

MIL-O-5606

31 January 1950

Superseding

AN-O-366

24 June 1947

MILITARY SPECIFICATION

OIL; HYDRAULIC, AIRCRAFT, PETROLEUM BASE

This specification was approved on the above date by joint action of the Air Force and Navy Departments for use in the procurement of aeronautical supplies.

1. SCOPE

1.1 Scope.-- This specification covers the general requirements for petroleum base hydraulic oil.

2. APPLICABLE SPECIFICATIONS, OTHER PUBLICATIONS, AND DRAWINGS

2.1 Specifications.-- The following specifications of the issue in effect on date of invitation for bids form a part of this specification to the extent specified herein:

Federal

| | |
|----------|--|
| QQ-A-355 | Aluminum-Alloy (Al-24) (Aluminum-Copper-Magnesium- (1.5%)-Manganese); Plates, Sheets, and Strips |
| QQ-C-501 | Copper; Bars, Plates, Rods, Shapes, Sheets and Strips |
| QQ-M-54 | Magnesium Alloy (1.5 Manganese); Plate and Sheet |
| QQ-P-416 | Plating; Cadmium (Electrodeposited) |
| VV-L-791 | Lubricants, Liquid Fuels, and Related Products; Methods of Sampling and Testing |

Military

| | |
|------------|--|
| MIL-F-5602 | Fluid; Reference, Shear Stability |
| JAN-P-105 | Packaging and Packing for Overseas Shipment - Boxes; Wood, Cleated, Plywood |
| JAN-P-106 | Packaging and Packing for Overseas Shipment - Boxes; Wood, Nailed |
| JAN-P-124 | Packaging and Packing for Overseas Shipment - Containers (Cans, Pails, and Drums), Metal |
| JAN-P-139 | Packaging and Packing for Overseas Shipment - Plywood; Container Grade |

Air Force-Navy Aeronautical

| | |
|-------------|--|
| AN-QQ-S-076 | Steel; Carbon-and-Alloy, Low, Plate, Sheet and Strip |
| AN-TT-C-516 | Coating; Protective, Organic (For Aircraft); General Specifications (Methods for Sampling and Testing) |

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U. S. Army

94-40645 Marking; Exterior, Domestic and Export
Shipment, by Contractors 1/

U. S. Air Force

40737 Marking: Aircraft Petroleum Product
Containers, Domestic and Export Shipment 1/

2.2 Other publications.- The following publications of the issue in effect on date of invitation for bids shall form a part of this specification to the extent specified herein.

Air Force-Navy Aeronautical Bulletin.-

No. 164 Procedure for Qualifying Petroleum Specialty
Products for Aircraft

Qualified Products List

QPL-5606-1 Oil; Hydraulic, Aircraft, Petroleum Base

Bureau of Supplies and Accounts

Navy Shipment Marking Handbook 2/

American Society for Testing Materials Standards

D445-46T Kinematic Viscosity, Tentative Method of Test for

(Copies of the above publication may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pennsylvania.)

2.3 Drawings.- The following drawings of the issue in effect on date of invitation for bids shall form a part of this specification to the extent specified herein:

Air Force-Navy Aeronautical Standard issue of U. S. Air Force Drawing.-

43K143 Stand Assembly - Hydraulic Fluid Test

(Copies of this specification and copies of the above military publications thereto required for Government procurement, and the Index of Military Aeronautical (AN or MIL) Standards may be obtained upon application to the Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio; or to the Commander, U. S. Naval Air Station, Johnsville, Pennsylvania. Military Specifications (aeronautical AN or MIL), ANA Bulletins, Qualified Products Lists, and ANA Drawings are available for purchase from the above agencies, acting as agents for the Superintendent of Documents. The price may be obtained from the Index of Military Aeronautical (AN or MIL) Standards or upon application to either of the above agencies, and payment shall be made by check or money order, payable to the Superintendent of Documents or the Treasurer of the United States.)

1/ Applicable only to Air Force purchases.

2/ Applicable only to Navy purchases.

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3. REQUIREMENTS

3.1 Materials.— The oil shall consist of products of pure petroleum with approved additive materials to improve the viscosity temperature characteristics and resistance to oxidation of the finished product, and 0.5 ± 0.1 percent by weight of tricresyl phosphate as an antiwear agent.

3.2 Petroleum base stock requirements.— The properties of the petroleum base stock used in compounding the finished oil shall be as specified below before addition of any other ingredients required by the specification.

TABLE I
Properties of Petroleum Base Stock

| Property | Value |
|----------------------------|---------------------|
| Pour Point (max) <u>1/</u> | : -59.4°C (-75.0°F) |
| Flash Point (min) | : 93.3°C (200.0°F) |
| Neutralization No. (max) | : 0.10 |
| Precipitation No. | : 0 |

1/ Pour point depressant materials shall not be used.

3.2.1 Aniline point.— The aniline point of the base stock shall be determined but shall not be limited. After extracting with sulfuric acid, as described in Section 4, the aniline point shall be not more than ±2.8°C (±5.0°F) from the aniline point of the unextracted oil. Samples of the base stock submitted for inspection tests shall not vary by more than ±2.8°C (±5.0°F) from the aniline point of the original sample submitted for Qualification tests.

3.2.2 Specific gravity.— The specific gravity of the base stock shall be determined but shall not be limited. Samples of base stock submitted for inspection tests shall not vary by more than ±0.008 at 15.6°C/15.6°C (60.0°F) from the specific gravity of the original sample submitted for Qualification tests.

3.3 Additive materials.—

3.3.1 Viscosity - Temperature coefficient improvers.— Approved polymeric materials may be added to the base petroleum oil in quantities not to exceed 10 percent by weight of active ingredient in order to adjust the viscosity of the finished fluid to the values specified in table II.

3.3.2 Oxidation inhibitors.— Approved oxidation inhibitors shall be added to the blend oil in quantities not to exceed 2 percent by weight.

3.3.3 The tricresyl phosphate shall conform to the properties set forth in the following:

3.3.3.1 Composition.— The tricresyl phosphate shall be a reaction product of cresylic acid and a phosphorus compound such as phosphorus oxychloride or a phosphorus halide.

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3.3.3.2 Odor.- The material shall have substantially no odor.

3.3.3.3 Specific gravity.- At 20°/20°C (68°/68°F) the specific gravity shall be between 1.150 and 1.180 (9.57 and 9.83 lbs/gal).

3.3.3.4 Nonvolatile content.- The nonvolatile content shall be not less than 99.80 percent.

3.3.3.5 Water test (dryness).- The tricresyl phosphate shall show no turbidity when mixed with 19 volumes of 60° Baume gasoline.

3.3.3.6 Acidity.- The acidity of the tricresyl phosphate shall not exceed 0.01 percent by weight as phosphoric acid.

3.3.3.7 Refractive index.- At 25°C (77°F) the refractive index shall be between 1.550 and 1.560.

3.3.3.8 Ester content.- The ester content shall be between 95 and 100 percent when calculated as tricresyl phosphate.

3.3.3.9 Free phenols.- The content of free phenols shall not exceed 0.05 percent.

3.3.3.10 Oxidizable substances.- Oxidizable substances shall not be present.

3.3.3.11 Phosphite content.- The phosphite content shall not be more than 0.05 percent by weight, calculated as tricresyl phosphite.

3.4 Finished oil.- The properties of the finished oil shall be as specified below:

TABLE II
Properties of Finished Oil

| Property | Value |
|--|---------------------|
| Viscosity in centistokes at 54.4°C (130°F) (min) | : 10.0 |
| Viscosity in centistokes at -40°C (-40°F) (max) | : 500 |
| Pour point (max) 1/ | : -59.4°C (-75.0°F) |
| Flash point (min) | : 93.3°C (200.0°F) |
| Precipitation No. | : 0 |
| Neutralization No. (max) | : 0.20 |

1/ Pour point depressant materials shall not be used.

3.4.1 Color.- The oil shall be clear and transparent, and shall contain red dye in concentration not greater than one part of dye per 10,000 parts of fluid by weight. The color of the undyed oil shall be not darker than number 1, ASTM Union Colorimeter.

3.4.2 Corrosion and oxidation stability.-

3.4.2.1 Corrosion.- The change in weight of steel, aluminum alloy, magnesium alloy, and cadmium-plated steel when subjected to the action of the oil for 168 hours shall not be greater than +0.2 milligrams per square centimeter of surface. The change in weight of copper under the same conditions shall be no greater than +0.6 milligrams per square

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centimeter of surface. There shall be no pitting, etching, or visible corrosion on the surface of the metals when viewed under magnification of 20 diameters. A slight stain on the surface of the copper shall be permitted, but dark brown, gray, or black stain shall be cause for rejection. A slight discoloration of the cadmium shall also be permitted.

3.4.2.2 Resistance to oxidation.- The oil shall not have changed more than -5 or +20 percent from the original viscosity in centistokes at 54.4°C (130.0°F) after the oxidation-corrosion test. The neutralization number using Bromothymol Blue as the indicator shall not have increased by more than 0.20 over the neutralization number of the original sample after oxidation as outlined in Section 4. There shall be no evidence of separation of insoluble materials or gumming of the oil.

3.4.3 Stability at low temperature.- The oil shall not gel, crystallize, solidify, or show evidence of separation of insoluble material after being maintained at a temperature not above -54°C (-65°F) for 72 hours. At the end of the storage time, turbidity shall be not greater than that shown by the turbidity standard of barium sulfate suspension as outlined in Section 4.

3.4.4 Shear stability.-

3.4.4.1 When pumped for 5000 cycles under the conditions and in the apparatus described in Section 4, the subject fluid shall show a percentage centistoke viscosity decrease at 54.4°C (130.0°F) and -40°C (-40°F) no greater than that obtained with shear stability reference fluid, Specification MIL-F-5602 when the test fluid is tested at a pumping rate at least as high but no greater than 10 percent higher than that for the reference fluid, and both tests are carried out consecutively in the same apparatus.

3.4.4.2 The oil shall not be appreciably darkened at the conclusion of the Shear-Stability test, and the neutralization number shall not have increased over the original neutralization number by more than 0.20.

3.4.5 Swelling of synthetic rubber.- Swelling of the standard synthetic rubber L by the test fluid shall be within the limits established by the low-and-high-swell reference fluids.

3.4.6 Evaporation.- Residue after evaporation of a thin film of the hydraulic oil for 4 hours at 65.6°C (150°F) shall be oily, and shall not be hard or tacky.

3.4.7 Copper-strip corrosion.- After exposure to the oil for 72 hours at 100°C (212°F) a freshly polished strip shall show no corrosion. A slight brown stain shall be permitted, but dark brown, gray or black stain, or pitting of the strip shall be cause for rejection.

3.5 Use of AN or MIL designations.- AN or MIL designations shall not be applied to a product except for Qualification test samples, in correspondence or sales matter, until notification has been received from the Qualifying Service that the product has been approved for aeronautical use.

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3.6 Workmanship.- The oil shall contain no admixture of resins, rubber, soaps, gums, fatty oils, oxidized hydrocarbons, or any other additive unless specifically approved by the Qualifying Service. The oil shall be entirely homogeneous and free from lumps of undissolved additive, water, dirt, lint, or sediment. At no time during the blending process or any operations subsequent thereto, shall the temperature of any of the components of the fluid, or the fluid itself, be greater than 149°C (300°F). Immediately before final packaging the oil shall be filtered through a blotter press.

4. SAMPLING, INSPECTION AND TEST PROCEDURES

4.1 Classification of tests.- The inspection and testing of aircraft hydraulic oil shall be classified as follows:

4.1.1 Qualification tests.- Qualification tests are those tests accomplished on samples submitted for qualification as a satisfactory product, and shall consist of all of the tests of this specification.

4.1.1.1 Qualification of petroleum base stock.- Separate Qualification tests shall be conducted for each petroleum base stock or blend of base stocks. Approval granted on hydraulic oil manufactured from any base stock shall not apply to oils manufactured from any other base stock.

4.1.2 Confirmation tests.- Confirmation tests are accomplished on a sample representative of the first batch of finished oil offered for delivery on a contract or order after the oil has passed the Qualification tests and has been given tentative approval and listing in the applicable List of Qualified Products.

4.1.3 Inspection tests.- Inspection tests shall be accomplished on material to be supplied under contract or order.

4.2 Qualification tests.-

4.2.1 Sampling instructions.- Qualification test samples shall consist of 10 gallons of hydraulic oil, 1 gallon of the petroleum oil base stock before the addition of additive agents, 1/2 pound of the additives used for improving the viscosity temperature coefficient, and 1 ounce of the compound used for improving the oxidation stability. In the event that additives are supplied as concentrated solutions, an equivalent quantity of the solution shall be furnished. Samples shall be forwarded to the Service specified in paragraph 6.4, prominently identified by securely attached durable tags marked with the following information:

Sample for Qualification Test
OIL; HYDRAULIC, AIRCRAFT PETROLEUM BASE
Name of Ingredient (or ingredient material)
Name of Manufacturer
Submitted by (name) (date) for Qualification tests in
accordance with the requirements of Specification
MIL-O-5606 under authorization (reference authorizing
letter).

4.2.1.1 Qualification samples shall be accompanied by a certified test report containing complete information as to the source and type of base stock and additive materials used, the formulation and composition of the finished oil, and laboratory data showing quantitative results of all tests required by this specification. Separate Qualification tests shall be required for each base stock used.

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4.2.1.2 Formulation sheets.- An example of a satisfactory form for the formulation sheet, indicating the percentage and nature of each ingredient is as follows:

| | |
|---|---------|
| Petroleum oil base stock | percent |
| Viscosity index improver (mfr name and No.) | percent |
| Oxidation inhibitor (mfr name and No.) | percent |

4.2.2 Tests.- The Qualification tests of hydraulic oil shall consist of all the tests specified under Inspection tests and, in addition, the ones contained herein.

4.2.2.1 Corrosion and Oxidation Stability.- A large pyrex test tube shall be fitted with a water-cooled reflux condenser, preferably of the Allihn type by means of a tight fitting shellacked cork or a ground glass connection. In the test tube shall be placed 100 ml of the fluid to be tested and weighed strips approximately 1-inch square of copper, Specification QQ-C-501, low-carbon steel, Specification AN-QQ-S-676; Aluminum Alloy, Specification QQ-A-355, magnesium alloy, Specification QQ-M-54; and steel cadmium plated in accordance with Specification QQ-P-416. The metals shall be arranged in such a way that they form a square with the magnesium specimen touching aluminum and steel but not copper as diagrammed in figure 1. A small hole shall be bored near each of the parallel edges of each specimen and the sheets then tied together with a high grade cord which had been previously washed with distilled water and dried. Two sets of holes may be used in each strip to give the square stability. Each specimen, except cadmium-plated steel, shall be polished with 3/0 emery cloth to remove all surface oxidation and contamination. Cadmium-plated steel specimens shall not be polished but shall be rinsed in analytical reagent grade benzene to remove contamination. The assembly, consisting of test tube, oil, and strips, shall be weighed to 0.1 gram and placed in a thermostatically controlled bath maintained at $121.1^{\circ} \pm 1.00^{\circ}\text{C}$ ($250^{\circ} \pm 1.8^{\circ}\text{F}$). A glass tube, one end of which has been drawn down to $1/16 \pm 1/64$ -inch orifice shall be introduced through the condenser in such a manner that it extends 1/4 inch from the bottom of the test tube in the center of the square and clean dry air shall be introduced at the rate of approximately 5 ± 0.5 liters per hour. At the end of 168 hours, the oxidation shall be discontinued, and the weight change of the assembly determined. The oil shall be examined visually for separation of insoluble material or gumming, and the viscosity and neutralization number of the oil shall be determined as specified in Section 4. Metal specimens shall be washed in CP Benzene, then in acetone, and dried before reweighing. The metal test specimens shall be reweighed to determine the change due to corrosion and they shall be examined under 20 X magnification to discover pitting or etching, if it exists. The loss of the oil for the period of test shall be not more than 8 percent. If the loss exceeds this value, the test shall be disregarded and a duplicate determination shall be made.

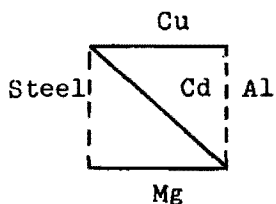


FIGURE 1. Arrangement of Metals for Corrosion and Oxidation Stability.

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4.2.2.2 Shear Stability.-- The shear stability reference fluid shall be tested immediately before or after the fluid under test, under the same conditions. The pumping rate for the test fluid shall be at least as high but no greater than 10 percent higher than that for the reference oil. If the results of the tests do not comply with the requirements of Section 3, both test fluid and reference fluid shall be tested consecutively under the same procedure twice more and if the requirements are satisfied in two of the three tests, the subject fluid shall be considered acceptable. Quantities of the hydraulic fluid not exceeding 3 gallons shall be pumped through a suitable hydraulic pump at a pumping pressure of 1000 ± 50 pounds per square inch, at 1740 ± 100 rpm and air inlet temperature of $37.8^\circ \pm 2.8^\circ\text{C}$ ($100.0^\circ \pm 5.0^\circ\text{F}$). An acceptable type of apparatus is shown in figure 2. Inlet suction shall be equivalent to 3 to 4 feet of lift of oil. Pressure relief shall be provided by a suitable hydrocone balanced relief valve. The rate of flow shall be not less than that indicated in table III at the allowable pumping speeds. A log shall be kept of the pumping tests, and reading shall be taken every 12 hours of the motor speed, outlet pressure, inlet temperature, and flow in gallons per minute. After 5000 cycles of continuous pumping, the oil shall be examined for deterioration. The number of cycles may be calculated by dividing the total flow of oil through the pump (in gallons) by the quantity of hydraulic fluid in the system in gallons. The fluid shall not appreciably darken or show visual evidence of decomposition, separation of additives, or sludge formation at the end of the pumping test. The viscosity of the oil at 54.4°C (130.0°F) and at -40°C (-40°F) shall not have changed more on a percentage basis than the shear stability reference fluid specified in Specification MIL-F-5602 tested at a comparable rate and both tests run consecutively. The neutralization number of the oil after completion of the pumping test shall be determined. Pump and throttling valve other than that specified in figure 2 may be used, provided that the test procedure is of such severity that the shear stability reference fluid shall show a decrease in the centistoke viscosity at 54.4°C (130.0°F) of not less than 15 percent after 5000 cycles of pumping.

4.2.2.3 Evaporation.-- A microscope slide shall be immersed in the hydraulic oil at room temperature. It shall then be removed and suspended by one end in an air oven at 65.6°C (150.0°F) for 4 hours. After removal of the slide and cooling to room temperature, the residual film shall be oily, and neither hard nor tacky.

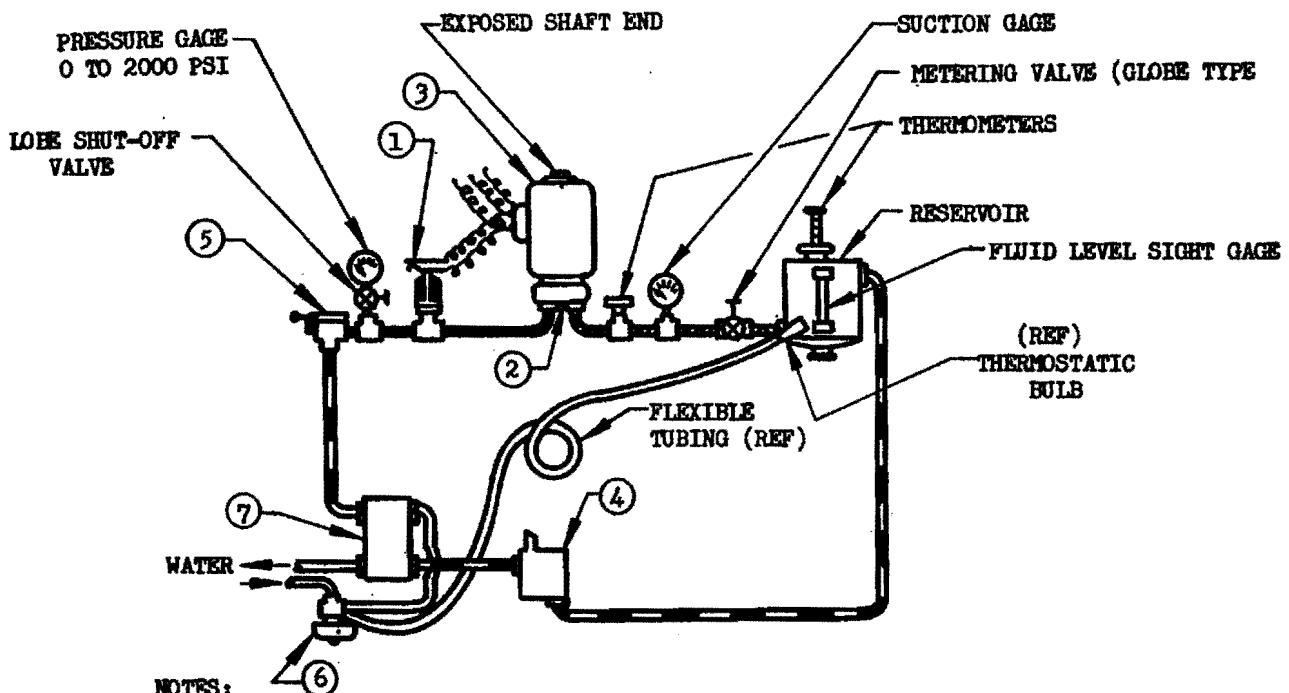
4.3 Confirmation tests.--

4.3.1 Sampling instructions.-- A confirmation test sample, consisting of 15 gallons of the oil shall be selected by the Inspector from the first batch of oil offered for delivery on a contract or order after the product has passed the Qualification tests and has been given tentative approval and listing in the corresponding List of Qualified Products. The Inspector shall select confirmation test samples from subsequent lots only upon explicit instructions from the Procuring Service. Samples shall be forwarded to the Service stated in paragraph 6.4, after being plainly and durably marked as follows:

For Confirmation Test at AMC
Specification MIL-O-5606
Oil; Hydraulic, Petroleum Base
Name of Manufacturer
Contract or Order Number
Batch Number

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Speed-Capacity Limits ^{1/}

| Speed of Pump | Capacity (Min) |
|---------------|----------------|
| RPM | GPM |
| 1650 | 1.1 |
| 1750 | 1.2 |
| 1850 | 1.3 |

^{1/} Intermediate speed-capacity limits may be determined by linear interpolation

NOTES:

- ① GENERAL ELECTRIC CO. PRESSURE GOVERNOR NO. CR2922, OR EQUAL
- ② USAF TYPE B-7 HYDRAULIC PUMP.
- ③ 2 HP, 3 PHASE, 60 CYCLE, 220 VOLT, AC MOTOR.
- ④ PITTSBURGH PDG-901-51, 1 INCH, RECORDING FLOW METER, OR EQUAL
- ⑤ VICKERS C-167E HYDROPHONE RELIEF VALVE, OR EQUAL
- ⑥ POWERS LIQUID TEMPERATURE CONTROL REGULATOR NO. 11, OR EQUAL
- ⑦ HARRISON PLATE TYPE HEAT TRANSFER UNIT NO. HE45, OR EQUAL
- ⑧ FLUID CAPACITY OF ENTIRE SYSTEM APPROXIMATELY 3 GAL.
- ⑨ HYDRAULIC LINES TO CONSIST OF; ALUMINUM, COPPER, STEEL, AND SYNTHETIC RUBBER HOSE.
- ⑩ FOR NECESSARY DETAILS SEE USAF DWG 43KL43.

FIGURE 2. Schematic Diagram to Hydraulic Fluid Test Stand

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4.3.2 Tests.- Confirmation tests shall consist of all the tests of this specification.

4.4 Inspection tests.- The contractor shall furnish all samples and shall be responsible for accomplishing the tests specified herein. When inspection is conducted at the contractor's plant, all inspection and testing shall be under the supervision of the Government Inspector. Contractors not having laboratory testing facilities satisfactory to the Government shall engage the service of a commercial testing laboratory acceptable to the Inspector. The contractor shall furnish test reports, in duplicate, showing quantitative results for all tests required by this specification, and signed by an authorized representative of the contractor or laboratory, as applicable. Acceptance or approval of material during course of manufacture shall in no case be construed as a guaranty of the acceptance of the finished product.

4.4.1 Sampling.- Inspection test samples shall be selected in accordance with Specification VV-L-791.

4.4.1.1 Synthetic rubber samples and high- and low-swell reference fluids.- Samples of the standard synthetic rubber and quantities of the high- and low-swell reference fluids will be furnished, upon request by the U. S. Air Force, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio. The rubber samples will be marked with an identifying letter and the date of manufacture. Samples shall not be used more than 6 months after the date of manufacture.

4.4.2 Tests.- Inspection tests of the oil shall consist of the tests specified herein:

4.4.2.1 The following tests shall be conducted in accordance with the applicable method given in Specification VV-L-791.

1. Pour Point
2. Flash Point (Open Cup)
3. Neutralization No. 1/
4. Precipitation No.
5. Specific Gravity

4.4.2.2. Aniline Point.-

4.4.2.2.1 Concentrated Sulfuric Acid of 37 Normal.- The normality of the acid used should be strictly held at 37 Normal.

4.4.2.2.2 Extraction Procedure.- A total of 25 ml of the sulfuric acid 37 N contained in a glass stoppered sulfonation flask, as described in Method 370.1 Specification VV-L-791, shall be cooled for 5 minutes in an ice water bath at a temperature of 0° to 4°C (32° to 39°F). The base stock sample shall be cooled to 15°C (59°F). A total of 15 ml of the

1/ Bromothymol Blue (1 percent bromothymol blue (dibromothymol-sulfonphthalein) in ethyl alcohol titrated to a blue end point) may be used as the indicator in lieu of phenolphthalein. If bromothymol blue is used as the indicator, neutralization number should be determined both before and after the oxidation test with this same indicator.

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sample shall then be pipetted into the acid, special care being taken to allow the sample to run slowly down the side walls of the flask to prevent mixing of the two layers. The acid-oil mixture shall be allowed to remain in the ice water bath for an additional 5 minutes. The mixture shall be shaken without removing from the cooling bath for 2 minutes, after which the flask shall be removed from the bath and shaken for an additional 10 minutes. Sufficient concentrated sulfuric acid shall then be added to the sulfonation flask to bring the residual insoluble oil into the neck of the flask. The mixture shall be centrifuged at 1000 rpm for 5 minutes to separate oil and acid. The procedure shall be repeated until a sufficient amount of oil has been recovered for determination of the aniline point. Before the aniline point is determined, the recovered oil shall be shaken thoroughly with a 5 percent solution of sodium carbonate and then dried with a desiccant.

4.4.2.2.3 Ten ml of extracted oil shall be carefully pipetted from the sulfonation flask for determination of aniline point, as described in Specification VV-L-791.

4.4.2.3 Tricresyl Phosphate.-- Sampling, inspection, tests, and test reports for tricresyl phosphate shall be in accordance with applicable methods of Specification AN-TT-C-516 except that the tests for phosphite determination, ester content, free phenols, and oxidizable substances shall be conducted as follows:

4.4.2.3.1 Phosphite Determination.-- Approximately 10 g of tricresyl phosphate shall be refluxed for 2 hours with 25 g of a 10 percent solution of hydrochloric acid. After cooling the mixture, 25 ml of petroleum ether or precipitation naphtha and 25 ml of a saturated sodium chloride solution shall be added. The mixture shall be shaken and transferred to a separatory funnel where the water layer shall be separated and the nonaqueous layer washed four successive times with 25 ml portions of saturated salt solution. Each portion of salt solution shall then be added to the original water layer and the nonaqueous layer discarded. The water layer shall then be neutralized with solid sodium bicarbonate, and distilled water added to make a volume of 300 ml. Then 10 ml of 0.05 normal iodine solution shall be added and the mixture allowed to stand in the dark for one-half hour. The mixture shall then be acidified cautiously with 25 percent acetic acid. The unreacted iodine shall then be titrated with 0.05 normal sodium thiosulfate solution. A determination similar to the above shall then be carried out with all reagents except the tricresyl phosphate. This constitutes a blank for correcting for the effect of the reagents. The amount of tricresyl phosphite shall then be calculated by means of the following equation:

$$(17.6) \frac{(A)(B-C-D)}{E} = \text{Weight percent of tricresyl phosphite}$$

Where A = normality of iodine solution
 B = milliliters of iodine solution originally added
 C = milliliters of iodine solution titrated with sodium thiosulfate solution
 D = milliliters of iodine solution used for blank
 E = grams of original sample

If the permissible content specified in Section 3 is exceeded, the test shall be conducted twice more under the same procedure; and if the requirements are satisfied in each of these repeat tests, the tricresyl phosphate shall be considered acceptable.

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4.4.2.3.2 Ester Content.- The ester content shall be determined in accordance with the procedure set forth by Specification AN-TT-C-516, except that the heating period shall be from 8 to 16 hours.

4.4.2.3.2.1 Ester Content (Alternate).- The ester may be decomposed by fusing with caustic potash or sodium peroxide and the phosphorus determined either gravimetrically or volumetrically, with ammonium molybdate.

4.4.2.3.3 Free Phenols.- A 10 g sample of the tricresyl phosphate shall be weighed and transferred to a 250 ml volumetric flask. Fifty ml of sodium hydroxide solution (2.5 percent) at 65°C (149°F) shall be added and the flask shaken vigorously for 3 minutes. This solution shall be diluted to 250 ml and filtered. A 100 ml portion shall then be pipetted into a 300 ml flask for titration. After the aliquet sample has been pipetted into the 300 ml flask, the 15 ml of sodium bromide-bromate solution (containing 10.09 g of sodium bromide and 2.95 g of sodium bromate per liter) shall be added from a burette, and then five ml of concentrated hydrochloric acid (sp gr 1.19). The hydrochloric acid shall be added quickly and the rubber stopper put in place immediately after which the flask shall be shaken and allowed to stand for 15 minutes. Ten ml of potassium iodide solution (6 percent) shall be added and the solution titrated with 0.05N sodium thiosulfate solution ($\text{Na}_2\text{S}_2\text{O}_3$), using starch solution (1 percent) as an indicator. The starch solution shall be added near the end of the titration. The fading out of the blue color marks the end point of the titration. A blank titration shall be run as above using the same reagents. The percentage of free phenols (cresol) shall be calculated as follows:

$$\frac{(\text{ml Na}_2\text{S}_2\text{O}_3 \text{ (blank)} - \text{ml Na}_2\text{S}_2\text{O}_3 \text{ (sample)}) \times \text{normality}^{1/}}{\text{Weight of Sample}} \times 4.50 = \% \text{ free phenols}$$

4.4.2.3.4 Oxidizable Substances.- Shake vigorously for 2 minutes a 10 g sample with 50 ml of freshly prepared 0.01N potassium permanganate solution. A change in the purple color within 30 minutes shall be indication of failure.

4.4.2.4 Viscosity.-

4.4.2.4.1 Viscosity at 54.4°C (130.0°F).- The viscosity at 54.4°C (130.0°F) shall be determined in accordance with ASTM Method D445-46T or by any other standard viscosimeter giving results within an accuracy of +1.0 percent and which can be converted to centistokes. For referee tests, the viscosity shall be determined by the ASTM Method D445-46T, and the thermometers used shall be certified by the National Bureau of Standards.

4.4.2.4.2 Viscosity at -40°C (-40°F).- The viscosity at -40°C (-40°F) shall be determined in a capillary pipette of the type used in ASTM Method D446-46T. Any suitable bath which is capable of being maintained at $-40^\circ\text{C} \pm 0.1^\circ\text{C}$ may be used. For referee tests a mercury-thallium thermometer marked in 0.1°C or 0.2°F scale division and calibrated at -40°C (-40°F) by the National Bureau of Standards shall be used for measuring temperature. One satisfactory type of apparatus is described in the following paragraph.

^{1/} Normality of the sodium thiosulfate solution used.

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4.4.2.4.2.1 A cylindrical pyrex jar of a size capable of holding several viscosity pipettes is used for the bath. Alcohol or other low melting liquid is used as the cooling medium. The jar is placed in a well insulated cold box containing 1-1/2- to 2-inch thick glass or plastic windows. Suitable openings in the portion of the box above the jar allow the introduction of the viscosity immersion heater. To insure adequate cooling facilities, the cold box is made large enough so that a large quantity of dry ice may be placed in it around the bath. The box is filled with dry ice, and the bath cooled by the cautious addition of dry ice to approximately -40°C (-40°F). The thermo-regulator and relay are used in conjunction with the heater to maintain the bath at $-40^{\circ} \pm 0.1^{\circ}\text{C}$ ($-40^{\circ} \pm 0.2^{\circ}\text{F}$). All viscosity pipettes used in the bath are connected to drying tubes at all times to prevent condensation of moisture on the inside.

4.4.2.4.3 Two viscosity determinations shall be made on each sample at -40°C (-40°F) with a minimum time interval of one hour between determinations, during which time the sample shall be maintained at $-40^{\circ} \pm 0.1^{\circ}\text{C}$ ($-40^{\circ} \pm 0.2^{\circ}\text{F}$). The difference in viscosity between the two determinations in centistokes shall be not greater than 1 percent.

4.4.2.5 Color.- The color shall be determined in accordance with "Color of Lubricating Oils by means of ASTM Union Colorimeter" as specified in Specification VV-L-791 and as follows:

- (a) The color of the hydraulic oil shall be compared in a 4-ounce oil sample bottle containing an oil not darker than ASTM No. 1 colored with National Aniline and Chemical Company "Oil Red Q" in the proportions of 1 ounce of dye to 100 gallons of oil. There shall be no readily discernible differences in the colors. The color determination may be supplemented by further comparison after artificial aging with oxygen or artificial sunlight in order to determine the color stability of the sample and the standard.

4.4.2.6 Stability at Low Temperature.-

4.4.2.6.1 Preparation of Turbidity Standard.- Twenty-five ml of a 0.00322 molar solution of barium chloride is measured into a 250 ml volumetric flask. To this are added 125 ml of distilled water and 25 ml of 0.50 normal sulfuric acid. The solution is then shaken well to insure complete precipitation. Approximately 25 ml of one normal sodium hydroxide are then added to make the solution alkaline. Fifty ml of a solution containing 200 parts per million of "National Erie Bordeaux B" red dye in distilled water are then added, giving a total volume of 250 ml of solution. The solution is then poured into an 8-ounce bottle. The bottle shall be stoppered and the suspension used within one-half hour of being prepared.

4.4.2.6.2 Storage of Oil.- A sample of the hydraulic oil shall be placed in a clean 8-ounce sample bottle which has previously been dried in an oven at 100°C (212°F) for not less than 24 hours. The bottle shall be tightly stoppered and stored at a temperature not higher than -54°C (-65°F) for 72 hours.

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4.4.2.6.3 Examination of Cloud Samples.- At the end of the 72-hour storage period, the sample shall be removed from storage and shaken vigorously for 10 seconds. There shall be no evidence of gelling, crystallization, or solidification of the oil. Turbidity shall be evaluated by visual comparison with the turbidity standard. Turbidity of the oil sample shall be not greater than that of the standard. The turbidity standard shall be shaken vigorously within 5 minutes prior to making any comparisons. If frosting interferes with the turbidity evaluation, the vessel containing the oil may be quickly dipped into a 50- (by volume) mixture of glycerine-methanol, previously cooled to the storage temperature. No more than 1 minute shall have elapsed between the time of removal of the oil sample from the low temperature storage and the completion of the test.

4.4.2.7 Swelling of Synthetic Rubber.- Tests on the increase in volume of synthetic rubber due to the swelling action of the hydraulic oil shall be determined after one week's immersion on specimens from the standard rubber sheets furnished by the Air Materiel Command. Standard rubber is designated as L rubber. Samples shall be cut from the standard sheet. They shall be smoothly buffed and shall weigh approximately 5 grams. Three specimens shall be used for each test. Swelling of the standard rubber shall be determined at the same time and in the same manner on the two standard swelling reference oils, high and low, which may be obtained from the Air Materiel Command.

4.4.2.7.1 An analytical or jolly balance shall be used to determine water displacement.

4.4.2.7.2 The cleanser shall be anhydrous ethanol or anhydrous methanol.

4.4.2.7.3 Procedure at 70°C (158°F).- The water displaced by each rubber specimen shall be determined with a jolly or an analytical balance and the displacement recorded. The specimens shall then be dried and immersed in the oils and allowed to remain immersed for 1 week, during which time the temperature of the oils shall be maintained at $70 \pm 1^\circ\text{C}$ ($158 \pm 2^\circ\text{F}$). At the end of the week each rubber specimen shall be removed from the hydraulic fluid, dipped into the cleanser, and wiped lightly with a soft cotton cloth. Within 5 minutes after wiping, the water displacement of the sample shall be determined a second time and the displacement recorded. The water used for the determination of the water displacement shall be maintained at room temperature. The percent increase in volume computed from the following equation shall be reported:

$$\Delta V = \frac{D_a - D_b}{D_b} \times 100$$

Where ΔV = Percentage increase in volume of the specimen
 D_a = Water displacement after immersion in hydraulic oil
 D_b = Water displacement before immersion in hydraulic oil

4.4.2.7.4 The swelling tests shall be accomplished in the hydraulic oil on two samples of rubber as specified above, and the average of the two results for each oil shall be reported. The test shall not be valid if the volume percent swelling of each individual test deviates more than 0.5 units from the average volume percent swell when the average swelling is in the range of 0 to 5 volume percent, and not more than one unit from the average volume percent swell when the average swelling is above 5 volume percent.

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4.4.2.7.5 The swelling of the rubbers in the hydraulic oil shall be between the limits of swell on these rubbers established by the rubber swellings standard fluids furnished by the Air Materiel Command. There shall be no disintegration or deterioration of any of the rubber samples in the oil.

4.4.2.8 Evaporation.- A microscope slide shall be immersed in the hydraulic oil at room temperature. It shall then be removed and suspended by one end in an air oven at 65.0°C (150.0°F) for four hours. After removal of the slide and cooling to room temperature, the residual film shall be oily, and neither hard nor tacky.

4.4.2.9 Copper-Strip Corrosion.- Test shall be conducted in accordance with Specification VV-L-791, Corrosion Test at 100°C (212°F) (Copper Strip) except that time of test shall be increased from 3 to 72 hours.

4.5 Rejection and retest.- Failure of any sample of hydraulic oil to conform to any one of the requirements of this specification shall be cause for the rejection of the lot represented. Hydraulic oil which has been rejected may be reworked or replaced to correct the defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished the Inspector. Units rejected after retest shall not be resubmitted without the specific approval of the Procuring Service.

5 PREPARATION FOR DELIVERY

5.1 Application.- The packaging, packing, and marking requirements specified herein apply only to direct purchases by or direct shipments to the Government.

5.2 Preservation.- Preservation requirements are not applicable.

5.3 Packaging.- The hydraulic oil shall be packaged in 1-quart or 1-gallon metal containers as specified by the Procuring Service. One quart containers shall be in accordance with Specification JAN-P-124, Type III. One-gallon containers shall be in accordance with Specification JAN-P-124, Type I, except that the screw-cap closure shall be omitted and handles are not required. The color of the exterior of all metal containers shall be red. All materials used in the construction of the containers shall be such as will not affect, or be affected by the contained hydraulic oil. Before filling, all containers shall be thoroughly cleaned and inspected to insure absolute absence of dirt, corrosion products, water or other materials which would contaminate or interfere with satisfactory operation of the hydraulic oil. The cleanliness of the containers shall be positive.

5.4 Packing.- Unless otherwise specified, the hydraulic oil in metal containers shall receive domestic packing. Shipping containers shall receive domestic packing. Shipping containers shall contain the same number of cans, shall be uniform in size, and snugly packed. The gross weight of the fully packed shipping container shall not exceed approximately 200 pounds.

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5.4.1 Domestic packing.-- Unless otherwise specified, the interior packages shall be packed in substantial commercial shipping containers so constructed as to insure acceptance by common or other carrier for safe transportation, at the lowest rate, to the point of delivery. Except as specified herein, the container shall conform to the requirements of Consolidated Freight Classification Rules in effect at the time of shipment, except that fiberboard when used, shall have a minimum Mullen test of 275 pounds. Containers shall be able to withstand storage, rehandling, and reshipment without the necessity of repacking.

5.4.2 Overseas packing.-- Unless otherwise specified, the interior packages shall be packed in shipping containers in accordance with Specification JAN-P-105 or JAN-P-106. Plywood, if used, shall be Type B, Condition I of Specification JAN-P-139.

5.5 Marking and/or Labeling.--

5.5.1 Unit packages.-- Each unit package shall be durably and legibly marked with the following information which shall appear in the same size type of lettering:

OIL; HYDRAULIC, AIRCRAFT PETROLEUM BASE
Specification MIL-O-5606
Equivalent British Material: Specification DTD-585
Product code number
Name of manufacturer
Contract or Order No.
Batch or lot number
Stock number (USAF or Navy as applicable)

INSTRUCTION: FOR AUTOMATIC PILOTS, HYDRAULIC SYSTEMS, SHOCK STRUTS, ETC., DESTROY ALL MARKINGS ON THIS CONTAINER WHEN EMPTY. THIS OIL IS NOT INTERCHANGEABLE WITH HYDRAULIC FLUID; CASTOR OIL BASE (BLUE COLOR).

5.5.2 Shipping containers.-- Each exterior container shall be marked as specified for unit packages; marked to indicate method of packing, and marked for shipment in accordance with the requirements of the applicable publications for Air Force or Navy shipments as indicated in Section 2.

6. NOTES

6.1 Intended use.-- The hydraulic oil covered by this specification is intended for use in automatic pilots, shock absorbers, breaks, flap-control mechanisms, and other hydraulic systems using synthetic sealing material.

6.1.1 The fluid is not interchangeable with hydraulic fluid, castor oil base, U. S. Air Force Specification No. 3586 or Navy Aeronautical Specification M-574.

6.2 Ordering data.-- Requisitions, contracts, and orders shall state the size of containers, the quantity, and whether overseas packing is desired. (See Section 5.) The material shall be purchased by volume, the unit being a U.S. gallon at 15.6°C (60°F). For Service purposes, the hydraulic oil shall not be purchased in other than 1-quart or 1-gallon containers.

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6.2.1 List of Qualified Products.-- Products considered acceptable under this specification are listed in QPL-5606-1.

6.3 British equivalent.-- The fluid covered by this specification is equivalent to that covered by British Specification DTD-585.

6.4 Provisions for Qualification Tests.-- Qualification tests are conducted in accordance with the principles set out in ANA Bulletin No. 164. The right is reserved to reject any bids on aircraft hydraulic oil which has not been subjected to the required tests and found satisfactory. The attention of manufacturers is called to this provision and they are urged to request authorization for tests of the hydraulic oil which they propose to offer to the Air Force and Navy under this specification. Requests for authorization of tests and for information as to the test fees involved should be addressed to the U.S. Air Force, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio; the Qualifying Service, with a copy to the Bureau of Aeronautics, Navy Department, Washington 25, D. C. It is to be understood that the manufacturer will pay all transportation costs involved. In the case of failure of the sample or samples submitted, consideration will be given to the request of the manufacturer for additional tests only after it has been clearly shown that changes have been made in the product which the Government considers sufficient to warrant additional tests.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

Custodian:
Air Force

Other interest:
Navy-BuAer