of this test method contains two different modes of test equipment operation. The primary difference between the modes of operation is the rate of fuel flow through the fiberglass coalescing material. Test method selection is dependent on the particular fuel to be tested.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1655 Specification for Aviation Turbine Fuels

D2550 Method of Test for Water Separation Characteristics of Aviation Turbine Fuels (Withdrawn 1989)[3]

D3602 Test Method for Water Separation Characteristics of Aviation Turbine Fuels (Withdrawn 1994)[3]

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

D7224 Test Method for Determining Water Separation Characteristics of Kerosine-Type Aviation Turbine Fuels Containing Additives by Portable Separometer

D7261 Test Method for Determining Water Separation Characteristics of Diesel Fuels by Portable Separometer

2.2 *Military Standards:*[4]

MIL-T-5624 Turbine Fuel, Aviation Grades JP-4, JP-5, and JP-5/JP-8 ST

MIL-T-38219 Turbine Fuel, Low Volatility, JP-7

MIL-T-83133 Turbine Fuel, Aviation, Kerosene Types, NATO F34 (JP-8), NATO F-35, and JP-8+100

3. Terminology

3.1 For definitions of terms used in this test method that are not shown below, refer to Test Methods D7224 and D7261.

3.2 *Definitions:*

3.2.1 *Micro-Separometer*[5] rating (MSEP[5] rating), *n—in the aviation fuel industry*, a numerical value indicating the ease of separating emulsified water from aviation (jet) fuel by coalescence as affected by the presence of surface active materials (also known as surface active agents or surfactants).

3.2.1.1 *Discussion*—MSEP ratings obtained using Test A and Test B are termed MSEP-A and MSEP-B, respectively.

3.2.1.2 *Discussion*—MSEP ratings are only valid within the range of 50 to 100, with ratings at the upper end of the range indicating a clean fuel with little or no contamination by surfactants, which is expected to show good water-separating properties when passed through a filter-separator (coalescing-type filter) in actual service.

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.05 on Fuel Cleanliness.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[5] 'MSEP', 'DSEP', and 'Micro-Separometer' are trademarks of EMCEE Electronics, Inc., 520 Cypress Ave., Venice, FL 34285.

3.2.2 *reference fluid, n—in MSEP and DSEP*[5] *[diesel separability] water separability tests*, a reference fluid base to which a prescribed quantity of a known surface active agent has been added.

3.2.2.1 *Discussion*—The known surface active agent is typically bis-2-ethylhexyl sodium sulfosuccinate, commonly referred to as AOT, dissolved in toluene.

3.2.3 *surfactant, n—in petroleum fuels*, surface active material (or surface active agent) that could disarm (deactivate) filter separator (coalescing) elements so that free water is not removed from the fuel in actual service.

3.2.3.1 *Discussion*—Technically, surfactants affect the interfacial tension between water and fuel which affects the tendency of water to coalesce into droplets.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *reference fluid base, n—in aviation MSEP water separability tests*, jet fuel that has been cleaned in a prescribed manner to remove all surface-active contaminants (agents), and having a minimum MSEP rating of 97.

4. Summary of Test Method

4.1 A water/fuel sample emulsion is created in a syringe using a high-speed mixer. The emulsion is then expelled from the syringe at a programmed rate through a standard fiberglass coalescer and the effluent is analyzed for uncoalesced water by a light transmission measurement. The results are reported on a 0-to-100 scale to the nearest whole number. High ratings indicate the water is easily coalesced, implying that the fuel is relatively free of surfactant materials. A test can be performed in 5 min to 10 min.

5. Significance and Use

5.1 This test method provides a measure of the presence of surfactants in aviation turbine fuels. Like Test Methods D2550 and D3602, this test method can detect carryover traces of refinery treating residues in fuel as produced. They can also detect surface active substances added to or picked up by the fuel during handling from point of production to point of use. Certain additives can also have an adverse effect on the rating. Some of these substances affect the ability of filter separators to separate free water from the fuel.

5.2 The Micro-Separometer has a measurement range from 50 to 100. Values obtained outside of those limits are undefined and invalid. In the event a value greater than 100 is obtained, there is a good probability that light transmittance was reduced by material contained in the fuel used to set the 100 reference level. The material was subsequently removed during the coalescing portion of the test, thus, the processed fuel had a higher light transmittance than the fuel sample used to obtain the 100 reference level resulting in the final rating measuring in excess of 100.

5.3 Test Mode A function of the separometer will give approximately the same rating for Jet A, Jet A-1, MIL JP-5, MIL JP-7, and MIL JP-8 fuels as Test Methods D2550 and D3602. Using Mode A water separation characteristic ratings of Jet B and MIL JP-4 fuels will not necessarily be equivalent to Test Method D2550 but will give approximately the same rating as Test Method D3602. All Micro-Separometers have Test Mode A capability.

TABLE 1 Applicable Test Mode for Various Fuels

Available Test Mode(s)	
Fuel	Applicable Test Mode
Jet A	A
Jet A-1	A
Jet B	A
MIL JP-5	A
MIL JP-7	A
MIL JP-8	A
MIL JP-4	B

5.4 The Test Mode B option is used to determine water separation ratings for MIL JP-4 fuels containing fuel system corrosion and icing inhibitors. These ratings are approximately the same as those obtained using Test Method D2550.

5.5 Selection of Mode A or Mode B depends on the specific fuel and specification requirement. Table 1 identifies the recommended test method for various fuels.

5.6 The basic difference between Modes A and B is the flow rate at which the water/fuel emulsion is forced through the standard fiberglass coalescer cell. The lapsed time required to force the emulsion through the coalescer cell in Mode A is 45 s ± 2 s, whereas, Mode B requires 25 s ± 1 s.

6. Apparatus

6.1 A Micro-Separometer[6,7] is used to perform the test. The unit is completely portable and self-contained, capable of operating on an internal rechargeable battery pack or being connected to an ac power source using power cords which are available for various voltages. Connection to an ac power source will provide power to the unit and affect battery recharge. The accessories as well as the expendable materials for six tests can be packed in the cover of the lockable case.

NOTE 1—An extensive study was performed to verify that the Mark X Micro-Separometer gives equivalent results to the Mark V Deluxe Micro-Separometer. See Research Report RR:D02-1647.[8]

NOTE 2—The Mark X has a universal power supply and requires only one power cord as compared to the Mark V Deluxe that requires individual power cords for different voltages.

6.2 The Micro-Separometer Mark V Deluxe and Mark X and associated control panel are shown in Fig. 1 and Fig. 2, respectively. The emulsifier is on the right side of the raised panel and the syringe drive mechanism is on the left side. The control panel containing the operating controls is mounted on

[6] The sole source of supply of the apparatus, the Model 1140 Micro-Separometer Mark V Deluxe and Mark X, known to the committee at this time is Emcee Electronics, Inc., 520 Cypress Ave., Venice, FL 34285, www.emcee-electronics.com. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[7] The Model 1140 Micro-Separometers Mark III and Mark V Standard versions may also be used, but they are no longer supported by the manufacturer. For operating procedures using these instruments, the user is referred to D3948–87.

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1647. Contact ASTM Customer Service at service@astm.org.

FIG. 1 Micro-Separometer Mark V Deluxe and Associated Control Panel

FIG. 2 Micro-Separometer Mark X and Associated Control Panel

the fixed panel in the left side of the case. Table 2 lists the manual and audio operating characteristics of the instruments.

6.2.1 All of the controls are located in a pushbutton array on the control panel. The pushbuttons illuminate when depressed thus indicating operational status. A circuit breaker located on the control panel provides protection for the ac power circuit.

6.2.2 The Mark X has an LCD display on the control panel that provides information to the operator during the test. The information includes test status and an error code that defines a malfunction in the Micro-Separometer.

6.2.3 The turbidimeter is located under the main control panel and consists of a well in which the sample vial is placed, a light source, and a photocell.

6.2.4 By depressing the ON pushbutton, the electronic circuits are energized. The ON pushbutton pulses on and off when the instruments are being operated by an ac source and constantly remains on when the battery (dc) pack is used. The lettered pushbuttons will sequentially illuminate on and off indicating READY operational status.

NOTE 3—Of the lettered (A-G) pushbuttons on the control panel of the Mark V Deluxe, only the A and B pushbuttons are applicable to this test method. Of the lettered (Jet A – Diesel) pushbuttons on the control panel of the Mark X, only the Jet A and Jet B pushbuttons are applicable to this test method.

6.2.5 The RESET pushbutton can be depressed at any time to cancel the test in progress and restore the program to the initial start mode. The lettered pushbuttons commence to sequentially illuminate, thus indicating a READY operational status enabling test mode selection.

6.2.6 *Mark V Operation:*

6.2.6.1 Selection of Test Mode A or Test Mode B programs is accomplished by depressing either the A or B lettered pushbutton. The depressed pushbutton illuminates and the sequential illumination of the other lettered pushbuttons ceases. The START pushbutton also illuminates.

6.2.6.2 The START pushbutton, when depressed initially, initiates the CLEAN cycle causing the syringe drive mechanism to travel to the UP position and the emulsifier motor to operate for the cleaning operation.

6.2.6.3 The START pushbutton, when depressed after the CLEAN cycle, initiates the automatic program sequence causing the read indicator and the two ARROWED pushbuttons to illuminate, indicating that a full-scale adjustment period is in effect. A numerical value also appears on the meter.

6.2.6.4 By depressing the appropriate ARROWED pushbutton, the displayed value on the meter can be increased or decreased, as required, to attain the 100 reference level for the vial of fuel sample in the turbidimeter.

6.2.7 *Mark X Operation:*

6.2.7.1 Selection of Test Mode A or Test Mode B program is accomplished by depressing either the Jet A or Jet B lettered pushbutton. The depressed pushbutton illuminates and the sequential illumination of the other lettered pushbuttons ceases. The CLEAN 1 pushbutton also illuminates.

6.2.7.2 The first and second clean cycles are initiated by depressing the CLEAN 1 and CLEAN 2 pushbuttons. The RUN pushbutton will illuminate at the end of the second clean cycle.

6.2.7.3 The automatic portion of the test sequence is initiated by depressing the RUN pushbutton.

TABLE 2 Manual and Audio Operating Characteristics of the Various Model 1140 Micro-Separometer Instruments

Available Test Mode(s)	Deluxe A and B	Mark X
Function		
Test Mode Select	Pushbutton	Pushbutton
Mode A	Depress A	Depress Jet A
Mode B	Depress B	Depress Jet B
Syringe Drive Speed Selection	Not required	Not required
Clean Cycle Depress Pushbutton	START	Depress Clean 1 Depress Clean 2
Automatic Sequence		
Initiate	START	Depress Run
Cancel	RESET	
1st Meter Read		
1st Meter Adjust	Depress ARROWED Pushbuttons	No Action Required
2nd Meter Read		
2nd Meter Adjust	Depress ARROWED Pushbuttons	No Action Required
Collect Sample	Short Tone and C/S Annunciator Lamp Illuminates	Short Tone and C/S Annunciator Lamp Illuminates
3rd Meter Read		
Record Measurement	Pulsed Tone Sounds 5 s into 3rd Meter Read	Steady Tone

6.2.7.4 The 100 reference level for the vial of fuel in the turbidimeter is set automatically and does not require any adjustment. If the turbidimeter could not auto adjust to 100, the error alert indicator illuminates and an ERR-04 is displayed.

6.3 Accessory equipment and expendable materials needed to perform the test are shown in Fig. 3 and consist of the following:

6.3.1 *Syringe Plug, (A)*—A plastic plug used to stopper the syringe during the CLEAN and EMULSION cycles.

6.3.2 *Syringe, (Barrel (B) and Plunger (C))*—A disposable plastic syringe.

6.3.2.1 Use of syringes other than those demonstrated to be free of surfactant contamination in a precision program such as described in Section 12 will render test results invalid.

6.3.3 *Vials,* (*D*), 25 mm outside diameter vial premarked for proper alignment in the turbidimeter well.

6.3.4 *Alumicel,*[9]Coalescer (*E*), is an expendable, precalibrated aluminum coalescer cell with a tapered end to fit the syringe. The coalescer has three labels as follows: Alumicel—D3948—JET FUEL.

6.3.5 *Pipet, (G) with Plastic Tip (F)*—An automatic hand pipet with a disposable plastic tip. A pipet is supplied with each Micro-Separometer.

6.3.6 *Water Container (H)*—A clean container of distilled water (supplied with each six pack).

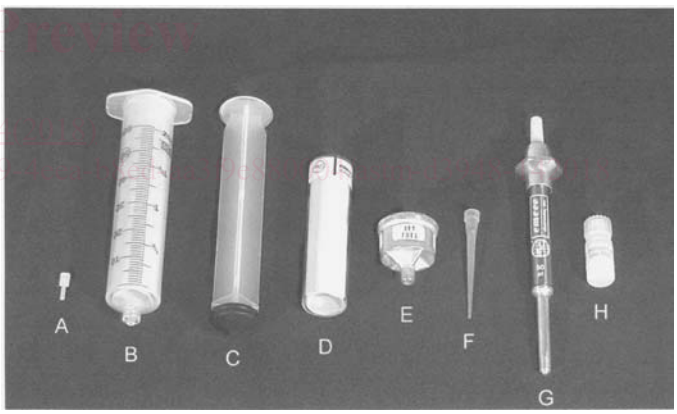

FIG. 3 Test Supplies and Small Parts

6.3.7 *Beaker, Catch Pan, or Plastic Container*—Supplied with each Micro-Separometer may be used to receive the waste fuel during the coalescence period of the test (not shown).

6.4 A new syringe, pipet tip, test sample vials, syringe plug, Alumicel coalescer, and distilled water are used in each test. These expendable materials are available in a kit, termed Micro-Separometer Six Pack, containing supplies for six tests (Fig. 4).[10]

[9] A registered trademark of Emcee Electronics, Inc.

[10] A kit containing six each of these test expendables is available from Emcee Electronics, Inc., 520 Cypress Ave., Venice, FL 34285.

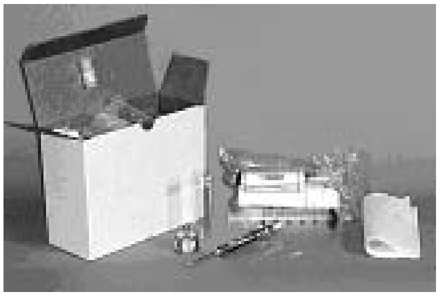

FIG. 4 Six Pack and Test Items

7. Reagents

7.1 *Aerosol OT,* solid (100 % dry) bis-2-ethylhexyl sodium sulfosuccinate.

7.2 *Toluene,* ACS reagent grade. (**Warning—**Flammable. Vapor harmful.).

7.3 *Dispersing Agent*—Toluene solution (**Warning—**Flammable. Vapor harmful.) containing 1 mg of Aerosol OT per millilitre of toluene.

7.4 *Reference Fluid Base*—A surfactant-free clean hydrocarbon material which is used to verify proper operation and is prepared in the manner described in Appendix X1. (**Warning—**Flammable. Vapor harmful.)

7.5 *Reference Fluids*—(**Warning—**Flammable. Vapor harmful.) (for checking the operational performance of the Micro-Separometer instrumentation) consist of increasing concentrations (0 mL⁄L to 1.2 mL/L) of dispersing agent added to the reference fluid base. The MSEP-A ratings for this range of concentration appear in Table 3 for Jet A, Jet A-1, MIL JP-5, MIL JP-7, and MIL JP-8 fuels, and in Table 4 for Jet B fuels using Mode A. The MSEP-B ratings for MIL JP-4 fuels using Mode B are shown in Table 5. The reference fluids are tested as described in Section 10 using the applicable mode of operation. If the results do not fall within the range of limits shown in Tables 3-5, the reference fluid shall be discarded, a fresh quantity of reference fluid prepared, and the check repeated. Repeated out-of-tolerance test results are cause for returning the instrument to the factory for adjustment and calibration. See Note 4.

NOTE 4—A Micro-Separometer Operation Manual is furnished with each instrument.

NOTE 5—The reference fluid base should have standard MSEP rating of 99+ without any dispersing agent; otherwise, the results may not be indicative of the accuracy of the instrument. Values obtained outside the measurement range from 50 to 100 are undefined and invalid.

7.5.1 Reference fluid shall be prepared by adding dispersing agent as described in 7.3 to a suitable quantity of reference fuel base contained in a properly equilibrated container or graduate.

7.5.1.1 If a new or nonequilibrated container is used, the additive may adsorb on the walls and the MSEP ratings may improve significantly. To equilibrate the container surface, an additive blend should be held for a minimum of 24 h, discarded, and replaced with a fresh blend.

7.5.1.2 For field use, instrument calibration can be verified by performing MSEP tests using a dilution of the dispersing agent (as prepared in 7.3), a reference fluid base (as prepared in Appendix X1), and distilled water. A 10:1 dilution is prepared by diluting 10 mL of dispersing agent with 90 mL of toluene (7.2). Since 1 mL of dilution is equal to 0.1 mL of dispersing agent, 50 µL of dilution is equal to 0.1 mL⁄L when added to 50 mL of reference fluid base. The 0.1 mL⁄L of dispersing agent corresponds to even multiples of the concentration levels listed in Tables 3-5. This facilitates using the 50 µL pipet (6.3.5) to add increments of 0.1 mL⁄L of dispersing agent, as well as the distilled water required for the MSEP test. Depending on the type of reference fluid base, the MSEP ratings are compared to the values listed in the applicable table for the particular concentration of dispersing agent used.

TABLE 3 Expected Performance with Jet A, Jet A-1, MIL JP-5, MIL JP-7, or MIL JP-8 Reference Fluid Containing a Dispersing Agent Using Mode A Operation

Concentration of Dispersing Agent, mL/L	Standard Rating	Limits for Acceptable Performance[A]	
		min	max
0	99	97	100
0.2	89	82	94
0.4	80	69	88
0.6	72	59	83
0.8	65	51	77

[A] Expected range of values obtained by using increasing amounts of dispersing agent used to verify instrument calibration.

TABLE 4 Expected Performance with Jet B Reference Fluid Containing a Dispersing Agent Using Mode A

Concentration of Dispersing Agent, mL/L	Standard Rating	Limits for Acceptable Performance[A]	
		min	max
0	99	96	100
0.3	92	86	97
0.6	88	81	95
0.9	86	78	94
1.2	79	69	90

[A] Expected range of values obtained by using increasing amounts of dispersing agent used to verify instrument calibration. Ranges developed by performing a linear regression (two sigma limits) on MSS data from RR:D02-1050.[11]

TABLE 5 Expected Performance with MIL JP-4 Reference Fluid Containing a Dispersing Agent Using Mode B

NOTE 1—Standard ratings are based on actual averages and the limits are based on ±½ calculated reproducibility value from the average. A standard rating of 99 was used for the base reference fuel instead of the actual average since this value is preferred.

Concentration of Dispersing Agent, mL/L	Standard Rating	Limits for Acceptable Performance[A]	
		min	max
0	99	93	100
0.2	88	83	93
0.4	81	76	86
0.6	74	69	79
0.8	69	64	74
1.0	64	59	69
1.2	60	55	65

[A] Expected range of values obtained using increasing amounts of dispersing agent used to verify instrument calibration. Developed using the data from eight of the ten laboratories of the 1983 test program. Refer to RR:D02-1274. See Note 4.

7.6 *Water,* clean, distilled, and surfactant free.

7.6.1 Use of water other than distilled water (such as tap water) will render test results invalid.

8. Preparation of Apparatus

8.1 Locate the instrument on a clean workbench in an area where the temperature is between 18 °C and 29 °C (65 °F and 85 °F) and does not vary more than ±3 °C (5 °F).

8.2 Open the case and raise the right panel until completely vertical and locked in place. If ac power is available, connect the power cord and turn the instrument on. If the internal battery power is used, ensure that the batteries are charged sufficiently to perform the desired number of tests. Low battery power is indicated when the power lamp does not illuminate. Connect the instrument to an ac power source for at least 16 h (full charge) prior to use. Approximately 25 tests can then be performed.

NOTE 6—If the battery in the Mark X is not charged sufficiently to run a test, an ERR-06 will be displayed indicating that the battery must be recharged.

8.2.1 Mark V Deluxe and Mark X instruments are turned on by depressing the switch (pushbutton) marked ON. The ON power indicator light will alternately pulse on and off when the instrument is connected to an ac power source and will stay on continuously when operated by the battery pack. Flickering of the power indicator light, during any portion of a test sequence being performed using battery power, indicates that recharging is necessary.

8.3 Have ready a supply of syringes, vials, Alumicel coalescers, syringe plugs, and pipet tips, as well as a clean container with distilled water. All of the items are furnished in the six pack provided with the instrument. In addition, have the pipet readily available.

8.4 Syringe drive travel times during the coalescing test period were initially calibrated at the factory for each mode of operation and have a significant bearing on the final test results. Both the Mark V Deluxe and Mark X instruments have self-check circuitry to detect out-of-tolerance syringe drive travel times.

NOTE 7—Syringe drive travel times exceeding the upper limit will cause the final results to measure high; conversely, travel times below the lower limit will cause the final results to measure low.

8.4.1 *Mark V Deluxe*—The alert indicator lamp (marked SYR) illuminates and depending on the degree (more than 3 s) of the out-of-tolerance condition, three short (1 s) tones will also sound. An occasional out-of-tolerance alert may be experienced due to some intermittent condition, which probably will not be indicative of instrument failure. However, repeated alerts are cause for returning the instrument to the factory for adjustment.

8.4.2 *Mark X*—During a test, the error alert indicator will illuminate and ERR-03 will be displayed indicating an out of tolerance syringe travel time. Error alerts ERR-01 and ERR-02 will be displayed if the syringe stalls while traveling up or down, respectively.

9. Sample Preparation

9.1 Under no circumstances shall test fuel be prefiltered as filter media can remove the very materials, surfactants, that the test method is designed to detect. If the test fuel is contaminated with particulate matter, allow such materials to settle out of the fuel before testing.

9.2 Special precautions concerning sample containers and sampling technique are discussed in Appendix X2. Extreme care and cleanliness are required in taking samples either directly into the test syringe or into a sample container. Before pouring the test sample from the container, wipe the container outlet thoroughly with a clean, lintless wiper; pour the test sample into a clean beaker or directly into the barrel of the test syringe.

NOTE 8—Test method results are known to be sensitive to trace contamination from sampling containers. For recommended sampling containers, refer to Practice D4306.

9.3 If the sample for test is not within the test temperature limits, 18 °C to 29 °C (65 °F to 85 °F), allow the sample to stand until an in-tolerance temperature is attained.

10. Procedure

10.1 Select either Mode A or B operation. (Refer to Table 1 for applicable Mode for a specific fuel.)

NOTE 9—Only JP-4 requires Mode B operation.

10.1.1 Depress either pushbutton A or B (Mark V), Jet A or Jet B (Mark X) for Mode A or B operation, respectively. Sequential illumination of the pushbuttons will cease and the depressed pushbutton will stay lit. The correct syringe drive speed is set automatically.

10.2 Remove the plunger from a new 50 mL syringe and wipe the tip using a clean, lintless wipe to remove any sheen caused by excess lubricant. Insert a plug into the exit hole of the syringe barrel, add 50 mL ± 1 mL of fuel, and place the syringe barrel on the emulsifier mount, turning to lock in place. Ensure that the syringe barrel is properly aligned concentrically with the mixer shaft and is not touching the propeller.

10.2.1 To mitigate the buildup of static charge, only nitrile gloves are recommended for use while handling the syringe barrel.

10.2.2 Ensure that the syringe barrel is properly aligned concentrically with the mixer shaft. Proper alignment can be verified by grasping the syringe barrel and moving the same until the propeller on the end of the mixer shaft is free and not touching. Misalignment can cause plastic shavings to form and collect on the coalescer filter material resulting in erroneous test results. This applies to all instruments manufactured and those which have not been serviced by Emcee Electronics, Inc. since July of 1988. Since that date, with ASTM approval, all new instruments and those returned for service have had a standoff installed on the mixer shaft to prevent the syringe barrel from coming into contact with the mixer blades.

10.3 Initiate the first CLEAN cycle by depressing the START (Mark V) or CLEAN 1 (Mark X) pushbutton as designated by the annunciator light. (**Warning—**Do not operate the mixer without having a syringe with fuel in place. The mixer bearings depend on the fuel for lubrication.)