



Designation: D4636 – 14

Standard Test Method for Corrosiveness and Oxidation Stability of Hydraulic Oils, Aircraft Turbine Engine Lubricants, and Other Highly Refined Oils¹

This standard is issued under the fixed designation D4636; 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.

INTRODUCTION

This test method is the result of combining Federal Test Methods 5307.2 and 5308.7. Features and details of both of these test methods are included, but the new test method is basically Method 5307.2 expanded to include Method 5308.7.²

1. Scope*

1.1 This test method covers the testing of hydraulic oils, aircraft turbine engine lubricants, and other highly refined oils to determine their resistance to oxidation and corrosion degradation and their tendency to corrode various metals. Petroleum and synthetic fluids may be evaluated using moist or dry air with or without metal test specimens.

1.2 This test method consists of a standard test procedure, an alternative Procedure 1, and an alternative Procedure 2. As there are variations possible with this test method, it will be up to the particular specification to establish the conditions required. In addition to temperature, the variables to specify if other than those of the standard procedure or alternative Procedure 1 or 2 are: test time, air flow and humidity, sample frequency, test fluid quantity, and metal specimen(s).

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3.1 *Exception*—The values in parentheses in some of the figures are provided for information only for those using old equipment based on non-SI units.

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 and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:³

D91 Test Method for Precipitation Number of Lubricating Oils

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D1193 Specification for Reagent Water

D3339 Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration

2.2 U.S. Federal Test Method Standards:⁴

FED-STD-791 Testing Method of Lubricants, Liquid Fuels, and Related Products

Method 5307.2 Corrosiveness and Oxidation Stability of Aircraft Turbine Engine Lubricants (Withdrawn)

Method 5308.7 Corrosiveness and Oxidation Stability of Light Oils (Metal Squares)

MIL-S-13282 Refined Silver (99.95) (P07015)

2.3 Other Standards:⁵

AMS 4616 Silicon Iron Bronze (C65900)

AMS 4908 Titanium Alloy—(8 % Mn) Annealed (R56080)

AMS 6490 Steel (M50) (T11350)

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 D02.09.0D on Oxidation of Lubricants.

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² FED-STD-791D is the parent document containing both test methods. As of publication on Nov. 6, 2009, it no longer contains withdrawn Method 5307.2.

³ 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.

⁴ Available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia PA 19111-5094 (<http://assist.daps.dla.mil>).

⁵ See ASTM DS 56, Metal and Alloys in the Unified Numbering System.

*A Summary of Changes section appears at the end of this standard

- QQ-A-671 Cadmium Anod (L01900)
- QQ-C-576 Copper Electrolytic Tough Pitch (ETP) (C11000)
- QQ-M-44 Magnesium Alloy AZ31B Condition H24 or H26 (M11311)
- QQ-S-698 Low-Carbon Steel 1010, CR Temper No. 4 or 5 (G10100)
- QQ-A-250/4 Aluminum Alloy 2024 T-3 or T-4 (A92024)

3. Summary of Test Method

3.1 This test method consists of a standard test procedure (see 10.1), an alternative Procedure 1 (see 10.2), and an alternative Procedure 2 (see 10.3). The standard test procedure uses washer-shaped metal specimens stacked on the air tube, 200 mL of test oil, 10 L/h air flow rate, and periodic test oil withdrawal and evaluation. Alternative Procedure 1 uses washer-shaped metal specimens, 165 mL of test oil, 10 L/h air flow rate, and no periodic test oil sampling. Alternative Procedure 2 uses square metal specimens tied together resting vertically in the large glass tube, 100 mL of test oil, 5 L/h air flow rate, and no periodic test oil sampling.

NOTE 1—Flow rates other than those listed in this test method may be required by various specifications; if they are so used, the modification to the test method should be stated in the test report.

3.2 A large glass tube containing a sample of oil and metal specimens is placed in a constant temperature bath and heated for the specified number of hours while air is passed through the oil to provide agitation and a source of oxygen. Typically, temperatures of the bath used are from 100°C to 360°C. Weighed metal specimens are placed in the tube during the test. Corrosiveness of the oil is determined by loss in metal mass, and microscopic examination of the sample metal surface(s). Oil samples are withdrawn from the test oil and checked for changes in viscosity and acid number as a result of the oxidation reactions.

3.3 Metals used in the basic test and alternative Procedure 1 are titanium, magnesium, steel (two types), bronze, silver, and aluminum. Metals used in alternative Procedure 2 are copper, steel, aluminum, magnesium, and cadmium. Other metals may be specified.

3.4 Sampling of the oil for analysis is done periodically throughout the test. Alternatively, no periodic samples are taken and a final viscosity and acid number are determined for comparison with those of the original untested oil.

3.5 At the end of the test, the amount of sludge present in the oil remaining in the same tube is determined by centrifugation. Also, the quantity of oil lost during the test is determined gravimetrically.

3.6 Air is used dry in the standard test. A humidifier may be used to provide controlled moist air, if required.

4. Significance and Use

4.1 This test method simulates the environment encountered by fully formulated lubricating fluids in actual service and uses an accelerated oxidation rate to permit measurable results to be obtained in a reasonable time. The use of metals provides catalytic reactive surfaces of those materials commonly found in real systems. The high temperature and air agitation help

accelerate the oxidation reactions that are expected to occur. Moisture in the air adds another realistic condition that encourages oil breakdown by facilitating acid formation.

4.2 Interpretation of results should be done by comparison with data from oils of known field performance. The accelerated conditions likely will cause one or more of the following measurable effects: mass change and corroded appearance of some metals; change of viscosity; increase in acid number; measurable reaction products in the form of sludge; and mass loss of oil due to evaporation.

4.3 This test method is most suitable for oils containing oxidation and corrosion inhibitors. Without such ingredient(s), the severe test conditions will yield rather drastic changes to the oil.

5. Apparatus

5.1 The main apparatus consists of the following items of standard wall borosilicate glassware as shown in Figs. 1-5:

5.1.1 Main Sample Tube (Fig. 1).

5.1.2 Sample Tube Head (Fig. 2).

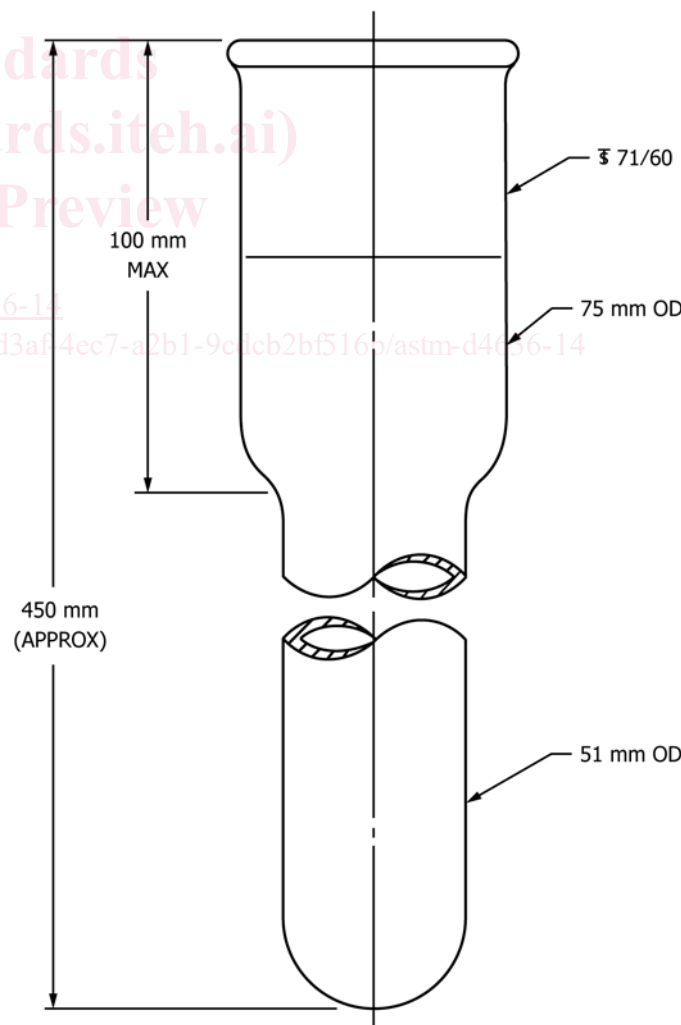


FIG. 1 Sample Tube

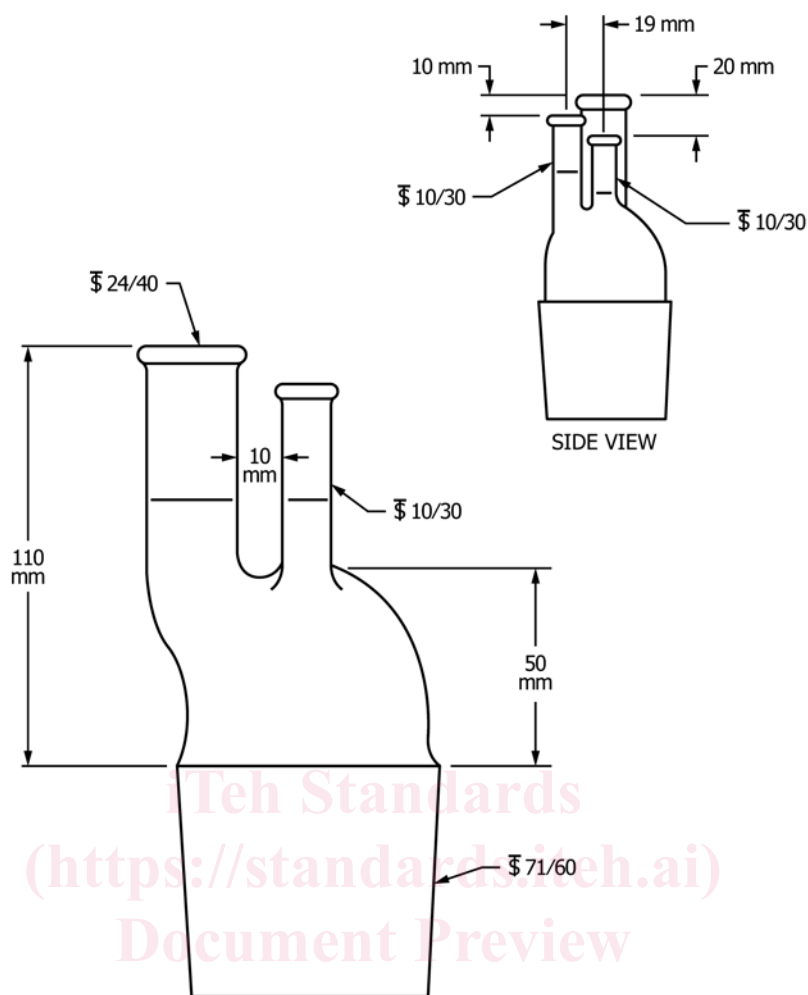


FIG. 2 Sample Tube Head

5.1.3 Air Tube⁶(Fig. 3).

5.1.4 Condenser, Allihn Type (Fig. 4).

5.1.5 Condenser, Allihn Type, Fig. 4 with 71/60 joint.

5.1.6 Assembled Apparatus (Fig. 5).

5.2 Additional glassware items and assembly accessories needed are:

5.2.1 Spacers (for Metal Specimen), of borosilicate glass, standard wall, 9-mm outside diameter, 6-mm length.

5.2.2 Oil Sampling Tube, Borosilicate Glass, 4-mm outside diameter, with sampling end approximately 600 mm to reach into the main sample tube. The tube is bent U-shape with exit end fitted by a one-hole stopper to a 25-mL filtering flask. The exit end may be any convenient length.

5.2.3 Adapter, polytetrafluoroethylene for 10/18 joint for sealing of air tube to sample tube head.

5.3 Other items and equipment are:

5.3.1 Heating Bath, constant temperature within $\pm 0.5^\circ\text{C}$ of test temperature with an immersion depth of 250 ± 20 mm. Oil baths or aluminum block baths are recommended, but above 220°C , use aluminum block bath or other similar non-oil-type

heating medium. (**Warning**—There are exposed hot surfaces on apparatus. Avoid contact with exposed skin by use of protective equipment as required.)

5.3.2 Hood, ventilation to adequately remove fumes during heating.

5.3.3 Air Supply, free of reactive contaminants. For dry air, dew point is -68°C maximum; for moist air, moisture is 10 ± 1 mg water/L air, standard conditions of $21^\circ\text{C}/105$ kPa.

5.3.4 Flowmeter, capable of measuring 10 ± 1 L/h at same standard conditions as in 5.3.3.

5.3.5 Balance, analytical, sensitivity 0.1 mg.

5.3.6 Balance, Laboratory, 2500-g capacity, 0.1-g sensitivity.

5.3.7 Centrifuge, capable of relative force of 840 ± 40 relative centrifugal force at the tip of the tubes.

5.3.8 Centrifuge Tubes, Test Method D91, cone-shaped, 100 mL.

5.3.9 Microscope, with 20-diameter magnification.

5.3.10 Assembly Fixture, wood (slotted to hold metal squares for tying with cord) as shown in Fig. 6.

5.3.11 Cord or Wire, for tying metal squares together. Suitable cord should be lightweight of cleaned linen, cotton, nylon, or ceramic fiber; suitable wire is nichrome or tantalum.

⁶ An 800-mm air tube may be used for alternate Procedure 1 or 2 when using the condenser as opposed to the sample tube head in the standard procedure.

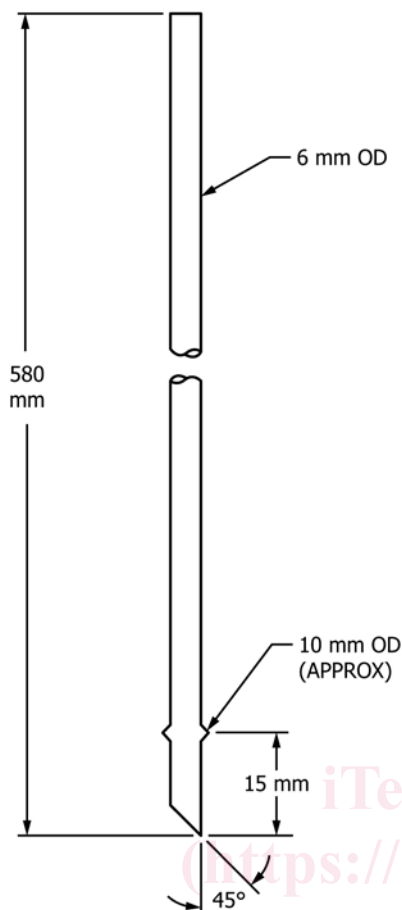


FIG. 3 Air Tube

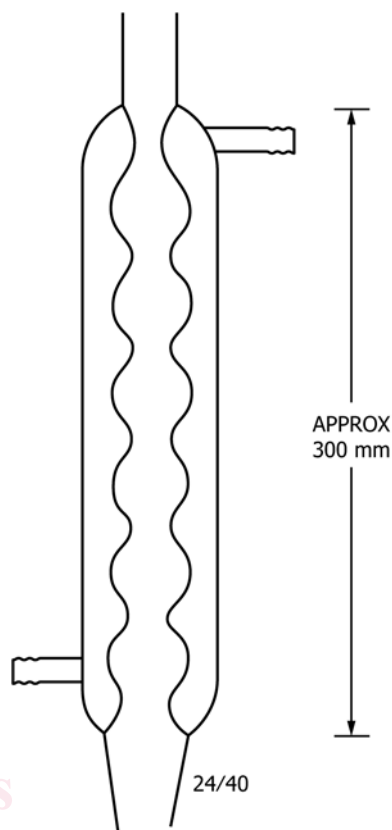


FIG. 4 Condenser, Allihn Type

5.3.12 When air must be conditioned, there is need for an air drier or humidifier. The method used is optional provided the air characteristics of 5.3.3 are attained. For drying, a satisfactory method is the use of a glass column containing 8-mesh anhydrous calcium sulfate with a column diameter such that velocity of air does not exceed 1.2 m/min. For humidifying, a satisfactory device is included in Appendix X1 to provide the required moist air.

5.3.13 *Oven*, optional, to dry glassware at elevated temperature.

5.3.14 *Forceps*, stainless steel.

5.3.15 *Thermocouple*⁷, 70 cm sheathed.

5.3.16 *Brush*, short-bristled, stiff (typewriter-cleaning brush or equivalent).

6. Reagents and Materials

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where

such specifications are available.⁸ Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Specification D1193. Referee situations require Type II distilled water defined by Specification D1193.

6.3 *Metal Specimens*:^{9, 10}

6.3.1 *Washer-Shaped Metal Specimens*, 6.35-mm inside diameter by 19.05-mm (¾-in.) outside diameter by 0.81 mm thick in the following metals:

R56080	Titanium 8 % Mn
M11311	Magnesium AZ31B
T11350	Steel M50
G10100	Steel grade 1010
C65900	Silicon-iron-bronze
P07015	Silver 99.95
A92024	Aluminum Alloy 2024 T-3 or T-4

⁸ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

⁹ The sole source of supply of the metal specimens known to the committee at this time is Metaspec Co., P.O. Box 27702, San Antonio, TX 78227-0707.

¹⁰ 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 committee¹, which you may attend.

⁷ A resistance temperature device (RTD) is also acceptable.

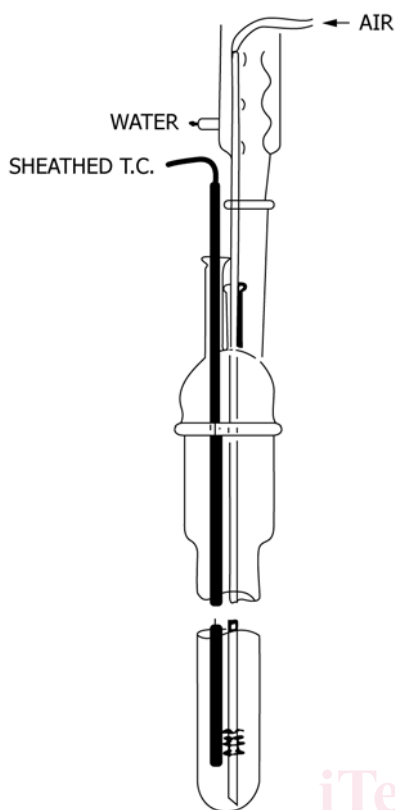


FIG. 5 Assembled Apparatus

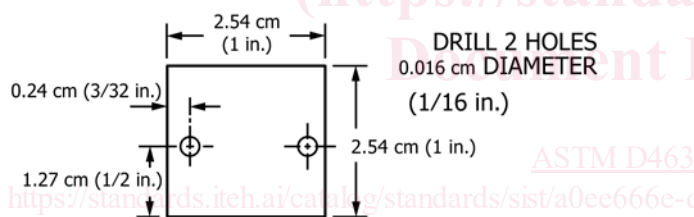
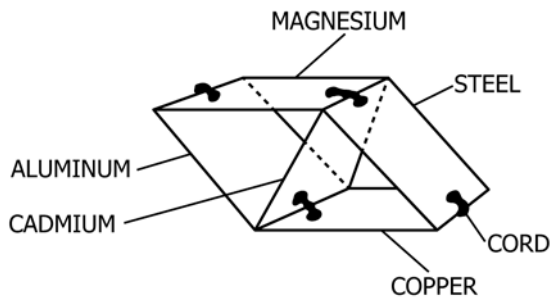


FIG. 6 Metal Square Dimensions and Arrangement



6.3.2 *Square-Shaped Metal Specimens* (as shown in Fig. 6), 0.81-mm by 25.4-mm square in the following metals:

C11000	Copper (ETP)
G10100	Steel Grade 1010
A92024	Aluminum Alloy 2024 T-3 or T-4
M11311	Magnesium AZ31B
L01900	Cadmium Anod

6.4 *Abrasive Paper*, silicon carbide of 240 and 400-grit. “Wet or dry,” “waterproof,” or iron-containing abrasives, such as natural emery, are not satisfactory.

6.4.1 *Silicon-Carbide Grains*, 150 mesh.

6.5 *Cotton*, absorbent.

6.6 *n-Heptane*. (**Warning**—Flammable. Harmful if inhaled.)

6.7 *Acetone*. (**Warning**—Extremely flammable. Vapors may cause flash-fire.)

6.8 *Nitric Acid*, concentrated. (**Warning**—Poison. Corrosive. Strong oxidizer.)

6.9 *Degreasing Solvents*:¹¹ *n*-Heptane or toluene.

6.10 *Carbon Remover for Glassware*^{12, 10} (**Warning**—Causes severe burns.)—Mix 35 mL of saturated sodium dichromate (aqueous) solution and 1000 mL of concentrated sulfuric acid. (**Warning**—Corrosive.)

6.11 *Glassware Cleaning Solution* (**Warning**—Causes severe burns.)—Mix 35 mL of MICRO¹³ in water or 35 mL of NOCHROMIX¹⁴ and 1000 mL of concentrated sulfuric acid.

6.12 *Metal Cleaning Solution*—Mix equal parts of 15 g NaOH per litre of water and 15 g of Na₃PO₄ per litre of water. (**Warning**—Corrosive.)

7. Hazards

7.1 As this test method investigates the corrosive effect of oil on metal in an artificial environment, precautions must be taken to prevent premature oxidation of metal specimens by stray chemicals during test preparations. The cleaned specimens shall be touched only by surfaces known to be free of interfering contaminants. Do not touch cleaned specimen(s) with hands. Maintain clean glassware (see Appendix X2) in a dust-free cabinet; rinse again and dry if clean glass has been stored unused for more than a week.

7.2 *Heating Bath*, *n*-heptane, toluene, acetone, carbon remover, nitric and sulfuric acids, and sodium hydroxide all require caution in handling as detailed in 5.3.1 and 6.6 – 6.12.

8. Sampling

8.1 As this test method is performed on uniform, finished oils, no special sampling procedure is needed for this oil.

8.2 Preparation of Metal Specimens:

8.2.1 Collect the required number and types of specimens to be used in the test method. Measure the diameter of each specimen and specimen hole to the nearest 0.1 cm.

8.2.2 Clean and polish the metal specimen face surfaces and inner and outer edges using 240-grit abrasive paper. Examine

¹¹ *n*-Heptane or toluene have been used in some laboratories; however, it is not known how this may affect the precision statement, which was determined using chlorinated solvents.

¹² The sole source of supply of the carbon remover for glassware known to the committee at this time is Oakite Products, Inc., 50 Valley Rd., Berkeley Heights, NJ 07922.

¹³ International Products Corp., P.O. Box 70, Burlington, NJ 08016-0070.

¹⁴ Godax Laboratories, Inc., 720-B Erie Avenue, Takoma Park, MD, 20912.

surfaces to ensure that no pitting, etching, or other signs of corrosion are present when viewed at 20× under the microscope.

8.2.3 From this point, handle specimens only with forceps, ashless filter paper, or clean polyethylene gloves. Store specimens immersed in separate containers of acetone until ready for final polishing.

8.2.4 Finish polishing metal washer specimens or square metal specimens. Use either technique described in 8.2.4.1 or 8.2.4.3.

NOTE 2—Square metal specimens are required by alternative Procedure 2 in 10.3.

8.2.4.1 Finish polishing with 400-grit paper to remove marks from previous polishing. A good technique is to place abrasive paper on flat surface, then rub the specimen with longitudinal strokes in a direction perpendicular to that used with 240-grit paper. Use a different sheet of paper for each metal type.

8.2.4.2 Swab polished specimens with *n*-heptane followed by acetone until a fresh cotton pad remains clean when wiped on the specimen.

8.2.4.3 Finish polishing both sides of each specimen to a mirror finish using 150-mesh silicon-carbide grit (held on an acetone-moistened cotton pad).

8.2.4.4 Clean all metal dust from each square by rubbing vigorously with clean pads of absorbent cotton until a fresh pad remains unsoiled.

8.2.4.5 Wash specimens in *n*-heptane, rinse with fresh solvent, and allow to air dry.

8.2.5 Store specimens in a dust-free place if to be used immediately or under *n*-heptane if there is to be delay before use.

8.2.6 Immediately prior to use, dry and weigh each metal specimen to the nearest 0.1 mg.

8.3 Oil Sample Size (Note 3 and Note 4):

8.3.1 The total sample requirement is 250 mL, 200 ± 2 mL for test and 50 mL for pretest determination of viscosity and acid number.

NOTE 3—An alternative Procedure 1, which deletes the requirement for periodic oil sampling throughout the test period may be specified. Alternative Procedure 1 requires an initial oil charge of 165 ± 2 mL (see 10.2).

NOTE 4—An alternative Procedure 2, which deletes the requirement for periodic oil sampling and requires square metal specimens instead of washer-shaped metal specimens may be specified. Alternative Procedure 2 requires an initial oil charge of 100 ± 1 mL (see 10.3).

9. Preparation of Apparatus

9.1 Cleaning of Glassware (from Previous Run):

9.1.1 Rinse all glassware items and the air tube adapter with degreasing solvent to remove residual oil, and air dry.

9.1.2 Fill or immerse the sample tube, air tube, and the 9-mm glass spacers in carbon remover at room temperature until carbonaceous deposits are removed. Water rinse after removal.

9.1.3 Wash all glassware items and the air tube adapter with detergent.^{15, 10} Rinse with water to remove detergent, and dry.

9.1.4 Fill and immerse all glassware items with glassware cleaning solution and soak for 3 to 16 h (see Note 5).

NOTE 5—This cleaning procedure is only necessary in a referee situation unless a cleaning solution, which is satisfactory to all parties involved, can be used.

9.1.5 Remove glassware from cleaning solution, rinse several times with tap water followed by distilled water, and oven dry (see Note 5).

9.1.6 Store all items in a dust-free cabinet until needed for test. If stored longer than 1 week, rinse again before use with distilled water and dry.

9.2 *Cleaning of Glassware (New)*—Proceed as in 9.1.3 and 9.1.6 in that order (omit 9.1.1, 9.1.2, 9.1.4, and 9.1.5).

9.3 *Assembly*—Assemble as shown in Fig. 5, using only the test oil to lubricate glass joints during assembly.

10. Procedure

10.1 Standard Test Procedure:

10.1.1 Determine acid number of the test oil in accordance with Test Method D664.

10.1.2 Determine the kinematic viscosity of the test oil at 40°C and 100°C in accordance with Test Method D445.

10.1.3 Turn on heating control to bring temperature of heating medium to a temperature that will maintain the oil sample within $\pm 0.5^\circ\text{C}$ of the specified temperature (**Warning**—There are exposed hot surfaces on apparatus. Avoid contact with exposed skin by use of protective equipment as required.).

10.1.4 When assembling the clean sample tubes and accessories, use only the actual test oil to lubricate joints of each assembly.

10.1.5 Slide the prepared metal washer specimens onto the air tube in the following order: aluminum (bottom), silver, bronze, low carbon steel, M50 steel, magnesium, and titanium (top). Use one glass spacer only between each metal specimen.

10.1.6 Place the air tube with specimens into the sample tube.

10.1.7 Position the sample tube head on the sample tube with the air tube protruding through the center glass joint.

10.1.8 Seat the TFE-fluorocarbon adapter on the air tube with the air tube resting on the bottom of the sample tube and tighten the gland.

10.1.9 Insert the 70-cm long-sheathed thermocouple making sure the closed end of the sheath is at least 10 mm from the sample tube wall.

10.1.10 Weigh the entire apparatus to the nearest 0.1 g.

10.1.11 Add 200 ± 2 mL of test oil in accordance with 8.3 to the sample tube, reweigh entire assembly to the nearest 0.1 g, and determine the mass of the sample added.

10.1.12 Position the sample tube in the heat medium at test temperature to an immersion depth of 250 ± 20 mm.

10.1.13 Insert the condenser and start water flow. Maintain water temperature at $18 \pm 3^\circ\text{C}$.

¹⁵ The sole source of supply of the detergent known to the committee at this time is Alconox, Inc., 215 Park Avenue South, New York City, NY 10003.