NOT MEASUREMENT SENSITIVE

MIL-H-53119(ME)
1 March 1991

MILITARY SPECIFICATION

HYDRAULIC FLUID, NONFLAMMABLE, CHLOROTRIFLUOROETHYLENE BASE

This specification is approved for use within the USA Belvoir Research, Development and Engineering Center, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification describes the characteristics of and provides the requirements for a chlorotrifluoroethylene base hydraulic fluid for use in hydraulic systems of selected armored vehicles through the temperature range -54 to +135 °C (see 6.1). This fluid is identified by the military symbol NFH.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

L-P-390 - Plastic, Molding and Extrusion Material, Polyethylene and Copolymers (Low, Medium, and High Density).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: USA Belvoir Research, Development, and Engineering Center, ATTN: STRBE-TSE, Fort Belvoir, VA 22060-5606 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 9150

MILITARY

MIL-B-26701 - Bottles, Screw Cap and Carboys, Polyethylene Plastic.
MIL-D-43703 - Drums, Shipping and Storage, Molded Polyethylene.
MIL-R-83485 - Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperature, Type II.

STANDARDS

FEDERAL

FED-STD-313 - Material Safety Data Sheets, Preparation and Submission of.
FED-STD-595 - Colors Used in Government Procurement.
FED-STD-791 - Lubricants, Liquid Fuels and Related Products; Methods of Testing.

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-290 - Packaging, Packing and Marking of Petroleum and Related Products

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents. The following other Government documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those in effect on the date of the solicitation.

DEPARTMENT OF LABOR (DOL)

OSHA 29 CFR 1920.1200 Hazard Communication Interpretation Regarding Lubricating Oils.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402).

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 97 - Pour Point of Petroleum Oils.
D 130 - Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test.
D 240 - Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter.

D 445 - Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity).
D 664 - Neutralization Number by Potentiometric Titration.
D 892 - Foaming Characteristics of Lubricating Oils.
D 1405 - Estimation of Net Heat of Combustion of Aviation Fuels.
D 1744 - Water in Liquid Petroleum Products by Karl Fischer Reagent.
D 2382 - Heat of Combustion of Hydrocarbon Fuels by Bomb Calimeter (High-Precision Method).
D 4057 - Manual Sampling of Petroleum and Petroleum Products.
D 4172 - Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method).

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

NATIONAL MOTOR FREIGHT TRAFFIC ASSOCIATION (NMFTA)

National Motor Freight Classification

(Application for copies should be addressed to the American Trucking Association, ATTN: Traffic Order Section, 2200 Mill Road, Alexandria, VA 22314.)

UNIFORM CLASSIFICATION COMMITTEE (UCC)

Uniform Freight Classification

(Application for copies should be addressed to the Uniform Classification Committee, ATTN: Tariff Publishing Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, (except for related associated detail specifications, specification sheets or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. Unless otherwise specified (see 6.2), a sample shall be subjected to first article inspection (see 6.3) in accordance with 4.4.

3.2 Material. The hydraulic fluids shall consist of a base stock consisting of a mixture of chlorotrifluoroethylene (CTFE) oligomers formulated with additive materials to improve the lubricity and antirust characteristics. Recycled CTFE shall not be excluded from use. Additive materials that improve the low temperature flow and viscosity-temperature characteristics (pour point depressants and viscosity index improvers) shall not be permitted.

3.2.1 Base stock requirement. The properties of the basestock used in formulating the finished hydraulic fluid, before the addition of any additive materials, shall be in accordance with table I when tested as specified in appendix, 30.1 and 30.2.

TABLE I. Properties of chlorotrifluoroethylene base stock.

Characteristic	Requirement
Unsaturation, minutes, minimum	60
Capillary gas chromatography, percent elution before trimer, maximum	11

3.3. Toxicity. The materials shall have no adverse effect on the health of personnel when used for its intended purpose. Questions pertaining to the toxic effects shall be referred by the procuring activity to the appropriate departmental medical service who will act as an advisor to the procuring activity.

3.3.1 Material Safety Data Sheets. Material Safety Data Sheets (MSDS) for each component ingredient of the finished product and the finished product shall be prepared in accordance with FED-STD-313 (see 6.6).

3.4 Properties. The properties of the finished hydraulic fluid described herein shall be as specified in tables II and III and in 3.4.1 through 3.4.9 when tested as specified in 4.6.2.

TABLE II. Properties of the finished fluid.

Characteristic	Requirement
Viscosity in centistokes	
at -54 °C, maximum	1200
at 38 °C, minimum	2.9
at 135 °C, minimum	0.60
Total acid number, maximum	0.6
Lubricity, four ball wear scar, millimeters, maximum	0.8
Vapor pressure at 121 °C, kPa, maximum	13.3
Pour point, °C, maximum	-60
Corrosion of copper, maximum	3a
Heat of combustion, Kcal/kg, maximum	2750
Hot manifold ignition, °C, minimum	925
Low temperature stability	pass
Water, ppm, maximum	200
Storage stability	pass

TABLE III. Solid contaminant particles.

Particle Size Range (Largest) Dimension, Micrometers	Allowable Number (maximum) Each Determination Automatic Count
5-15	10,000
16-25	1,000
26-50	150
51-100	20
Over 100	5

3.4.1 Corrosiveness and oxidation stability.

3.4.1.1 Corrosiveness. When tested as specified in FED-STD-791, method 5308, the change in weight of steel, aluminum alloy, magnesium alloy and cadmium subjected to the action of the hydraulic fluid shall be not greater than ±0.2 milligrams per square centimeter of surface. The change in weight of copper under the same conditions shall be not greater than ±0.6 milligrams per square centimeter of surface. There shall be no pitting, etching, nor visible corrosion on the surface of the metals when viewed under magnification of 20 diameters. Any corrosion produced on one surface of the copper shall be not greater than No. 3a of ASTM D 130. A slight discoloration of the cadmium shall be permitted.

3.4.1.2 Resistance to oxidation. When tested as specified in FED-STD-791, method 5308, the fluid shall not have changed more than 5 percent from the original viscosity in centistokes at 40 °C after the oxidation corrosion test. The total acid number shall not have increased by more than 0.20 from the acid number of the original sample. There shall be no evidence of separation of insoluble materials nor gumming of the fluid.

3.4.2 Swelling of synthetic rubber. When tested as specified in FED-STD-791, method 3603, the volume increase of the fluorocarbon elastomer, Viton GLT (as referenced in MIL-R-83485, type II) by the fluid shall be within the range 25 to 40 percent.

3.4.3 Solid particle contamination. When samples taken for particle count are tested in accordance with 4.6.3, in a clean, dust free atmosphere, the number of solid contaminant particles per 100 mL of the fluid shall not exceed the number specified in table III (see 6.8).

3.4.4 Foaming characteristics. When tested at 25 °C, as specified in ASTM D 892, the foaming tendency and foam stability shall be determined. The foam volume at the end of a 5 minute blowing period shall not exceed 65 mL. The foam shall have completely collapsed at the end of a 10 minute settling period. (A ring of small bubbles around the edge of the graduate shall be considered complete collapse.)

3.4.5 Compatibility. The hydraulic fluid shall be compatible in all concentrations with each of the fluids approved under this specification when tested as specified in 4.6.4. The hydraulic fluid shall be miscible with other approved fluids in all proportions from -54 to 135 °C, in that no formation of resinous gums, sludges or insoluble materials shall occur.

3.4.6 Thermal stability. When tested as specified in appendix 30.3, the hydraulic fluid shall not have changed more than 5.0 percent from the original viscosity in centistokes at 40 °C and the total acid number shall not have increased by more than 0.20 over the original value of the fresh fluid. The change in weight of the steel balls shall be not greater than ±0.2 milligrams per square centimeter of surface. The change in weight of the naval bronze under the same conditions shall be not greater than ±0.5 milligrams per square centimeter of surface. There shall be no pitting, etching nor visible corrosion on the surface of the balls. The presence of black particles in the post test fluid shall also be considered a cause for failure. The test shall be invalid if the bomb weight loss exceeds 0.500 grams.

3.4.7 Corrosion protection. When tested as specified in appendix 30.4, the hydraulic fluid shall afford protection against corrosion of polished steel panels by showing no more visible corrosion and no greater weight change than the reference panels that were immersed in standard reference fluid A (see 6.4).

3.4.8 Bulk modulus. When tested as specified in appendix 30.5, the isothermal secant bulk modulus of the finished fluid at 27.6 MPa and 40 °C shall be not less than 1242 kPa (17,640 psi).

3.4.9 Pump endurance. When tested as specified in appendix 30.6, the pump and fluid shall meet the requirements of appendix 30.6.8.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.4).
b. Quality conformance inspection (see 4.5).
c. Inspection of packaging (see 4.7).

4.3 Toxicity. The contractor shall have the toxicological product formulations and associated information available for review by the contracting activity to evaluate the safety of the material for the proposed use through the submission of the Material Safety Data Sheet detailed in FED-STD-313 (see 3.3 and 6.6).

4.4 First article inspection. First article inspection shall consist of tests for all the requirements of this specification. Failure of any test shall be cause for rejection.

4.5 Quality conformance inspection. Quality conformance inspection shall consist of a sample for tests (see 4.5.3), samples for examination of filled containers (see 4.5.4), and the tests specified in table IV. Samples shall be labeled completely with information identifying the purpose of the sample, name of product, specification number, lot and batch number, date of sampling and contract number. Unless otherwise specified, sampling of the hydraulic fluid shall be in accordance with MIL-STD-105.

TABLE IV. Quality conformance tests.

	Paragraph	
Inspection	Requirement	Test Method
Total acid number	Table II	Table VI
Viscosity	Table II	Table VI
Low temperature stability	Table II	Table VI
Solid particle contamination	3.4.3	4.6.3
Foaming characteristics	3.4.4	Table VI
Water content	Table II	Table VI
Lubricity	Table II	Table VI
Saturation (base fluid only)	Table I	30.1

4.5.1 Bulk lot. A bulk lot (batch) is an indefinite quantity of a homogeneous mixture of material offered for acceptance in a single isolated container; or manufactured in a single plant run (not exceeding 24 hours) through the same processing equipment, with no change in ingredient material.

4.5.2 Packaged lot. A packaged lot is an indefinite number of unit containers of identical size and type, offered for acceptance, and filled with a homogeneous mixture of material from one isolated container; or filled with a homogeneous mixture of material manufactured in a single plant run (not exceeding 24 hours) through the same processing equipment, with no change in ingredient materials.

4.5.3 Sample for tests. Samples for tests shall be taken in accordance with ASTM D 4057. This sample shall be subjected to all the applicable quality conformance tests. If the sample for tests fails any of the quality conformance tests, the inspection lot shall be rejected. In addition, a random sample of base oil shall be selected for each lot of the finished fluid and shall be subjected to all the applicable quality conformance tests for base oil.

4.5.4 Sample for examination of filled containers. A random sample of filled unit containers and a sample of shipping containers fully prepared for delivery shall be selected from each lot of fluid in accordance with MIL-STD-105.

4.5.5 Sample for determination of solid particle count. Samples of filled and sealed containers shall be taken at such periodic intervals as to be representative of each day's operation. The number of samples taken each day shall be in accordance with MIL-STD-105, inspection level S-3. The sample size and number of determinations shall be as specified in table V. In the event of a solid particle contamination count failure, the referee method shall be the automatic particle counter method calibrated with latex spheres.

TABLE V. Sample for particle contamination.

Container	Sample Size (mL) 1/	Number of Determinations Per Sample
1 pint	100	1
1 quart	100	1
1 gallon	200	2
5 gallon	300	3
30 gallon	600	6

1/ Each determination shall be made on 100 mL portions of the sample. Should the particle count on any individual determination be considered excessive, two additional determinations on another sample from the same container may be used. The container shall be thoroughly shaken immediately prior to withdrawing each 100 mL portion for such additional determinations. The arithmetic average of the two closer particle counts shall be considered the particle count of the sample.

4.6 Method of inspection and test.

4.6.1 Inspection. Inspection shall be in accordance with FED-STD-791, method 9601 and 4.6.5 of this specification.

4.6.2 Tests. The hydraulic fluid properties shall be determined in accordance with the applicable methods specified in table VI, 4.6.3, 4.6.4, and appendix 30.1 through 30.6. Physical and chemical values specified in section 3 apply to the average of the determinations made on the samples for those values which fall within any stated repeatability or reproducibility limits of the applicable test method.

TABLE VI. Test methods for basestock and hydraulic fluid properties.

Characteristic	Test Method FED-STD-791	ASTM	Para.
Saturation of base fluid			30.1
Capillary gas chromatography			30.2
Viscosity		D 445	
Total acid number		D 664	
Lubricity		D 4172 1/	
Vapor pressure	3480		
Pour point		D 97	
Copper corrosion		D 130	
Heat of combustion		D 2382, D 240, or D 1405	
Hot manifold ignition	6053		
Low temperature stability, -54 °C	3458		
Water		D 1744	
Storage stability	3465		
Corrosiveness and oxidation stability	5308		
Swelling of synthetic rubber	3603		
Particle size			4.6.3
Foaming		D 892	
Compatibility			4.6.4
Thermal stability			30.3
Corrosion rate evaluation procedure			30.4
Bulk modulus			30.5
Hydraulic pump test			30.6

1/ Condition B.

4.6.3 Particle size. Particle size shall be measured by the use of automatic particle counters. Directions in the manual for the respective instrument shall be followed.

4.6.4 Compatibility. Samples of candidate hydraulic fluid in amounts of 20, 100, and 180 mL shall be mixed with samples from each of the fluids previously approved under this specification. Total volume of each mixture shall be 200 mL. Mixtures shall be prepared in 250 mL stoppered flasks. The flasks shall be thoroughly agitated and then stored in an oven at 135 °C for 2 hours. At the end of this time, any signs of sediment, turbidity or crystallization in any of the mixtures shall constitute failure of the test. The samples shall then be stored at -54 °C for a period of 2 hours. Slight turbidity, at this time, that later disappears will be permitted in the samples.

4.6.5 Examination of filled containers. Samples selected in accordance with 4.5.4 shall be examined for compliance with MIL-STD-290 with regard to fill, closure, sealing, leakage, packaging, packing and marking requirements. Any container having one or more defects or under the required fill shall be

rejected. If the number of defective or underfilled containers exceeds the acceptance number for the appropriate sampling plan of MIL-STD-105, the samples shall be rejected.

4.7 Inspection of packaging. The packing and marking shall be examined and tested for compliance with the quality assurance provisions of MIL-STD-290 and any other requirements specified in section 5, herein.

5. PACKAGING

5.1 Packaging and packing. The packing of the of the hydraulic fluid shall be in accordance with the level B or C (see 6.2) requirements of MIL-STD-290. Unless otherwise specified, the fluid shall be furnished in 1 pint (0.5 liter), 1 quart (0.95 liter), 1 gallon (3.8 liter), and 5 gallon (19.0 liter) containers conforming to MIL-B-26701, and made from blue (see 5.1.2) high density polyethylene (see 5.1.1). 30 gallon containers shall conform to MIL-D-43703 and shall be made from blue high density polyethylene. Just prior to filling, all containers shall be thoroughly cleaned, rinsed with clean, filtered fluid and examined to insure the absolute absence of dirt, fibers, lint, water or other foreign contaminants.

5.1.1 High density polyethlene containers. Containers shall be fabricated from high density polyethylene (HDPE) material conforming to L-P-390, type I, class H, grade 5.

5.1.2 Color of containers. High density polyethylene containers shall be blue, the color approximating Color number 25183 of FED-STD-595.

5.2 Marking. The marking shall be in accordance with MIL-STD-290. Manufacturers/suppliers of this product shall provide a hazard warning label in accordance with the Hazard Communication Standard, 29 CFR 1910.1200. The appropriate warning shall convey the specific physical and health hazards including target organ effects of the material. This label shall be affixed to each container.

6. NOTES

(This section contains information of a general or explanatory nature which is helpful, but is not mandatory.)

6.1 Intended use. The hydraulic fluid covered by this specification is intended for use in selected armored vehicles where requirements for vulnerability reduction and crew survivability are so specified, with use applications being in gun recoil mechanisms, turret control systems, braking and steering systems of tracked vehicles, and in other hydraulic systems using synthetic sealing materials. It should be noted that this fluid is not a "flush and fill" replacement for MIL-H-46170 (FRH) or MIL-H-6083 (OHT). The user must determine the applicability of nonflammable hydraulic fluid, particularly in the areas of lubricity requirements, seal compatibility, metallurgy, and system fluid flow requirements.

6.1.1 Storage conditions. Prior to use in the intended equipment, the product may be stored under conditions of covered or indoors storage in geographic areas ranging in temperature from -54 to +50 °C. Because of the

stringent particle contamination requirements of this fluid, special care must be taken to prevent deterioration of the container, which would make the fluid unusable.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.
b. Issue of DODISS to be cited in the solicitation (see 2.1.1 and 2.2).
c. Whether a first article sample is required (see 3.1 and 4.4).
d. Quantity and unit package size (see 5.1).
e. Level of packaging and packing with requirements in detail (see 5.1).
f. Method of sampling and inspection if other than specified (see 4.2).
g. Test report, if required by acquisition agency (see 6.3.1).

6.2.1 Purchase unit. The fluid covered by this specification should be purchased by volume, the unit being a U.S. gallon of 231 cubic inches at 15.6 °C.

6.3 First article inspection. When first article inspection is required, the contracting officer should provide specific guidance to offerors concerning the requirements for testing of the preproduction sample of the offered product. Testing should be performed in the contractor's plant, in a Government laboratory, or in a Government approved laboratory. When testing is performed by the contractor or by an independent laboratory, written certification, signed by a responsible officer of the supplier involved, should be furnished stating that the preproduction samples have met all of the requirements of this specification. In addition, a laboratory report should be furnished listing all of the tests performed and the data obtained.

6.3.1 First article test results. Copies of the approved documentation (see 6.3) and a one-gallon sample of the offered product should be sent to the specification preparing activity (see 6.3.2).

6.3.2 Specification preparing activity. Information and instructions regarding first article inspection under this specification may be obtained from the Department of the Army, Belvoir Research, Development and Engineering Center, ATTN: STRBE-VFH, Ft. Belvoir, VA 22060-5606.

6.3.3 Waiver of first article inspection. First article inspection may be waived at the option of the procuring agency when both of the following conditions have been met:

a. The preproduction sample of the product has passed all of the preproduction inspection requirements within the previous four years.
b. The supplier certifies in writing that the composition of the formulated hydraulic fluid is the same as that of the product which previously met all of the preproduction inspection requirements.

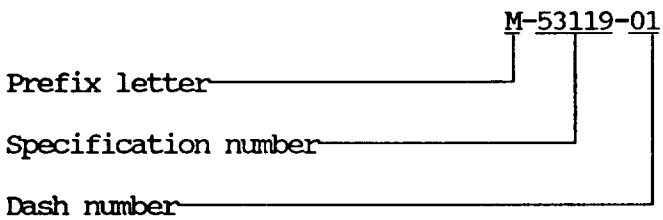
Neither the approval of the preproduction sample nor the waiving of preproduction inspection requirements will relieve the supplier of the obligation to fulfill all other requirements of this specification.

6.4 Standard samples. Samples of the standard fluids (saturation standard, trimer fluid, standard formulated fluid, standard basestock) used may be obtained from the Department of the Army, Belvoir Research, Development and Engineering Center, ATTN: STRBE-VFH, Fort Belvoir, VA 22060-5606.

6.5 Substitutability data. Chlorotrifluoroethylene base hydraulic fluids are not compatible with any other military hydraulic fluids and should not be substituted for any other hydraulic fluids. Hydraulic systems for CTFE base hydraulic fluids are significantly different from hydraulic systems of other military hydraulic fluids. CTFE base hydraulic fluids cannot be used in hydraulic systems of other military hydraulic fluids and other military hydraulic fluids cannot be used in CTFE base fluid hydraulic systems.

6.6 Material Safety Data Sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.7 Part or identifying number (PIN). Chlorotrifluoroethylene base hydraulic shall be identified by a PIN consisting of an "M" prefix and basic specification number followed by a two-digit number taken from table VII indicating the national stock number (NSN) and corresponding container size as shown in the following example:



(PIN numbers will not be in effect as National stock numbers have not been established at the date of this specification.)

TABLE VII. National stock numbers, sizes, dash numbers.

Size/unit of issue	NSN	Dash number
1 pint can (Pt)	9150-	01
1 quart can (Qt)	9150-	02
1 gallon can (Gal)	9150-	03
5 gallon drum (Dr)	9150-	04
30 gallon drum (Dr)	9150-	05

6.8 International interest. Certain provisions of this specification (see 3.4.3 and 4.6.3) are the subject of international standardization agreement (STANAG 3713 - Determination of Particulate Matter in Aerospace Hydraulic Fluids using a Particulate Size Analyzer). When amendment, revision, or cancellation of this document is proposed that will modify the international agreement concerned, the preparing activity will take appropriate action through

international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.9 Disposability. Identification and scrupulous segregation of the CTFE hydraulic fluid from other materials at the point of generation is critical for proper disposal. Recycling is the preferred method of disposal, pending establishment of a recycling program by the fluid manufacturer or a third party. Otherwise, the used and unusable fluid must be disposed of by a professional hazardous waste disposal firm or other acceptable disposal alternative. Incineration of the CTFE hydraulic fluid in a non-RCRA incinerator or disposal in a non-RCRA landfill is not permitted.

6.10 Subject term (key word) listing.

Chlorofluorocarbons
Chlorotrifluoroethylene
CTFE
Fluid, hydraulic
Hydraulic fluid
Nonflammable hydraulic fluid
NFH

Custodian:
Army - ME

Preparing activity:
Army - ME

Review activities:
Army - MD, SM
DLA - GS

Project 9150-A810

User activities:
Army - AR, AT, CD, MI, TM

TEST METHODS FOR EVALUATING A NONFLAMMABLE, CHLOROTRIFLUOROETHYLENE BASE HYDRAULIC FLUID

10. SCOPE

10.1 This appendix covers in detail certain laboratory test methods required to evaluate nonflammable hydraulic fluid. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS.

20.1 Non-Government documents. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

SOCIETY OF AUTOMOTIVE ENGINEERS, INC (SAE)

J403 - Chemical Compositions of SAE Carbon Steels.
J405 - Chemical Compositions of SAE Wrought Stainless Steels.

(Application for copies should be addressed to the Society of Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.)

30. REQUIREMENTS

30.1 Saturation determination method for CTFE (to test for oxidizable materials).

30.1.1 Apparatus.

a. Spectrophotometer (UV quartz cuvettes path length 10 mm) settings:

Slit: 1.0 nm
Absorbance scale for acetone (blank): 0-2.0
Absorbance scale for samples and standard: 0-1.0
Scan rate: 50 nm/min
Wavelength scanned: 650 nm to 425 nm
Recorder settings:
5 cm/min
full scale 100 mv

b. Constant temperature bath set at 25 °C ±1 °C.

c. Balance capable of weighing ±0.0001g.

30.1.2 Materials.

a. 10 mL pipet
b. Test tubes: 25 mm x 200 mm, pyrex
c. Hamilton micro syringe, type 710N
d. Small flask
e. Reagent grade acetone, certified ACS (spectroanalyzed)
f. Double distilled water
g. Potassium permanganate, crystals, reagent grade, ACS
h. Standard CTFE saturation test fluid (see 6.4)

30.1.3 Procedure.

a. Turn on spectrophotometer and bath to warm up.
b. Clean test tubes with distilled water and reagent grade acetone. Dry in oven. Clean micro syringe with acetone. Dry under nitrogen.
c. Prepare a 1 percent solution of potassium permanganate with the double distilled water. Cover with paraffin film or stopper.
d. In clean test tubes add 1.0 ±0.05 grams of standard test fluid to two test tubes and 1.0 ±0.05 grams of sample to another two test tubes. Cover with aluminum foil.
e. Prepare a blank (10 mL of acetone in test tube).
f. Use micro syringe to add 0.06 mL of 1 percent potassium permanganate to blank, shake and swirl, record time, and quickly transfer test tube to bath set at 25 ±1 °C.
g. Approximately 15 minutes after blank is in bath, add 10 mL of acetone to standard, shake and swirl, then add 0.06 mL of 1 percent potassium permanganate solution, swirl, record time, and quickly place standard in bath.
h. After 60 minutes remove first sample (blank), observe color, quickly transfer into clean cuvette and place in spectrophotometer. Check settings of spectrophotometer. Start spectrophotometer and recorder (zero the recorder). Scan 650 nm to 425 nm, making sure blank run is set on absorbance scale (0 - 2.0). Measure and record absorbance at 528 nm. Stop at 425 nm, remove sample, clean cuvette and set up for next run. Set absorbance scale (0 - 1.0).
i. Remove the standard from water bath, observe color, quickly transfer to cuvette, and proceed as in step h. Record absorbance at 528 nm. The other samples will be tested in the same manner.
j. Compare the duplicate standard's absorbance. They should not show a difference of greater than 0.04 absorbance units. If they do, repeat the test using acetone distilled from a ptoassium permanganate solution.
k. If the absorbance of the sample under test is equal to or greater than the absorbance of the standard CTFE sample, the test fluid is considered satisfactory and passes. If the absorbance of the test sample of CTFE is lower than the standard, the test shall be considered a failure.

30.2 Capillary gas chromatography method for analysis of chlorotrifluoroethylene (CTFE) fluid.

30.2.1 Scope. This method covers the gas chromatographic analysis of a CTFE fluid.

30.2.2 Summary of method. A candidate CTFE fluid and a standard CTFE trimer fluid are analyzed by a gas chromatographic system. The concentration of the peaks is calculated by taking the percent of the total area contributed by each peak. The total percent of the candidate sample peaks eluting earlier than the standard trimer are reported.

30.2.3 Materials.

a. Hewlett Packard gas chromatograph, model 5710 or equivalent, adapted for use with capillary columns with a flame ionization detector or equivalent.
b. Fused silica capillary column, length 12 meters, diameter 0.22 mm, methyl silicone, carbowax 20M deactivated stationary phase or equivalent.
c. Chlorotrifluoroethylene trimer standard (see 6.4).
d. Syringe, 5 microliter capacity.
e. Linear recorder, 0 to 1 millivolt.
f. Sample vials.
g. Hewlett Packard autosampler model 7671A (optional).
h. Hewlett Packard 3354 lab automation system or equivalent system for peak integration and calculation.

30.2.4 Procedure. Execute a gas chromatographic run of the trimer standard and the CTFE base fluid by following the gas chromatographic conditions below.

Model: Hewlett Packard 5710A or equivalent adapted for capillary column use

Column:	
Length:	12m
Diameter:	0.22mm
Liquid phase:	methyl silicone, carbowax 20M deactivated-fused silica
Support:	none
Split ratio:	100 to 1
Auxiliary gas:	He, 40 mL/min
Carrier gas:	He
Carrier gas flow rate:	1 mL/min
Chart speed:	0.66 cm/min
Detector:	FID
Attenuation:	10 x 16
Temperature	
Injector:	250 °C
Detector:	250 °C
Column:	100-250 °C

Temperature program rates:	8 °C/min	
	Initial hold:	8 min
	Final hold:	8 min

30.2.5 Calculations of the CTFE base fluid areas.

a. Add up all the peak areas.
b. Express each peak area as a percent of the total.
c. State that the area percent is the same as the true composition.

$$C_i = \frac{A_i}{n} \times 100$$

C_i = concentration of component i
A_i = area of component i in units of microvolt-seconds
n = total area for entire run, microvolt-seconds

The assumptions used in this calculation are:

The detector responds quantitatively in the same way to all sample components; that is, all response factors are the same.

All components are eluted from the column.

All components are detected and therefore are represented as peaks.

The Hewlett Packard 3354 Lab Automation System carries out this integration.

30.2.5 Results. New CTFE samples with less than 11 percent of the total concentration eluting before the trimer standard as measured (retention time [RT] 2.35 minutes for the above described system) are regarded as acceptable CTFE fluids. Figures 1 and 2 show representative chromatograms.

30.3 Thermal stability test.

30.3.1 Apparatus.

a. Test cell material and configuration is shown in figure 3.
b. The materials of the 1.27 cm diameter balls are M10 and 52100 steels and naval bronze.
c. Suitable heat source for appropriate temperature with ±1 °C control.

30.3.2 Pre-test procedure.

a. Clean balls and test cell (for duplicate analysis) with suitable solvent in an ultrasonic bath for five minutes.
b. Repeat step (a) two more times with fresh solvent.
c. Dry test cells in an oven at 100 °C for one hour.
d. Wipe balls dry with lint-free tissue.
e. Weigh balls to nearest 0.0001g and record. Repeat (d) and (e) until weight change is less than 0.0001g.

30.3.3 Test procedure.

a. Place balls in test cells with M-10 on bottom and 52100 on top.
b. Add 20 ±0.1 mL of test fluid in each test cell.
c. Bubble lamp grade nitrogen through fluid for 5 minutes and quickly cap test cells.
d. Weigh test cells and record to nearest 0.1g.
e. Place test cells in heat source for 72 hours at 135 °C. Entire 1.9 cm tube section of the test cells should be heated. The safety head must be out of the heated zone.

30.3.4 Post-test procedure.

a. Remove test cells from heat source and allow to cool.
b. Weigh test cells and record to nearest 0.1g.
c. Clean balls and weigh as in pre-test procedure.
d. Determine percent viscosity change at 40 °C and total acid number on fluid, per ASTM D 445 and ASTM D 664, respectively.

30.3.5 Results. Test cell weight loss should be less than 0.5g, or the test results are considered invalid.

30.4 Corrosion rate evaluation procedure (CREP) for CTFE hydraulic fluids.

30.4.1 Scope. The following corrosion rate evaluation procedure (CREP) is used to determine the relative corrosion protection afforded by corrosion inhibited, nonflammable, chlorotrifluoroethylene hydraulic fluids.

30.4.2 Summary of method. Precleaned, preweighed metal coupons are coated with the test oil formulation and with two standard reference fluids (corrosion inhibited nonflammable fluid and uninhibited basestock). The three test coupons are then suspended together in the 92 ±1 °C vapor phase of boiling distilled water for a 60 minute residence time. At the end of this exposure cycle the metal coupons are cleaned, dried, and reweighed to five decimal places to determine the metal weight change due to corrosive attack. The three coupons are visually compared. Duplicate samples are run simultaneously in identical apparatus.

30.4.3 Apparatus, materials and reagents. The following are used in this procedure.

a. Reaction kettle: PYREX, 2000 mL capacity, complete with cover having a finely ground flange for a tight seal. The cover has one standard taper 34/45 female joint in the center and three standard taper 24/40 female joints spaced 120 degrees apart with their centers 5.1 centimeters (cm) from the center of the cover.
b. Bushing type reducing adapter, standard taper 34/45 male outer joint, standard taper 24/40 female inner joint.
c. Allihn condenser, water cooled, 40.0 cm jacket length, with a standard taper 24/40 male joint to match the female joint of the standard taper 34/45 to 24/40 bushing type reducing adapter.
d. Ace-thread offset adapter, with a No. 7 ace-thread or equivalent, a threaded nylon bushing, and a buna-N O-ring.

e. Air injection tube, borosilicate glass, 85.0 cm in length, 0.6 cm outside diameter (OD) with one end flared from 0.6 cm to 1.2 cm OD over a distance of 3 cm at one end of the tube.
f. Glass stopper with glass loop. Hollow pennyhead stopper with glass loop fabricated from 0.3 cm OD glass rod; the distance from the base of the stopper to the base of the glass loop is 0.9 cm.
g. Perforated teflon splash suppressor, fabricated from 0.32 cm teflon sheet stock. Splash suppressor disk is 12.7 cm in diameter and perforated with 0.64 diameter holes in seven equally spaced rows, with the center row passing through the diameter.
h. Metal test coupons conforming to AISI-1010 (SAE J403). (Corrosion test coupons are fabricated from open-hearth, kilned, low carbon, No. 4 soft temper strip steel. The coupon dimensions are 5.08 x 1.27 x 0.16 cm (2.0 x 0.5 x 0.06 inch), with one hole 0.24 cm (0.09 inch) in diameter drilled 0.32 cm (0.12 inch) from one end of the test coupon and centered across the width. All surfaces and edges of the test coupons are polished to a 10 to 20 microinch finish so that faces are entirely free of pits, scratches or other imperfections. All surface grinding is in the direction parallel to the length of the coupon. The test coupons are then coated with a nonvolatile, water insoluble rust preventative and packaged in a moisture-proof package for shipment or storage. Coupons available from Metaspec, Box 27707, San Antonio, TX 78227.
i. Suspension wire, AMS 5680, stainless steel, 20 gage, cut and formed to the required geometrical configuration.
j. Boiling beads, PYREX, 0.3 cm diameter.
k. Hot plate, electric, Thermolyne model SP-13115 or equivalent.
l. Air flowmeter, Matheson mass flowmeters or rotometers or equivalent.
m. Metering valve for air flow control, Whitey model 22rS4 or equivalent.
n. Compressed dry air, size A cylinder, complete with two stage regulator.
o. Laboratory timer, model 171 Universal timer or equivalent.
p. Analytical balance, readability 0.1 mg.
q. Desiccator.
r. Wiping tissues.
s. 240 and 320 grit silicon carbide paper.
t. Distilled water.
u. Toluene, reagent grade.
v. Acetone, reagent grade.
w. Methanol, absolute, reagent grade.
x. Dow Corning High Vacuum grease, or equivalent.
y. Coupon draining chamber to provide dust free environment for oil draining cycle. A scaled-down version of the box described in ASTM D 1748, appendix A1.13 or equivalent.
z. Camera, Polaroid type.
aa. Die set for numbering coupons.
bb. Laboratory aluminum foil.
cc. Standard reference fluid A = Formulated CTFE (0,05 percent 3M L1478 and 0.5% barium dinonlynaphthalene sulfonate) (see 6.4).
dd. Standard reference fluid B = CTFE (A02) basestock (see 6.4).

30.4.4 Test specimen preparation.

a. Six metal coupons are required for each test.
b. Identify each coupon using die-cut 0.32 cm (0.12 inch) numbers positioned immediately below the suspension hole.
c. Clean the metal coupons by hand polishing with 240 and then 320 grit silicone carbide paper for one minute on each side.
d. Rinse the coupons with water, air dry, and store in a solution comprised of 50 parts toluene and 50 parts absolute methanol until final cleaning.
e. Final cleaning is accomplished by immersing each coupon in boiling toluene, flash drying, and immersing in boiling acetone and flash drying again.
f. Store the test coupons in a desiccator for 30 minutes to equilibrate to ambient temperature, then weigh to five decimal places prior to testing.
g. Maintain specimen cleanliness by handling with forceps.

30.4.5 Test apparatus assembly. Prepare two identical test set-ups so that duplicate test results may be obtained.

a. After carefully cleaning and drying all glassware, place the reaction kettle on the hot plate and add approximately ten boiling beads to the reaction kettle to preclude bumping and splashing of the boiling distilled water.
b. Place the teflon splash suppressor in the reaction kettle so that it is loosely seated against the base of the kettle.
c. Coat the ground glass flange of the reaction kettle with a thin film of silicone grease to prevent condensate leakage and center the cover on the reaction kettle.
d. Fit the center female joint with a standard taper 34/45 to 24/40 reducing type bushing adapter.
e. Insert the male joint of the Allihn condenser into this bushing adapter and insert the male joint of the threaded offset adapter into the female joint at the top of the condenser. Support the condenser as required.
f. Insert the glass air inlet tube through the center of the Allihn condenser and offset adapter and seal with an O-ring in the threaded bushing of the adapter. Position the air inlet tube so that the flared end is 5.1 cm (2.0 in) above the base of the kettle.
g. Place the glass stoppers with the glass hooks in the remaining three female joints of the cover.
h. Form the coupon suspension hooks, shaped from the AMS 5680 20-gage stainless steel wire, so that the bottom edge of the test coupon is 11 cm (4.3 inch) from the base of the kettle.
i. Prepare the regulated dry air source using the micrometer valve for flow control and the calibrated flow meter for air flow measurement.

30.4.6 Test procedure.

a. After assembling the test apparatus, remove the reaction kettle and cover from the hot plate, leaving the condenser and air flow assembly attached to the support stand.

b. Preheat the hot plates and allow to equilibrate at the highest setting.
c. Start the water flow through the condenser.
d. Add 100 mL of distilled water to the reaction kettle and re-assemble the apparatus on the equilibrated hot plate.
e. Establish an air flow rate of 500 standard cubic centimeters per minute (SCCM) to the reaction kettle before the water starts to boil. This high air flow keeps the temperature around the coupons at approximately 92 °C.
f. Allow the system to equilibrate for 60 minutes before the test specimens are introduced.
g. Maintain test temperature of the kettle by loosely wrapping the kettle and glassware below the condenser with aluminum foil to avoid cooling by drafts.
h. Immerse two of the previously prepared test coupons in the each of the three fluids (test fluid, standard reference fluid A, standard reference fluid B) for five minutes.
i. Remove the coupons and suspend in a vertical position in a dust free environment for 15 minutes.
j. Remove the excess oil at the bottom edge of the test coupons by light quick dabbing with a wiper.
k. Suspend the test coupons (one coated with each fluid in each reaction kettle) by the wire hooks from the glass stoppers and insert in the reaction kettle for 60 minutes.
l. Remove the test coupons from the reaction kettle at the end of the test and photograph before cleaning.
m. Numerically rate the appearance of the coupon of the tested fluid, comparing it to the coupons that were immersed in the standard reference fluids. The coupons corresponding to standard reference fluid A (with corrosion inhibitor) and standard reference fluid B (basestock) are rated 10 and 0, respectively. Visual ratings are based on a linear interpolation of the sample coupon compared to the two reference coupons.
n. Remove all loose material from the coupons by wiping with a paper tissue or laboratory wipe.
o. Immerse the coupons in boiling toluene for five minutes, and in boiling acetone for five minutes.
p. Flash dry the coupons and place in a desiccator to equilibrate to ambient temperature.
q. After 30 minutes, weigh the test coupons to five decimal places, and calculate the weight change.

30.4.7 Results. A weight change of greater than 20 mg is considered a failure. A visual rating of less than 8 is considered a failure.

30.5 Bulk modulus.

30.5.1 Apparatus. The bulk modulus of the hydraulic fluid shall be determined using a calibrated precision capillary pycnometer of the type shown in figure 4 (modified 21 T 50 Jersuson or equivalent). A suitable pressure vessel and auxiliary equipment for this determination are shown in figures 5 and 6.

30.5.2 Procedure. The pycnometer volume to capillary diameter ratio shall be chosen to provide a precision of measurement for liquid density of ±2 parts in 10,000. The pycnometer shall be charged with candidate fluid to the top of the capillary at 40 °C constant-temperature bath, allow equilibrium to be reached, and take volume reading at atmospheric pressure. (Since the precision of the unit depends on visual readings, care must be taken to avoid errors due to parallax and distortion in the pressure vessel window and the walls of the constant-temperature bath.) Increase nitrogen pressure to a new level, and after a 1-hour soak, take a third reading. For any pressure range, the secant bulk modulus is defined by the following equation:

$$\text{Bulk modulus} = \frac{-V\ (\text{delta } P)}{V - (\text{delta } V_g)}$$

Where:

V is the original volume of the fluid
delta V is the observed volume change due to P increase in pressure
delta P is the pressure change between the two measurements in kPa
delta V_g is the correction factor

The correction factor (delta V_g) considers the bulk modulus of glass in determining the true volume of the pycnometers at pressures above atmospheric. The bulk modulus of pyrex glass is 3.28×10^7 kPa (4.77×10^6 psig).

Therefore:

$$\text{delta } V_g = \frac{-V\ (\text{delta } P)}{3.28 \times 10^7}$$

30.6 Test for performance of hydraulic fluid in a high performance hydraulic pump.

30.6.1 Scope. This method is used for determining the performance of hydraulic fluid in a high performance aircraft hydraulic pump. Evaluation is based on the ability of the hydraulic pump to maintain performance throughout the cycle, composite wear of pump parts, measured by way of case drain flow, and the physical and chemical condition of the hydraulic fluid monitored throughout the test.

30.6.2 Method summary. The test involves the cyclic operation of a hydraulic pump in a closed loop test stand, for a total of 500 hours. Prior to the test, the pump is prepared as described herein.

30.6.3 Sample size. A minimum of 15 liters (4 gallons) of test fluid is required.

30.6.4 Test pump. "VICKERS" inline type, pressure compensated pump model PV3-075-15 is used for this evaluation.

30.6.5 Test apparatus.

30.6.5.1 Test stand. Figure 7 shows the schematic diagram of the test stand. The test stand consists of a drive motor, throttling valve, heat exchanger,

reservoir, filters, pressure relief valve, check valve, hand pump and instrumentation. The throttling valve serves as a flow control device. Working volume of the fluid in the test loop should be between 3 liters (0.8 gallon) and 3.8 liters (1.0 gallon). The reservoir is not in the test loop, but provides makeup fluid only when fluid samples are taken or leakage occurs. All lines, fittings and other metallic components shall be made of stainless steel (such as AISI 316 [SAE J405]) or materials compatible with chlorotrifluoroethylene (CTFE) base hydraulic fluids. Table VIII shows the description of components successfully used by the U.S. Air Force for CTFE pump tests. Information in table VIII is provided for reference only.

TABLE VIII. Components used on WRDC/MLBT pump test stands.

No.	Description	Manufacturer	Part Number
1.	Pressure transducer	Sensotec	Model A & Model Z
2.	Hand hydraulic pump	Teledyne Republic	3-1158-18 & 914-8028
3.	Valves	Hoke	2200 Series
4.	Pressure relief valve	Nupro	SS-4R3A5
5.	Check valve	Nupro	SS-CHS8-1
6.	Flow meter	Flow Technology (FTI)	FT-12AX20-LB
7.	Flow filter	Aircraft Porous Media, PALL	AD-3258-12HM5, M8815/1-12
8.	Filter element	Aircraft Porous Media, PALL	AC7031F1297Y3 (5 microns)
9.	Pressure gauge	McDaniel Controls, Inc.	Code F, P SS 0-1000 psi
10.	Throttling valve	McGraw Edison Company	Model 5061
11.	Throttling valve	General Controls Company	7605MDSRJ

30.6.5.2 Instrumentation.

30.6.5.2.1 Temperature measurements. Provisions shall be made for thermocouple installation as listed below. Total system accuracy shall be calibrated to ±1 °C to measure test fluid temperature. Thermocouples shall be shielded and unless specified, shall be immersed to the midstream and located as close to the components as practical.

Variable	Location
Pump inlet temperature	In pump inlet line
Pump outlet temperature	In pump outlet line
Throttling valve (T/V) outlet temperature.	In T/V outlet line
Case drain temperature	In case drain line

30.6.5.2.2 Flow measurements. Provisions shall be made for fluid volume flow measurements with a resolution of ±0.4 lpm (±0.1 gpm). Fluid flow in the pump outlet and case drain line shall be measured.

30.6.5.2.3 Pressure measurements. Provisions shall be made for fluid pressure measurements with a resolution of ±6.9 kPa (±1 psi). Pressure sensors shall be installed to monitor the following:

a. Pump inlet pressure.
b. Pump outlet pressure.
c. Case drain pressure.
d. Main filter pressure drop.
e. Case drain filter pressure drop.

30.6.5.2.4 Pump speed. Provision shall be made for pump shaft speed measurement with a resolution of ±10 rpm.

30.6.5.2.5 Torque measurements. Provision shall be made to measure torque on the pump shaft, with a resolution of ±0.6 N-m (±5 in-lb).

30.6.6 Materials.

30.6.6.1 CAUTION. SOME MATERIALS ARE TOXIC AND HAZARDOUS. The chemical material listed in this section must be handled carefully. Method 10000T, Material Handling Safety Precautions, is a reference which lists all toxic and hazardous materials cited in FED-STD-791. The synonyms, life hazard, flammability, handling and storage precautions, emergency treatment and measures, and spill practices of each chemical are explained.

30.6.6.2 Cleaning solvent. Heptane may be used for cleaning parts as described herein. Chlorinated solvents must not be used for cleaning.

30.6.7 Procedure.

30.6.7.1 Preparation for test.

30.6.7.1.1 Pump preparation. A new pump shall be used for every test. Preservative fluid from the pump casing shall be drained. Pump shall be completely disassembled, cleaned thoroughly with heptane, blow dried with nitrogen and placed in an oven at 66 °C for 30 minutes. All elastomeric seals shall be replaced with "VITON" seals. Pump shall be assembled and the casing filled with the test fluid. During disassembly and reassembly, care must be taken to install the pistons in their original cylinder bores.

30.6.7.1.2 Test stand preparation. Test stand shall be completely disassembled and thoroughly cleaned by spraying heptane on all the parts. All fittings, lines and other components shall be cleaned to remove any residual metal and fluids from previous tests. If necessary, a piece of clean cloth (cheese cloth or similar) shall be run through the tubings for cleaning. Parts may be blow dried with nitrogen and placed in an oven at 66 °C for 30 minutes to remove any solvent left on the parts. All elastomeric seals shall be replaced with new "VITON" Seals. Test pump, as prepared in 30.6.7.1.1 shall be mounted on the drive motor/torque sensor assembly. Splines on the pump shaft shall be adequately lubricated with a fretting-corrosion resistant grease. Test stand shall be filled with 9-11 liters (2.5-3 gallons) of the test fluid. Any air in the system shall be removed to avoid cavitation damage to the components. Air bleeding procedure may vary from one test stand to another. A typical bleeding procedure used by the U.S. Air Force in its pump tests is listed in 30.6.7.1.3.

30.6.7.1.3 Bleeding procedure.

a. Using the hand pump, the hydraulic test fluid is slowly pumped into the reservoir. At this time, the valve in the line connecting the reservoir to the test loop is left closed (see figure 7).
b. After the correct amount of test fluid is pumped into the system, the hand valve is opened to allow the fluid to get into the test loop.
c. Approximately 5 psig of nitrogen pressure is then applied to the system.
d. Next, after applying the pressure, two or three fittings are chosen to be bleed ports. Fittings higher in elevation relative to the rest of the system are usually chosen since trapped air tends to seek the highest points in the system. These fittings are loosened until the trapped air ceases to escape and the fluid begins seeping around the fitting.
e. At this time, pump/motor shaft is turned manually to circulate the fluid in the test loop and to migrate the air to the bleed ports. Because air bubbles are slow rising, the system is left untouched for 15-20 minutes. The system is bled at this time allowing for the trapped air at the bleed ports to be released.
f. Step (e) is repeated 3-4 times.
g. System pressure is increased to 15 psig and step (e) is repeated 3-4 times.
h. Pressure is increased to 50-55 psig and step (e) is repeated 3-4 times.
i. The pump shaft is rotated at about 500 rpm for 5-10 seconds. Bleeding is done after 20-30 minutes. This procedure is repeated 3-4 times.
j. Step (i) is repeated except the motor speed is increased to 5000 rpm and maintained for 10-15 seconds.
k. The pump/motor shaft is rotated at 5000 rpm for 2-3 throttling valve cycles (2-3 minutes). The system is bled after 20-30 minutes. This step is repeated 3-4 times.
l. The pressure is dropped to 5 psig. System is bled after 20-25 minutes.
m. System pressure is increased back to 50-55 psig and the pump/motor shaft is rotated at 5000 rpm. The system is monitored for sound. If there is still trapped air in the system, a peculiar rough noise is heard. This noise is similar to cavitation noise. If air is still present, steps k,l,m must be repeated until the system is running smoothly and no air escapes the bleed ports.

NOTE: The bleeding procedure may take a lengthy 2 days or a brief 8 hours to obtain satisfactory results.

30.6.7.2 Test run.

20.6.7.2.1 Test duration. Duration of the test will be 500 hours.

30.6.7.2.2 Test cycle. Pump will be run at maximum flow rate for 60 seconds and then at minimum flow rate for 60 seconds. This alternate cycling shall be maintained throughout the test duration. Hereafter, the maximum flow cycle is referred to as TVO (throttling valve open) and the minimum flow rate cycle is referred to as TVC (throttling valve closed).

30.6.7.2.3 Test parameters. The following parameters shall be maintained during the test.

Test Parameter	Maximum	Minimum
Pump speed (rpm)	5100	5000
Main flow rate (TVO) lpm(gpm)	49 (13)	44 (11.5)
Main flow rate (TVC) lpm(gpm)	15 (4)	11 (3)
Pump inlet pressure kPag(psig)	481 (70)	345 (50)
Pump outlet pressure kPag(psig)	21030 (3050)	19651 (2850)
Bypass fluid temperature C	124	116
Fluid temperature at any location, °C	124	

30.6.7.2.4 Fluid Samples. A 40 to 60 mL fluid sample shall be taken from the test stand at the following intervals.

Sample No.	Test Hours
1	4 - 6
2	20 - 30
3	45 - 50
4	90 - 110
5	140 - 160
6	190 - 210
7	240 - 260
8	290 - 310
9	340 - 360
10	390 - 410
11	440 - 460
12	490 - 500

30.6.7.2.5 Data recording. Test parameters shall be recorded every 15 - 25 hour interval. Typical data sheets are shown in figure 8.

30.6.7.2.6 Mechanical problems. Problems experienced in the test stand during the testing may be corrected. No modifications to the pump may be made during a test.

30.6.8 Evaluation criteria.

30.6.8.1 Failure criteria. The fluid shall be considered to have failed the test if any of the following occurs.

a. Pump fails catastrophically.
b. Pump fails to maintain pressure and flow.
c. Case drain (pump bypass) flow increases to twice its value at the start of test.
d. Fluid temperature rise in the pump is more than 11 °C.
e. A fluid sample fails the criteria listed in table IX.

TABLE IX. Fluid sample failure criteria.

Determination	Limit
Fluid appearance	Cloudy when sampled (failure)
Kinematic viscostiy change, % cSt at 40 °C	10 max
Total acid number mg KOH/g	1.0 max
Capillary gas chromatography, % new peaks	2 max
Water, ppm	250 max
Metal analysis	Report

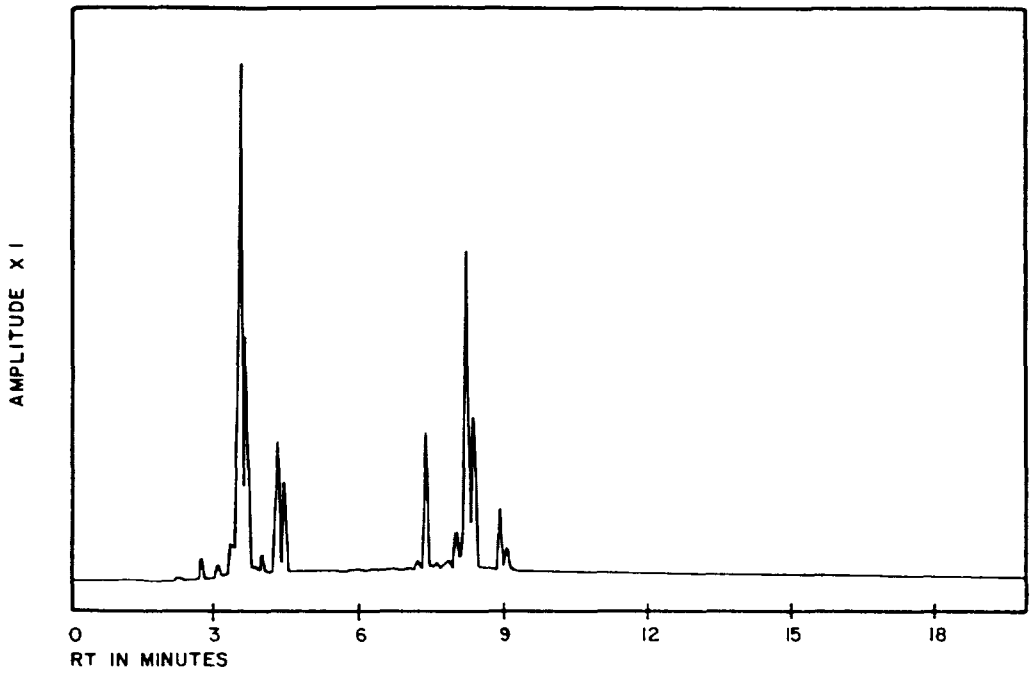


FIGURE 1. Capillary GC of CTFE base fluid.

X-4931

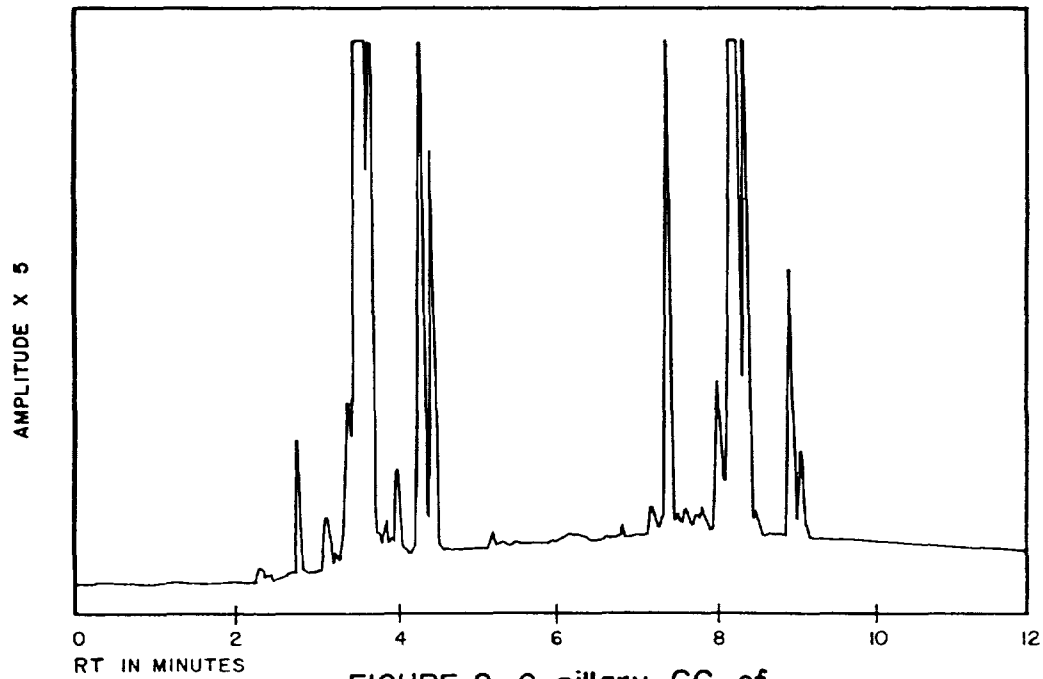


FIGURE 2 Capillary GC of CTFE base fluid

X-4932

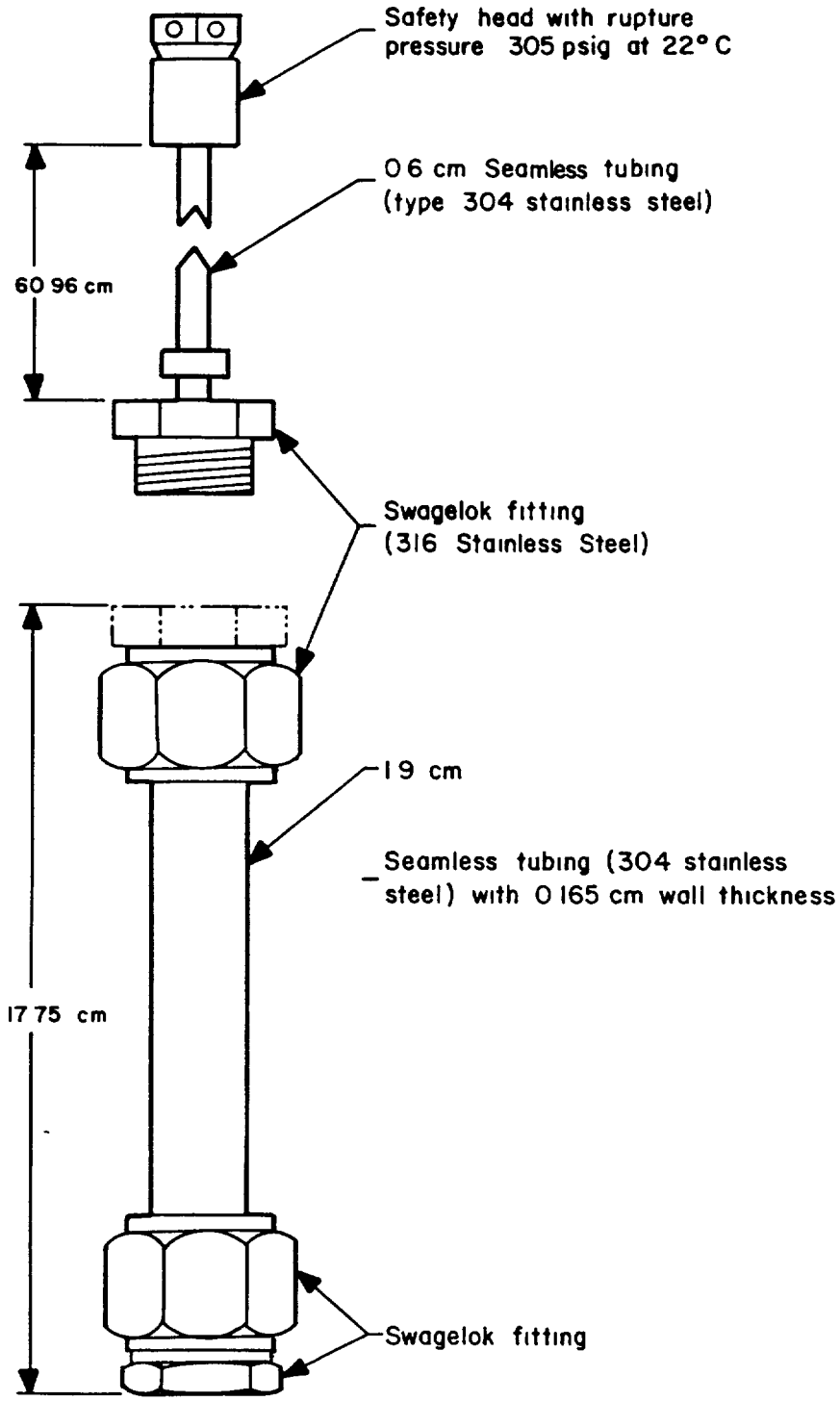


FIGURE 3. Thermal stability test cell. X-4933

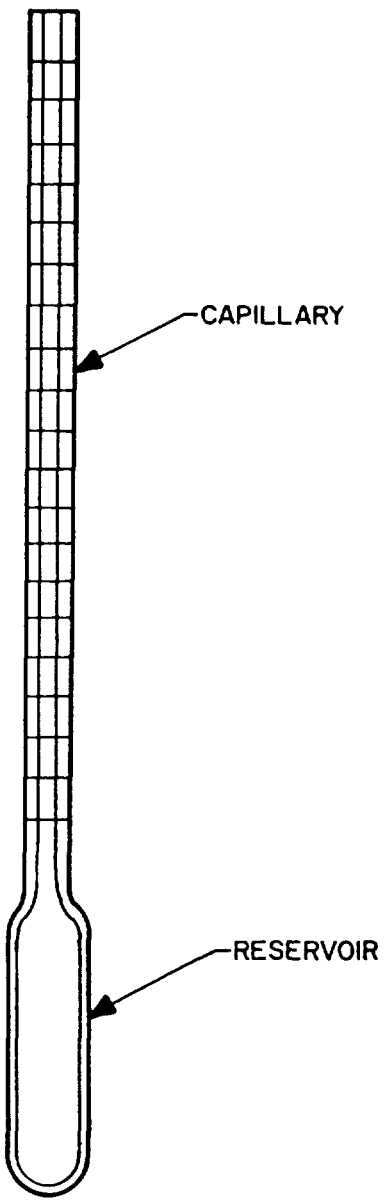


FIGURE 4. Precision capillary pycnometer.

X-4934

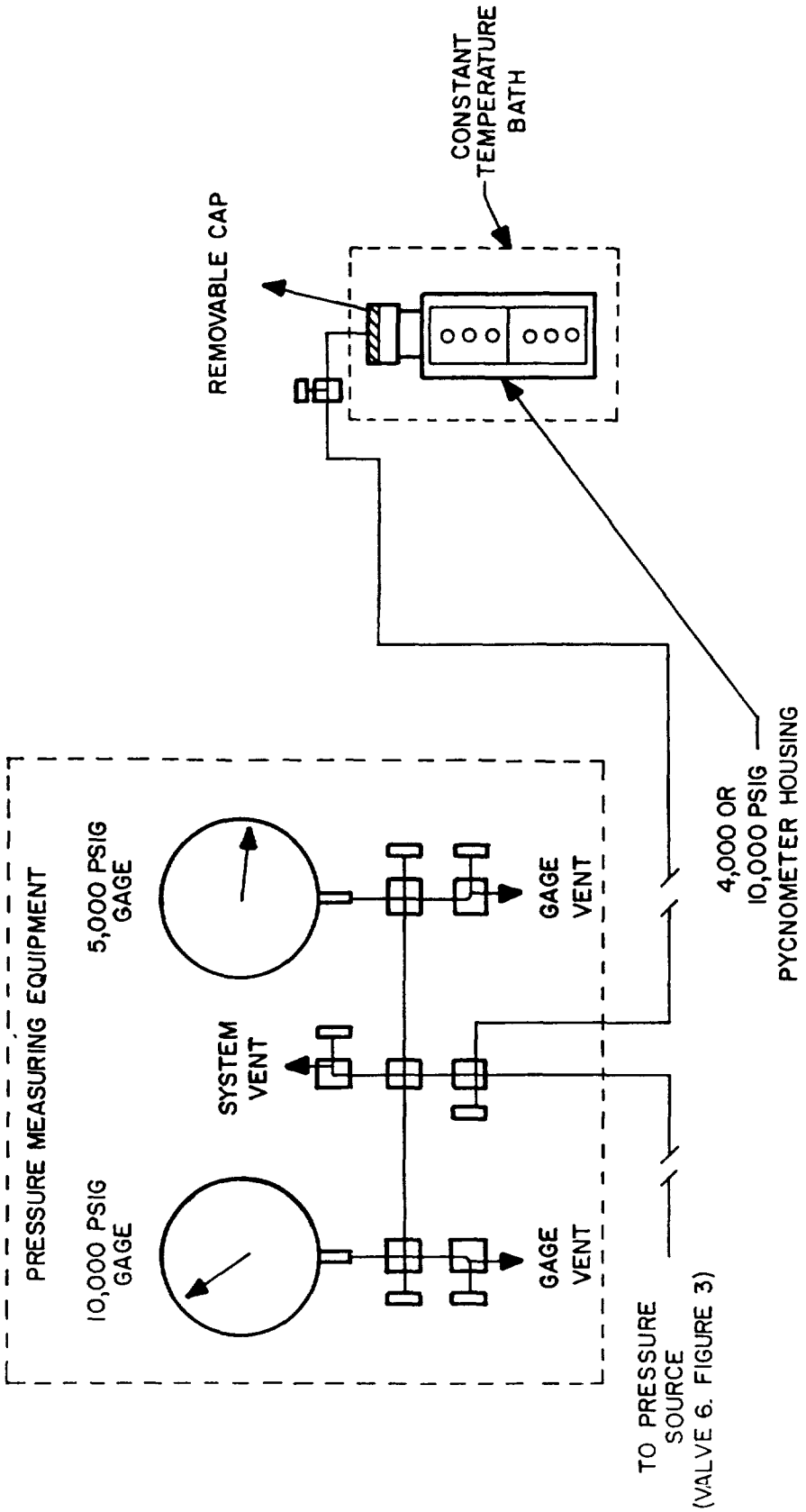


FIGURE 5. Diagram of bulk modulus equipment.

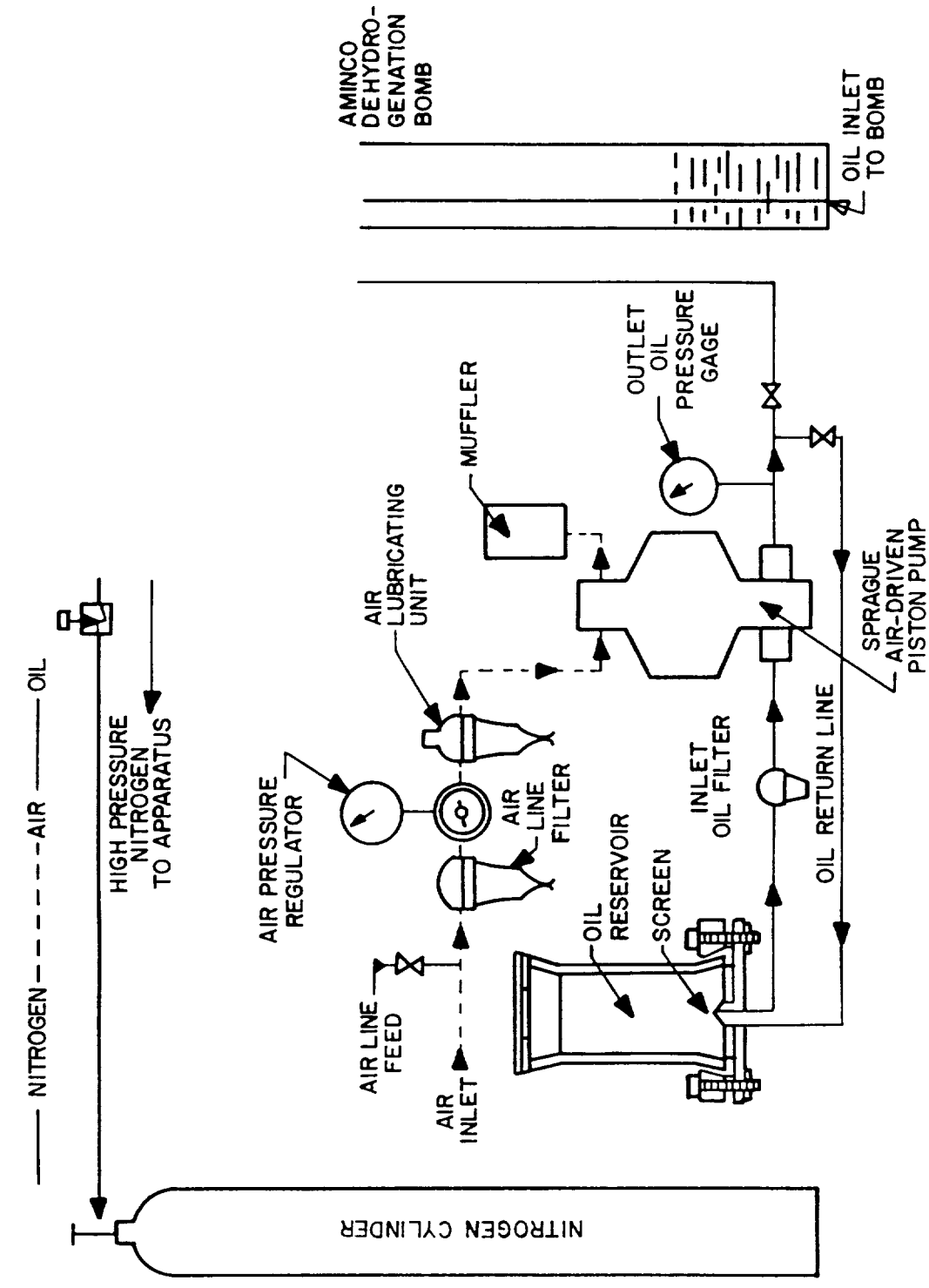


FIGURE 6 Auxillary equipment.

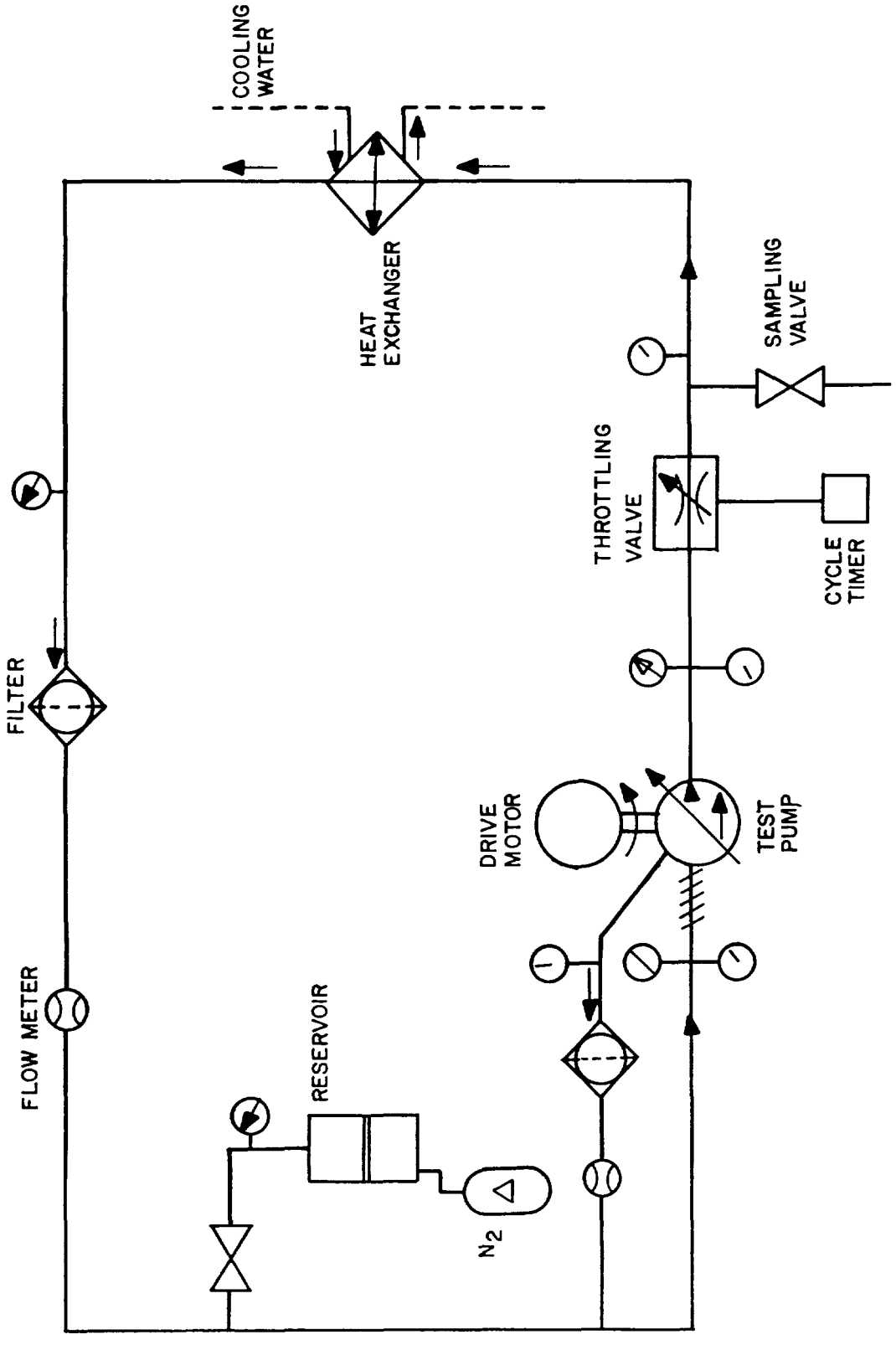


FIGURE 7. Schematic of Aircraft Hydraulic Pump Test Stand.

Sample Number	Test Hours	Fluid Appearance	% Kinematic (a) Viscosity Change @ 40C	TAN (b) Capilary Gas (a) Change Chromatography mg KOH/g New Peaks, %	Water ppm (c)	Metal Analysis	Infrared (d) Spectro-Photometry
Baseline from fluid container	-	Clear, amber	-	-			
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

a. Provides an indication of inadvertent system contamination.
b Must be performed soon after the sample is taken; no later than twelve hours.
c Provides an indication of stand heat exchanger leaks.
d Optional; recommended for system and/or fluid diagnostics.

FIGURE 8. Pump test fluid sample data sheet (sample).

X-4966

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-H-53119(ME)	910301

3. DOCUMENT TITLE
Hydraulic Fluid, Nonflammable, Chlorotrifluoroethylene Base

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)
	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code) (1) Commercial	(2) AUTOVON
	(703) 664-5717	354-5717
c. ADDRESS (Include Zip Code) US Army Belvoir RDE Center ATTN: STRBE-TSE Ft. Belvoir, VA 22060-5606	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT Defense Quality and Standardization Office 5203 Leesburg Pike Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	