(NAVY) NAVAIR 17-15-50.2
(ARMY) TM 38-301-2
(AIR FORCE) T.O. 33-1-37-2
(COAST GUARD) CGTO 33-1-37-2

JOINT OIL ANALYSIS PROGRAM MANUAL

VOLUME II

SPECTROMETRIC AND PHYSICAL TEST LABORATORY OPERATING REQUIREMENTS AND PROCEDURES

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SECTION I

INTRODUCTION

1-1. Purpose. The purpose of Volume II is to standardize Joint Oil Analysis Program (JOAP) operating procedures and provide standardization guidance for JOAP laboratories.

1-2. Applicability. The provisions of this manual apply to all activities of the Departments of the Army, Navy, and the Air Force participating in the JOAP and to laboratories operating under contract or mutual assistance agreements.

1-3. Manual Change Procedures. Detailed procedures for manual changes are contained in Volume I.

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SECTION II

SPECTROMETRIC LABORATORY OPERATING REQUIREMENTS

2-1. Introduction. This section contains information and instructions regarding space and staffing requirements, and equipment and consumable supplies that are recommended for operation of a JOAP laboratory performing spectrometric analysis. Additional information for laboratories performing physical property testing is contained in Section IV.

2-2. Facilities. Laboratory square footage space requirements have been omitted for fixed land based laboratories since operational requirements, work loading, service directive specifications, and facility availability vary so widely between service activities. Activities experiencing problems with space requirements should refer inquiries to the appropriate service oil analysis program manager.

a. Shipboard Laboratories. The optimum shipboard laboratory should have 200 square feet of working area to allow for semi-permanent spectrometer shock mounting with adequate bulkhead clearance to allow access to equipment for required maintenance and servicing and to provide adequate space for administrative/records filing and storage of supplies and spare parts. The area must be free of explosive/corrosive fumes, provided with positive ventilation and exhaust, and should be environmentally controlled with respect to both temperature and humidity.

b. Mobile Laboratory. A mobile laboratory should have at least 200 square feet of floor space, be completely self contained (equipment, supplies and work space) and capable of deployment. The spectrometer should be shock mounted and the facility should be capable of air transport without any disassembly. All environmental control features should be built-in, with only external grounding and power plug-in required for immediate operational capability.

2-3. Staffing Requirements. See Section IV for physical testing manpower requirements.

a. The number of personnel required for a laboratory will vary depending on the assigned workload, the utilization of civilian or military personnel, the utilization of manual or automated data recording and the type and location of the laboratory. These requirements are to be used as guidelines only and are calculated based solely on spectrometric analysis. Additional staffing may be necessary for physical testing manpower requirements. In general, the number of personnel required for spectrometric analysis may be computed as follows:

(1) Automatic Recording, $P = W/1100$

(2) Manual Recording, $P = W/865$

P = number of personnel required
W = estimated workload in samples per month

b. A certified evaluator must be present during all hours of laboratory operations. All Army laboratories must employ two certified evaluators full-time. Army requirements for certification of laboratory evaluators are in Appendix N.

2-4. JOAP Training.

a. Training Courses Available

(1) Defense Joint Oil Analysis Program Training Courses available:

Title	Course No.
Atomic Emission Spectrometer	J3AZP2A752-000
Physical Properties Testing	J3AZP2A752-003
Ferrography Testing	J3AZP2A752-004

NOTE

The Air Force Non Destructive Inspection (NDI) course, J3ABP2A732-000 (or equivalent), includes evaluator training and operation/maintenance of the Model M spectrometer equivalent to training provided in course J3AZP2A752-000.

(2) A model M spectrometer maintenance training course is available from Spectro, Inc.

NOTE

It is highly recommended that personnel scheduled for spectrometer maintenance training posses an electronics background.

b. Training Requests

(1) Army/Air Force - submit training requirement(s) in accordance with established service procedures.

(2) US Navy/US Marine personnel: Ms. Sheila Nelson
Naval Station Norfolk
Naval Personnel Development Command
DSN 564-2996 ext 3223
COMM 757-444-2996 ext 3223

US Coast Guard: AETCM Dukes
Training Quota Management Center
Chesapeake Va
COMM 757-366-6582

2-5. JOAP Laboratory Instruments. The following atomic emission rotrode instruments are approved for use in the JOAP and are eligible for JOAP certification when enrolled and operated by DOD laboratory personnel.

a. Baird A/E35U-3. This fluid analysis spectrometer has been the standard instrument for the JOAP. The dash 3" is configured for the detection of up to 20 elements. It should be operated in a temperature and humidity controlled laboratory environment. This instrument is no longer being manufactured/procured and is being replaced by newer JOAP approved instrumentation.

b. Baird A/E35U-3A. Also known as the "FAS-2C", this spectrometer is an updated version of the A/E35U-3. It has essentially the same characteristics as the "dash 3". This instrument is no longer being manufactured/procured and is being replaced by newer JOAP approved instrumentation

c. Baird MOA. This Multielement Oil Analyzer is a bench top portable spectrometer designed for both mobility and laboratory use. It has many of the same features and internal parts as the A/E35U-3 and -3A spectrometers. this spectrometer can be used in harsher environments. If standardization must be repeated periodically while deployed under adverse conditions, standardization is made simple through computer assistance. The spectrometer is configured for the fifteen JOAP elements.

NOTE

The MOA II is not an approved JOAP instrument.

d. Spectroil Plus. Spectro, Inc. modified the Spectroil Jr. spectrometers to what we now refer to as the "Jr. plus" or "Plus". The Plus is also a bench top spectrometer designed for both laboratory and mobility use. This spectrometer can be used in harsh environments. If standardization must be repeated periodically while deployed under adverse conditions, standardization is made simple through computer assistance. The spectrometer is configured for the fifteen JOAP elements. This instrument is no longer being manufactured/procured and is being replaced by newer JOAP approved instrumentation.

e. Spectro, Inc. Model M. The "M" has many of the features of the "Plus". Additionally, it has many built-in safety features for power applications and routine operation. It also was designed for both laboratory and mobility use. It also has computer assisted standardization capability. The spectrometer is configured for the fifteen JOAP elements.

f. Spectro, Inc. Model M/N. The "M/N" is essentially the same as the "M". The "M/N has electromagnetic Interference (EMI) protection that meets the requirements of the US Navy. Additionally, the "M/N" has a convenient port for measuring the source frequency. Adjustment of the source frequency is made with a control that has been placed in the burn chamber.

2-6. Other JOAP Instrumentation

a. Fourier Transform Infrared (FT-IR) Oil Analyzer Spectrometer. The FT-IR spectrometer system quantitatively measures fuel, coolant, water, and monitors oxidation, oil additive depletion, lubrication degradation, and incorrect fluid contamination. The FT-IR spectrometer technology provides a means to evaluate a variety of fluid conditions that lead to component failures in oil lubrication systems.

b. Ferrography Automated. Personal computer application for debris and wear particle analysis trending that has software capability in trending evaluation techniques. Ferrography is used in support of fine filtration equipped components to identify abnormal component failures through enhanced diagnostic techniques. Ferrography detection ranges from 8 to 200 microns size wear particles. Iron (Fe) is the primary element evaluated for types of wear such as spalling, rubbing, and cutting wear particles.

2-7. Instrument Requirements.

a. Environmental controls. If possible, temperature and humidity should be controlled to 75 ±3◦F and approximately 50 percent or less relative humidity. If no controls are available, spectrometer standardization will be more frequent. If a computer is used or is an integral part of the instrument, problems may occur if excessive heat is encountered. For spectrometers designed for mobility purposes, these requirements are not necessary. However, for efficient computer operation and to prevent frequent standardization, it is advisable to have some control over the environment, even in a mobility environment.

b. Power requirements. Refer to the spectrometer manufacturer's information concerning the application power to the instrument as the requirements vary from instrument to instrument and country to country. Ensure that all measures are taken to set up the instrument for the correct voltage and frequency (Hz) before applying power. If a multimeter is available, ensure the voltage is constant and within specifications.

c. Exhaust vent. Fumes from the spectrometer must be vented to the outdoors to protect the operator. If you are operating the spectrometer outdoors with mobility equipment, vent the exhaust away from the operator to a sufficient distance to avoid inhalation of fumes.

2-8. Laboratory Supplies Required.

a. Spectrometric Oil Standards. The same standards are used for the standardization of atomic emission and atomic absorption spectrometers.

(1) Description. The D-12 standards contain the same weight of each of 12 elements (aluminum, chromium, copper, iron, lead, magnesium, nickel, silicon, silver, sodium, tin, and titanium). The D-3 standards contain the same weight of each of 3 elements (boron, molybdenum, and zinc). The D19-0 PPM standard is a base oil with no elements added. In the manufacture of the D-12 and D-3 standards, soluble complex metallo-organic compounds are blended in hydrocarbon base oil with a stabilizing agent. All standards have a minimum flash point of 340◦F (171.1◦C) and a viscosity of approximately 245 centistokes at 100◦F (37.6◦C).

(2) Ordering Standards. The D19-0 PPM, D-12, and D-3 standards are available in 8 ounce bottles through normal supply sources as stock numbered items. The D19-0 PPM and D-12 standards are manufactured by the Joint Oil Analysis Program Technical Support Center, Pensacola, Florida, and are distributed to all users through the Item Manager, the Defense Supply Center Richmond, 80 Jefferson Davis Highway, Richmond, VA 23297-5864.

(a) Standards available.

Designation	***Elements	Available Concentrations	Shelf Life
D-19	None	0	*30 months
D-3	B, Mo, Zn	100	*12 months
D-12	Fe, Al, Cr, Cu, Pb, Na MG, Ni, Si, Ag, Sn, Ti	**5, 10, 30 50, 100 ,300	*30 months

* **Shelf/service life assigned to Spectrometric Oil Standards is finite with no extensions allowed.** Standards reaching service life shall be locally disposed of in accordance with applicable service regulations.

NOTE

Up to 2 bottles of expired oil standards, normally referred to as "slop oil", may be retained for use for warm-up burns. Higher concentrations of expired standards such as 50, 100 or 300 ppm are best for this purpose. These slop oil bottles must be clearly marked on the label as slop oil - “for warm-up burns only" to ensure that they are not used for standardization of the spectrometer.

** The 5 PPM concentration is not applicable to AOAP laboratories.

*** JOAP elements and their symbols are as follows:

Element	Symbol	Element	Symbol
Aluminum	Al	Nickel	Ni
Barium	Ba	Silicon	Si
Boron	B	Silver	Ag
Cadmium	Cd	Sodium	Na
Chromium	Cr	Tin	Sn
Copper	Cu	Titanium	Ti
Iron	Fe	Zinc	Zn
Lead	Pb		
Magnesium	Mg		
Manganese	Mn		
Molybdenum	Mo		

(b) Applicable stock number for the zero PPM, D-3 and D-12 standards are as follows:

PPM Concentration	National Stock Number
0	1RM 9150-00-179-5137-SX
5	1RM 9150-01-307-3343-SX
10	1RM 9150-00-179-5145-SX
30	1RM 9150-00-179-5144-SX
50	1RM 9150-00-179-5143-SX
100 (D-3)	1RM 9150-01-283-0249-SX
100 (D-12)	1RM 9150-00-179-5142-SX
300	1RM 9150-00-179-5141-SX

(3) Stocking Standards. Due to shelf life control requirements of spectrometer oil standards, local supply departments are prohibited from maintaining standards in stock. Standards ordered through local supply activities will be forwarded from the Navy Inventory Control Point stocking point. Therefore, it is recommended that laboratories frequently inventory standards on hand, maintain no more than 6 months usage level on hand, and order replacement stock 30 to 45 days in advance of anticipated requirements.

b. Electrodes. Both disc and rod electrodes listed below are operating activity expense items and must be ordered through normal supply channels from Defense General Supply Center, Richmond, VA 23297. A suggested 6-month supply is listed in table 2-1. For a list of JOAP tested and approved electrodes, e-mail a request to: corr@joaptsc.navy.mil

Electrode	P/N	Unit of Issue	NSN
Rod (6 inches long)	M8971-2-2	Box (50 ea)	5977-00-464-8433
Disc (0.200 inch thick)	M8971-1-2	Box (500 ea)	5977-00-464-8496

TABLE 2-1. QUANTITIES OF ELECTRODES AND BOTTLE CAPS FOR SIX (6) MONTHS

Expected Number of Samples per Month	Electrodes Disc	Rod	Bottle Caps
Up to 1000	16 boxes	6 boxes	8,000
1000 to 3000	40 boxes	16 boxes	20,000
3000 to 5000	64 boxes	26 boxes	32,000

NOTE

Shipboard and mobile laboratories should order sufficient electrodes to last a full deployment. Six-inch rod electrodes normally provide for 25 to 30 analyses; disc electrodes are for one time use only. Individual packages of electrodes should not be opened until needed, and different manufacturer's electrodes should not be intermixed (see paragraph 3-3).

c. Oil Sample Containers.

(1) Bottle caps NSN 6640-01-042-6583, with nomenclature of Cap, Screw, Bottle & Jar, P/N24-3600, 24 MM size 24, white urea linerless plastic will be used for performing sample analysis when a JOAP approved cap is not provided with the oil analysis bottle. They may be obtained either through normal supply channels or by open purchase. A suggested six-month supply is listed in table 2-1.

(2) Reusable fluid holders (aluminum boats) are used for daily standardization and daily standardization checks of atomic emission rotrode spectrometers and are available through normal supply channels under NSN 6650-00-086-1571.

d. Miscellaneous Supplies.

(1) Atomic Absorption Spectrophotometer Equipped Laboratories.

Item	Unit of Issue	National Stock No.
Cleaning Compound	QT	6850-00-227-1887
Towel, Paper 40 Sq In.	BX (16,800 ea)	7920-00-721-8884
Disk, Filter 47 mm 100's	BX (1,350 ea)	7920-00-965-1709
Diluter	EA	American Scientific Prod. P/N P4927-11
Disc, Bacterial Filtering	PG	6640-00-299-8692
Acetylene, Technical	CF	6830-00-270-8216
Cylinder		
Cylinder Gas Nitrous (250 gal)	EA	8120-00-130-1921
Cylinder Gas Nitrous (2000 gal)	EA	8120-00-130-1941
Nitrous Oxide (250 gal)	EA	6505-00-130-1920
Nitrous Oxide (2000 gal)	EA	6505-00-130-1940
Filter, Disc	EA	6640-00-299-8691
Acetone, Technical	CN (5 gal)	6810-00-184-4796
Methyl Isobutyl Ketone (MIBK)	GL	6810-00-286-3785
Xylene	GL	6810-00-598-6600
Syringe, Hypodermic, 5 ml	EA	6515-00-754-0406
Syringe, Hypodermic, 20 ml	EA	6515-00-380-4300
Test Tube 13 x 100 MM	PG (125 ea)	6640-00-443-3750
Tubing, 0.023 I.D. x 0.038 O.D.	EA	Perkins-Elmer P/N 4710-PPE-801S

(2) Atomic Emission Spectrometer Equipped Laboratories.

Item	Unit of Issue	National Stock No.
Cleaning Compound	QT	6850-00-227-1887
Paper Towel	40 Sq In.	7920-00-721-8884
Disk Filter	47 mm 100's	7920-00-965-1709
Stop Watch TBI	EA	6645-00-250-4680
Ultrasonic Cleaner (BF)	EA	4940-00-164-8997
Optical Alignment Fixture	EA	6650-00-119-9412
Adjustment Fixture	EA	6650-00-119-9413
Electrode Sharpener	EA	6650-00-498-8182

(3) Electron solvent has been approved for use in the JOAP program as a replacement for Trichloroethane. See paragraph 3-4.b (2) for units of issue and NSN's

2-9. Forms Required.

a Oil Analysis Record (DD Form 2027) is required for those laboratories performing manual recording of oil analysis data and is available through normal forms distribution channels.

b. Oil Analysis Request (DD Form 2026) may be required by the laboratory to replace damaged or oil soaked copies for analysis results entry and return to customer activities (as required by service policy).

c. Oil Analysis Recommendation and Feedback Form, DA Form 3254-R (Army laboratories).

2-10. Publications Required.

The following publications are required for daily operational reference guides for oil analysis laboratories as indicated.

a. All Oil Analysis Laboratories.

(1) Message Address Directory: Army DA Pamphlet 25-11, Navy USN PLAD 1, as appropriate.

(2) Joint Oil Analysis Program Manual, NAVAIR 17-15-50, TM 38-301, T.O. 33-1-37. All laboratories should have Volumes I, II and III. Laboratories providing support for nonaeronautical equipment should have Volume IV.

(3) ADP System Users Guide (as applicable).

b. Laboratories Using A/E35U-3.

(1) Technical Manual, Operation Instructions/Maintenance Instructions, Fluid Analysis Spectrometer, Type A/E35U-3, Air Force T.O. 33A6-7-24-1, Navy NAVAIR 17-15BF-62.

(2) Technical Manual, Illustrated Parts Breakdown, Fluid Analysis Spectrometer, Type A/E35U-3, Air Force T.O. 33A6-7-24-4, Navy NAVAIR 17-15BF-63.

(3) Maintenance Manual Supplement, NAVAIR 17-15BF-62.1. (Army and Navy)

(4) Technical Manual, Periodic Maintenance Requirements Manual Fluid Analysis Spectrometer A/E35U-3/-3A/FAS-2C, NAVAIR 17-600-131-6-2. (Navy only)

c. Laboratories using FAS-C2 spectrometers.

(1) Operation and Maintenance Instructions, Fluid Analysis Spectrometer A/E35U-3A (FAS-2C), Air Force T.O. 33A6-7-24-11, Army TM 9-6650-306-14, Navy NAVAIR 17-15BF-92.

(2) Illustrated Parts Breakdown, Fluid Analysis Spectrometer A/E35U-92.3A (FAS-2C), Air Force T.O. 33A6-7-24-14, Army TM 9-6650-306-24P, Navy NAVAIR 17-15BF-92.1.

d. Laboratories using Baird MOA spectrometers.

Baird User's Guide for Multielement Oil Analyzer. (Manufacturer's manual, no number assigned).

e. Laboratories using Spectro, Inc. Spectroil Jr. Plus spectrometers.

Spectro, Inc. Spectroil Jr. Plus Instruction Manuals. Operation and Maintenance Manual. Volume II is Detailed Maintenance. (Manufacturer's manual, no number assigned.)

f. Laboratories using Spectro, Inc. Model M and M/N spectrometers.

(1) Spectro, Inc. Model M/N Operation and User Maintenance Manual, Air Force T.O. 33B4-2-29-1 US Navy NA 17-15BF-95.

g. Army Oil Analysis laboratories. (Additional publications required.)

(1) The Army Material Maintenance Policies, AR 750-1, in the Maintenance Management UPDATE.

(2) Aeronautical Equipment Army Oil Analysis Program (AOAP), TB 43-0106.

(3) The Army Maintenance Management System, DA PAM 738-750, in the Maintenance Management UPDATE.

(4) Oil Analysis Standard Interservice System Users Manual.

SECTION III

SPECTROMETRIC LABORATORY OPERATING PROCEDURES

3-1. Introduction. This section provides general instructions concerning laboratory operating procedures, laboratory reports, requests for spectrometer maintenance, requests for technical assistance and contingency operations.

3-2. Sample Processing.

a. Processing and evaluation priority shall be as follows:

(1) Special aeronautical.

(2) Routine aeronautical.

(3) Special nonaeronautical.

(4) Routine nonaeronautical.

b. Each laboratory shall process samples, evaluate results, and transmit recommendations to the customer as soon as possible during normal working hours on a non-reimbursable basis. Aeronautical samples shall be processed within 24 clock hours of receipt and nonaeronautical samples within 72 clock hours of receipt, weekends and holidays excluded. Equipment specific variations to these time requirements are noted in the specific equipment tables in volumes III and IV.

c. If delays are expected in processing priority samples, the laboratory shall notify the customer as soon as possible.

d. The laboratory shall normally request a special sample for verification of analysis prior to a recommendation for maintenance action.

3-3. Disposal of Oil Sample Bottles and Caps. All oil sample bottles (glass and plastic); bottle caps, plastic tubing and unused oil shall be segregated for disposal and disposed of in accordance with local base requirements.

3-4. Spectrometer Preparation and Operation. All spectrometers require preliminary preparation prior to operational use. Daily standardization checks in accordance with procedures identified in the manuals for each spectrometer shall be performed once each day prior to operation. If the daily standardization check is out of allowable tolerances, a complete standardization shall be performed in accordance with the applicable spectrometer manual. A complete standardization shall be accomplished at least once each week. Correct frequency, or breaks per half cycle, is essential for repeatable results. Those spectrometers that do not have any automatic frequency adjustment shall be checked at least once every 2000 burns. Periodic standardization checks shall be made throughout the operational period. At a minimum, these checks will be made when switching from analysis of aeronautical to non-aeronautical samples (or vice versa) and whenever the spectrometer has not been operated for 30 minutes or more. The following instructions also apply:

a. All Laboratories. Personnel shall not smoke, eat, or drink in close proximity to oil analysis equipment, sample preparation areas, or ADP equipment.

b. Atomic Emission Laboratories.

(1) Electrodes. An analysis obtained on a sample using one manufacturer's electrodes will frequently vary from results obtained on the same sample when using electrodes from another manufacturer. Therefore, when a change is made from one manufacturer's to another manufacturer's electrodes (either rod, disc, or both), or a change in lot or batch number of the same manufacturer occurs, a daily standardization check must be performed using the new electrodes before continuing operations. Also, ensure that the operator performs a disc-offset procedure if this procedure is required for the spectrometer in use (typically Spectro, Inc. Model M and M/N). Refer to the spectrometer manual.

(a) Rod electrodes should be resharpened only on one end after each burn. The sharpening process must remove all contamination from the previous burn. Contamination is readily visible as stains/discolorations on the flat face and the sides of the electrode and must be completely removed in order to preclude contamination of subsequent analysis burns. The resharpened end should have a smooth, polished appearance and the slight point on the sharpened end must be geometrically centered. Rod electrodes must not be handled by the sharpened end in order to avoid contamination.

(b) Disc electrodes are for one time use only and must be discarded after each sample analysis. Electrodes should not be picked up or touched with the hands but should always be handled with a tissue to avoid the possibility of contamination. Discs should not be poured out in an open container, but should be left in the original container until ready for use. Dropped or spilled electrodes should be discarded due to the possibility of contamination.

(2) Sample Holders. Aluminum boats (NSN 6650-00-086-1571) shall be used for standardization of the JOAP atomic emission rotrode spectrometer and for daily standardization checks. White caps (NSN 6640-01-042-6583) will be used as sample holders for all sample analyses except when analyzing low flash point fluids. Low flash point fluids shall be analyzed using the aluminum boat with cover (NSN 6650-01-011-3472). If an insufficient amount of fluid is available for analysis to fill a cap, an aluminum boat may be used for the analysis. Aluminum boats and covers must be thoroughly cleaned before reuse. Electron is the primary fluid recommended for cleaning the aluminum boats and covers. Any solvent that dissolves the oil may be used, but the solvent must have no metallic content to contaminate the boats and covers and present no serious health risk to the user or the environment. The solvent must also not affect the sample stand components when used for cleaning the sample stand. No cleaner may be used that has a flash point below 140 degrees F or one, which is considered an ozone depleting substance. Consult with your local environmental personnel to ensure that any fluid that is used is completely safe and that correct usage and disposal procedures are in effect. Here is information for obtaining electron:

Unit of Issue	NSN
55 gallons drum	6850-01-375-5555
6 gallons	6850-01-375-5553
1 gallon	6850-01-375-5554
Aerosol spray (12 cans per box)	6850-01-371-8048
Pump spray (12 per box)	6850-01-371-8049

(3) Sample Excitation Stand Cleaning. The excitation stand area must be kept clean in order to obtain accurate analyses. Dirt and oil, in addition to distorting sample results, may also cause high-voltage arcing, which may result in damage to the instrument. The cleaning procedures and schedules given in NAVAIR 17-15BF-62/USAF T.O. 33A6-7-24-1 must be complied with.

3-5. Data Recording, Processing, and Warehousing

a. The US Army data is processed and warehoused by the US Army Program Management office at Redstone Arsenal, Huntsville, AL. The US Navy data is processed and warehoused by the US Navy Program Management office at Pensacola NAS, Pensacola, FL. The US Air Force data is processed and warehoused by the JOAP-TSC at Pensacola NAS, Pensacola, FL.

(1) Laboratories shall submit data to their respective service database as directed by the Service Program Manager or as contained in Volume I, page 4-9.

(2) Each Service Program manager is responsible for routine data transfer to the other services.

NOTE

JOAP laboratory personnel are responsible for ensuring that all processed oil analysis results are entered into the applicable service database. This includes assigned, temporarily assigned, transient, and deployed assets. The analysis information shall be supplied to the owning organization or home base location for database entry or update of records as applicable. Retain a copy of the analysis data until receipt is confirmed to ensure that no analysis data is lost.

Army only: The AOAP Program Manager will provide technical assistance and initiate corrective software program changes to the Oil Analysis Standard Interservice System (OASIS) laboratory operating system. If OASIS software support is required, contact the AOAP Manager as follows:

COMMANDER
ATTN AMXLS LA BLDG 3627
USAMC FIELD SUPPORT ACTIVITY PROVISIONAL
REDSTONE AL 35898-7466
AOAP Hot Line DSN: 645-0869 / (256) 955-0869
Data Facsimile: 746-9344 / (256) 876-9344
DDN address: aoap@logsa.army.mil

(3) Data Reports. Routine reports are produced from laboratories and from the service database. Examples of some of the reports available are included in Volume I in appendices C and D (D is Army only)

b. Automated laboratories. Detailed information concerning automated systems to access the computer file data and for entry of variable sample data into the computer files. Entry of sample analysis data on the DD Form 2026 by the laboratory is not required unless required by individual service policy for return of the DD Form 2026 to the customer.

(1) The DD Form 2026 is used as a source document for basic information to access the computer file data and for entry of variable sample data into the computer files. Entry of sample analysis data on the DD Form 2026 by the laboratory is not required unless required by individual service policy for return of the DD Form 2026 to the customer.

(2) DD Form 2027 is not normally used by automated laboratories unless required for backup or temporary records in the event of automated system failure.

(3) The requirements for assignment of sample numbers by service activities is the same as that specified in paragraph 3-5.c. for non-automated laboratories.

c. Non-Automated Laboratories. The following information is for use by those non-automated

laboratories required to transmit manually accumulated data into the JOAP database and may be directed for use by other service program managers for their automated laboratories experiencing ADP equipment failure.

(1) DD Form 2026 is used as a source document to locate existing DD Form 2027 and complete the variable data section or to initiate new DD Form 2027. The DD Form 2026 is also used by Air Force non-automated laboratories for submission of data for entry into the JOAP data base (see Appendix A for specific Air Force data submission instructions), and may be directed for use by other service program managers in appropriate circumstances.

(2) DD form 2027, (figure 3-1), is used as an historical record of equipment monitored. Non-Air Force activities that are not designated to transfer data to the data base shall complete DD Form 2027 using information from the DD Form 2026 and laboratory analysis data and retain DD Form 2027 on file as the historical record for each item of equipment monitored. These laboratories may use either coded or plain language data entries, whichever is locally desired. Laboratories will comply with individual service directives for sending non-automated data into the JOAP database.

(3) Data from the DD Form 2026 are transferred to the DD Form 2027 as follows:

(a) Permanent Data Section: The information for this section is provided by the oil analysis request (DD Form 2026). This data, once entered on the DD Form 2027, rarely changes but should be verified at the time of each subsequent data entry.

NOTE

When instructions for a data entry item specify, “leave blank”, laboratory personnel may use these data entry blocks for any purpose desired locally. Each laboratory supervisor will determine which, if any, of the data entry blocks will be used locally and for what purpose.

1. Component Control Number (CCN) - leave blank.

2. Equipment Model/APL - enter the equipment/component model name from DD Form 2026 and/or the appropriate model code from Appendix B.

3. Equipment Serial Number - enter the equipment/component serial number being monitored (Engine, Gearbox, etc. that was sampled).

4. Type Equipment Code - leave blank.

5. Customer - enter the major command listed on the DD Form 2026 or the appropriate code from Appendix C.

6. Customer Identification - enter the activity’s name and unit identification code (UIC). (USAF-enter base code.)

7. Lab - enter your laboratory name or JOAP code from Appendix D as appropriate.

8. End Item Model/Hull Number - enter End Item Model/Hull number as given on DD Form 2026 and/or the appropriate code from Appendix B.

9. End Item Serial Number - enter end item serial/bureau number.

10. Type Oil - leave blank.

(b) Variable Data Section: The information for this section is also provided by the oil analysis request (DDForm 2026) but changes with each sample processed and recorded.

1. Sample Number - Army laboratories shall enter sample number. Air Force and Navy laboratories shall enter sample number. Air Force and Navy laboratories shall enter the sample number assigned by the customer and listed on the DD Form 2026.

a. If no customer sample number is assigned, Air Force and Navy laboratories will assign a temporary control number, process the sample in the normal manner and contact the customer by appropriate means, depending upon customer location and request a sample number. The omission of a sample number shall not delay the processing of a sample or the customer notification of analysis results.

b. The monthly reporting period shall be the first through the last day of each month. The first digit of the sample number will be monthly designator identified as follows:

1 - Jan	4 - Apr	7 - Jul	O - Oct
2 - Feb	5 - May	8 - Aug	N - Nov
3 - Mar	6 - Jun	9 - Sep	D - Dec

c. The second part of the sample number shall be composed of three numerical digits and will follow the monthly designator. Sequence numbers will be assigned in ascending order beginning with 001 each month, e.g., 234th sample submitted in Feb will be reflected as sample number 2234.

2. Data Index - USN leave blank. USAF leave blank for routine documentation. For file maintenance actions, see Appendices A and E.

3. Date Sample Analyzed - enter Julian date sample analyzed.

4. Response/Turn Around Time - enter the number of days in transit as calculated by subtracting the date the sample was taken from the date the sample was analyzed. Air Force laboratories will enter the total sample response time in whole hours to include elapsed hours from the time that the sample was taken to the time that the laboratory completed sample processing and issues laboratory recommendation. (Army laboratories - leave blank.)

5. Last Lab Recommendation - leave blank.

6. Hours/Miles Since Overhaul - enter the number of hours/miles since new or

7. Overhauled as applicable.

8. Hours/Miles Oil Change - enter the number of hours/miles since oil change.

9. Reason for Sample - enter the appropriate reason sample submitted code from Appendix F.

OIL ANALYSIS RECORD

COMPONENT CONTROL NO (CCN)	EQUIPMENT MODEL/APL	EQUIPMENT SERIAL NUMBER	TYPE EQUIPMENT CODE	CUSTOMER	CUSTOMER IDENTIFICATION	LAB	END ITEM MODEL/HULL NUMBER	END ITEM SERIAL NUMBER	TYPE OIL	REMARKS

SAMPLE NUMBER	DATA INDEX	JULIAN DATE SAMPLE ANALYZED	RESPONSE TIME	LAST LAB RECOMMENDATION	HOURS/MILES SINCE		REASON FOR SMPL	SPECTROMETRIC ANALYSIS																			VALIDATION	LAB RECOMMENDATION	ACTION TAKEN	DISCREPANT ITEM	HOW MALFUNCTIONED	HOW FOUND
					OVHL	OIL CHG		FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN						

DD FORM 1 AUG 76 2027 REPLACES DA FORM 4161 OCT 73 AND NARFP FORM 13710/997 OCT 71 WHICH WILL BE USED

Figure 3-1. Oil analysis Record (DD Form 2027)

NOTE

If the DD 2026 reports that oil was added since the last sample data was submitted, use wear-metal columns Ba, Cd, and Mn to record the unit of measurement in Ounces (O), Pints (P), Quarts (Q), or Gallons (G), the numerical quantity of oil added, and the oil consumption rate in unit quantity per hour. (For example, Q1-0.5; i.e., 1 quart of oil added and a consumption rate of 0.5 quarts per hour.) To determine the oil consumption rate, compute the operating hours between oil additions by subtracting previously reported oil addition time since oil change (TSOC) or time since overhaul (TSO) from latest oil addition TSOC or TSO. Divide the reported quantity of oil added by the operating hours calculated above for the oil consumption rate per operative hour. The oil consumption rate trend provides additional information to aid the laboratory evaluator and maintenance personnel in evaluating equipment condition. The individual taking the sample must ensure that all oil added since the last sample (regardless of the number of hours between samples) is documented on the DD2026, including oil added after the current sample is taken so that the rate of oil usage can be correctly determined. For example, over the course of 100 hours between samples, oil has been added 8 times and added after the current sample for a total amount of 1 quart.

(d) Post Analysis Data:

1. Validation - this block is normally left blank. However, it may be used to identify the laboratory operator/evaluator for laboratory management purposes.

2. Laboratory Recommendation - after laboratory evaluation of sample results, enter the appropriate recommendation code from Appendix G.

(e) Feedback Data (if applicable):

1. Action Taken - enter the appropriate action taken code from Appendix H.

2. Discrepant Item - enter the appropriate discrepant item code from Appendix I.

3. How Malfunctioned - enter the appropriate how malfunctioned code from Appendix J.

4. How Found - enter the appropriate how found code from Appendix K.

3-6. Analytical Data Evaluation. Techniques for evaluating analytical results, evaluation criteria, and the methodology for establishing criteria are contained in Volumes III and IV.

3-7. Response to Customers.

a. Response Requirements. Each laboratory is required to provide analysis results, recommendations, and additional information, when applicable, to customers as shown below. Shorter laboratory response time requirements than those specified in paragraph 3-2 may be assigned by parent program management offices since response time requirements vary according to type equipment, operational and mission differences and individual service requirements. Equipment specific variations to these time requirements are noted in the specific equipment tables in volumes III and IV.

(1) Army and Navy. Upon receipt, laboratory personnel shall stamp the DD Form 2026 with a sample number and the date received.

(2) The Army requires the processed DD Form 2026/DA Form 5991-E, Oil Analysis Request, to be returned to the submitting Army unit personnel.

(a) Laboratory personnel shall circle in red all incomplete or obviously incorrect entries on DD Form 2026 submitted with samples and a copy of the incorrect or incomplete DD 2026 shall be returned to the customers OA for corrective action. Laboratories shall return the processed DD Form 2026 stamped with either PROCESSED (date) NORMAL RESULTS" or "PROCESSED (date) ABNORMAL RESULTS" to all customers. The laboratory shall annotate the DD Form 2026 with the laboratory recommendation and if the recommendation is other than normal with enough information to identify what was abnormal. For example. "High iron" or "low viscosity." At a minimum. DD Form 2026 will be returned once a week.

(b) Each laboratory is required to provide information to customers that will enable the customer to ensure that all samples taken were received and analyzed by the laboratory. For samples with normal results, return of the processed DD Form 2026 will serve as notification of completion of sample analysis. For samples with abnormal results, the laboratory shall advise the owning unit of the laboratory recommendation either in person or by telephone within 24 clock hours of sample receipt for aeronautical samples and within 72 clock hours of sample receipt for nonaeronautical samples, weekends and holidays excluded. Navy laboratories shall maintain a log of all telephone calls, message traffic, and/or personal contacts made because of recommendations made on equipment with abnormal oil analysis results.

(c) Laboratories shall provide units with Oil Analysis Standard Interservice System reports as required. Navy laboratories, at a minimum, shall issue the following reports:

Monthly:

Report	Subsystem	Distribution
Monthly Activity	Aeronautical	Squadron
Components Enrolled	Aeronautical	Squadron
	Ship	Ship
	Ground	Company
Workload Summary	Aeronautical	Wing or CAG
	Ship	Squadron
	Ground	Battalion or Base

Weekly:

Report	Subsystem	Distribution
Received and Processed	Ship	Ship

At a minimum, Army laboratories shall provide the Components enrolled in AOAP and the Resample and Type Recommendation Reports monthly to all using units.

(d) Army Only. Requests for samples and oil changes shall be made on DD Form 2026. recommendations for maintenance actions shall be made on DA Form 3254-R, Oil Analysis Recommendation and Feedback. Once initial contact is made in person or by telephone, the laboratory shall follow up with a DA Form 3254-R for all on-post units and for off-post nonaeronautical Reserve and National Guard units. For aeronautical Reserve and National Guard units and for off-post active Army units (aeronautical and non-aeronautical) the laboratory shall follow up initial contact with a priority message confirming initial contact and a DA Form 3254-R by mail. The DA Form 3254-R shall be forwarded within 24 clock hours following the initial contact. A DA Form 3254-R and instructions for laboratory preparation of the form are in Appendix M.

(2) Air Force laboratories and Navy non-aviation samples do not require the processed DD Form 2026 to be returned. They should ensure that the customer is notified of the receipt and processing of all samples. due to message traffic restrictions, this may normally be accomplished by telephone or personal contact. Navy laboratories shall also be responsible for providing adequate analysis information to the customer, as directed by responsible authority, to enable the customer to comply with the requirement imposed by OPNAVINST 4790.2G to maintain records of oil analysis results to highlight equipment trends.

(3) Interservice Response Requirements. Laboratories performing interservice fluid analysis service shall comply with the requirements of the customer's parent service regarding sample response unless alternate response procedural agreements between services are reached.

(4) Samples Requiring Amplified Response. All laboratories must provide sample analysis results, including laboratory recommendation information when applicable, to the customer activity for all types of samples listed below:

(a) All special samples.

(b) All samples for which the analysis indicates possible discrepancy.

(c) All samples suspected to be invalid.

(d) All samples for which response is specifically requested by the operating activity in special circumstances.

b. Content and Terminology. Each response shall contain the following information:

(1) Equipment Model and Serial Number and End Item Model and Serial Number. This information is provided by the customer on the Oil Analysis Request (DD Form 2026).

(2) Sample Analysis. The sample analysis shall be reported as normal, marginal, high, or abnormal for individual metal content.

(3) Date Sample Taken. As provided on DD Form 2026.

(4) Recommendations. Each response shall contain the complete recommendation description corresponding to the applicable recommendation code.

NOTE

Laboratory recommendations are indeed only recommendations. It is the customer's responsibility to take appropriate corrective action. If a disagreement between the laboratory and customer arises concerning corrective action, the discrepancy should be entered in the equipment forms by laboratory personnel and corrective action taken, if any, entered by the customer.

c. Method of Response. Each laboratory response shall be prepared and delivered as follows:

(1) Results Involving Operational/Flight Safety. Whenever analysis of any sample results in a laboratory determination that operational/flight safety is affected, the laboratory shall immediately provide detailed Information to the customer by telephone, when possible, followed by priority message (or memorandum for on base responses if desired) for confirmation of results and recommendations.

(2) Results Not Involving Operational/Flight Safety. Whenever analysis of a sample results in a recommendation requiring the customer to take action, but does not involve operational/flight safety, reports shall be made verbally followed by a memorandum report for on base/post customers (except in cases where Information copies of official notification correspondence are required by higher commands) and by message,

speed letter or letter, as appropriate for off base/post customers.

(3) Message Format. A recommended format for a priority message for use in reporting analysis results Involving operational/flight safety follows:

FROM: LABORATORY
TO: CUSTOMER
INFO: SERVICE OIL ANALYSIS PROGRAM MANAGEMENT OFFICE
COGNIZANT FIELD ACTIVITY (USN) /ITEM MANAGER (USAF)
(Engine/component removal recommendations only)

TYCOM (USN) /MAJOR COMMAND (USA, USAF)
(Engine/component removal recommendations only)

OTHER INFO ADDRESSEES (as directed by individual service requirements)

UNCLAS
SUBJ: JOAP OIL SAMPLE ANALYSIS REPORT
REF: (A) NA 17-15-50/TM 38-301/T.O. 33-1-37
1 IAW REF (A) FOLLOWING REPORT SUBMITTED
a. SAMPLE NUMBER (if assigned) AND TYPE (routine/ Special).
b. DATE SAMPLE TAKEN.
c. END ITEM IDENTIFICATION (serial/indent number).
d. EQUIPMENT MODEL AND SERIAL NUMBER.
e. SAMPLE ANALYSIS RESULTS (normal, marginal, high, Abnormal for specific elements).
f. RECOMMENDATIONS (use plain language corresponding to specific recommendation codes) RECOMMEND DO NOT FLY, DO NOT CHANGE OIL, SUBMIT CHECK SAMPLE ASAP, ETC.

(4) Laboratory responses to contractor customers requiring oil analysis support in support of a contract with a component of DOD shall contain the same information as responses made to military operating activity customers.

3-8. Transfer of Oil Analysis Records. Any time that an oil analysis customer relocates, either deployed or permanently, and oil analysis services are required at the new location, the transfer of workload and provision of services shall be handled through the normal chain of command in order to ensure orderly transfer of support. unusual problems encountered should be referred to the appropriate service oil analysis program management office for resolution.

a. Transient Equipment Records. Transient customers are responsible for obtaining complete oil analysis records for their equipment from the losing laboratory and for delivery of the records to the gaining laboratory at the new operating site. If sufficient time is not available to comply with these procedures prior to departure, the customer shall notify the losing laboratory concerning the relocation and the losing laboratory shall mail all required oil analysis records to the gaining laboratory.

b Permanent Relocation/Temporary Deployment. Whenever the oil analysis workload is transferred from one laboratory to another due to customer transfer, the following instructions apply:

(1) Transferring Activity (Customer). The customer activity is responsible for notifying the home base (supporting) oil analysis laboratory concerning transfer/deployment schedules in advance of departure. advance notice is required in order to provide the laboratory sufficient time for orderly processing of records for transfer to the new supporting laboratory to avoid disruption in equipment oil analysis monitoring schedules.

(2) Transferring/Losing Laboratory. The losing laboratory will forward equipment oil analysis records directly to the gaining laboratory unless directed otherwise by competent authority. The losing laboratory shall ensure that each equipment record transferred is complete, accurate and legible.

(a) When both the losing and gaining laboratories are equipped with appropriate automated systems the record transfer may be accomplished using ADP products in accordance with instructions provided by the appropriate service program management office.

(b) When only one or neither laboratory is equipped with an automated data system, a copy of records must be made for transfer. Either a hardcopy computer record printout or copies of DD Form 2027, refer to figure 3-1, may be used, depending upon the losing laboratory capabilities.

(c) The following actions will be taken by transferring/losing laboratories:

1. Customer Temporary Deployment.

a. Retain original oil analysis records.

b. Forward copies of records to gaining laboratories.

c. Update or replace original records upon return of customer/equipment and notify deployment site laboratory of records receipt.

NOTE

In cases where equipment will be deployed for lengthy periods exceeding normal laboratory equipment data retention periods, losing laboratories may elect to transfer the original records and retain copies only for the

normal retention period.

2. Customer Permanent Transfer.

a. Retain copies of oil analysis records.

a. Forward original records.

c. Destroy copies retained either upon notification of receipt of records by the gaining laboratory or at the expiration of the normal record retention period as desired.

(3) Gaining laboratory. The historical records for gained equipment will provide a baseline for evaluations and recommendations when providing service to the new customer. Problems encountered in data transfer should be immediately referred to the appropriate program management office. The gaining laboratory will take the following actions upon receipt of newly gained equipment oil analysis records:

(a) Notify losing laboratory when oil analysis records have been received and screened for completeness, accuracy, and legibility.

(b) Initiate new records if required.

(c) If deployed customer, forward original of records accumulated during deployment to the customers home base supporting laboratory upon completion of deployment. Format of records for transfer will be determined by ADP capabilities of both laboratories involved. Retain data/copies of records until notified of records receipt by customer's home base supporting laboratory.

(4) Lost oil analysis records. In the event copies of oil analysis records are lost during transfer, either the customer or the gaining laboratory, as appropriate, should request new copies of the oil analysis records from the losing laboratory.

NOTE

The above procedures also apply to an operating activity that is reassigned to another service's laboratory.

3-9. Disposal of Oil Analysis Records. The original copy of an oil analysis record may be destroyed by the originating laboratory 12 calendar months after receipt of the last sample from the item of equipment involved. laboratories with ADP capability will utilize normal purge routines specified by parent service.

3-10. Contingency Operations. Whenever a JOAP laboratory becomes inoperative, the following procedures apply.

a. If operational capability cannot be restored within a reasonable time consistent with operational safety, as determined by the appropriate program manager or the on-site commander for deployed units, the laboratory shall contact their program management office and the back-up laboratory listed in the JOAP Directory (or as directed by the applicable program manager) and provides the following information:

(1) Estimate of duration of laboratory downtime.

(2) Number of samples backlogged.

(3) Average number of samples received daily.

(4) Method of transporting samples to back-up laboratory.

b. Temporary additional staffing, TAD/TDY of personnel from an inoperative laboratory for the

reassignment of workloads may be necessary. The two laboratories shall negotiate staffing requirements and coordinate with local management as required. (At those bases/posts having no government or contract laboratories, US govemment personnel shall negotiate workload transfers and personnel support for the laboratories.) Staffing problems not settled between affected laboratories shall be referred to the appropriate OAP management office for resolution.

c. If the laboratory supports customers of more than one service, the disposition of backlogged samples shall be coordinated between the appropriate service program management offices.

3-11. Requests for Spectrometer Maintenance.

a. Army Laboratories. After exhausting local capabilities for repair, Army laboratories shall forward diagnostic data to the JOAP-TSC. The diagnostic data may be forwarded in message format as shown in Appendix L or in comparable format by telephone. If troubleshooting, consulting, and advisory support by the JOAP-TSC is unsuccessful, the JOAP-TSC will refer the laboratory to the Army program management office for further action. The program director is responsible for coordination of all on-site maintenance/service visits by the spectrometer manufacturer's representatives.

b. Navy Laboratories. After exhausting local capabilities for repair, Navy laboratories shall contact the appropriate NATEC Detachment for assistance. Requests for assistance shall be made in accordance with COMNAVAIRLANT/COMNAVAIRPAC INSTRUCTION 4350.3 series.

(1) East coast laboratories (NADEP Cherry Point, NADEP Jacksonville, Corpus Christi NAS Truax FieldNAS Key West, NAS Oceana, NAS Sigonella, SIMA Mayport, MID ATLANTIC LAB Norfolk and Atlantic Fleet ships will address messages to NATEC DET MIRAMAR CA //3.7BD//, NATEC DET OCEANA VA //3.7BD// and NAVOAPROGMGR PENSACOLA FL //3.2//.

(2) West coast laboratories NAS Lemoore Ca, NAS Meridian, NAS Fallon, NAS Whidbey WA, MCAS Yuma, USS INCHON, NAVSHIPYD Pearl Harbor, SIMA San Diego and Pacific Fleet ships operating off the west coast or in the vicinity of Hawaii will address their messages to NATEC PAC SAN DIEGO CA //3.7/VA1//, with info copies to NATEC DET MIRAMAR CA //3/7BD//, NATEC SAN DIEGO CA//3.7.4//, and NAVOAPROGMGR PENSACOLA FL //3.2//.

(3) NAF Atsugi, USS ESSEX, USS KITTY HAWK and ships deployed to the WESTPAC and Indian Ocean area will forward their messages to NATEC PAC SAN DIEGO CA//3.7BA1//, NATEC DET ATSUGI JA//3.7BD//, NATEC DET MIRAMAR CA//3.7BD// with info copies to NATEC SAN DIEGO CA//3.7.4//, NAVOAPROGMR PENSACOLA FL //3.2//.

(4) NATEC LANT NORFOLK and NATEC PAC SAN DIEGO will coordinate spectrometer maintenance support in their respective areas. If support capabilities are exhausted and if additional support is required, request for contractor support from the NAVOAPROGMGR PENSACOLA FL //3.2//.

c. Air Force Laboratories. After exhausting local maintenance capabilities, Air Force laboratories shallcontact the spectrometer manufacturer for additional telephonic troubleshooting assistance. If the problem still cannot be resolved, Air Force laboratories shall contact the Program Management Office, OC-ALC TIEO, 4750 Staff Drive, Tinker AFB, OK 73145-3317 for contractor on-site support.

d. The JOAP-TSC will provide troubleshooting, consulting, and advisory maintenance support as requested. If unsuccessful, the JOAP-TSC will refer the laboratory to the appropriate service program management office for coordination of on-site assistance visits if required. Direct liaison is encouraged between the JOAP-TSC, PMEL, NATEC and laboratory activities. Since local availability of spare parts is limited, diagnostic data must be accurate and complete.

e. Army and Navy laboratories located near Air Force bases may negotiate with Air Force PMEL

personnel for spectrometer maintenance. Support will be at the discretion of the Air Force Major Command involved.

3-12. Spectrometer Protection during Shutdown Periods. During in port shutdown periods in excess of two weeks and during shutdown periods when spectrometer protection is required, such as shop renovation or shipyard repair, laboratory managers shall ensure that laboratory personnel protect the spectrometer from contamination (dust, paint chips, moisture, etc.). A plastic covering, taped to form a complete barrier is recommended for this purpose.

3-13. JOAP Certification and Correlation Programs. The JOAP Certification and Correlation Programs are primary elements of the JOAP quality assurance initiative to ensure standardization of procedures and quality of oil analysis by the JOAP laboratories. Follow the specific spectrometer operators' manual for any additional special standardization recommendations/requirements prior to the analysis of correlation samples such as optical alignment or a check of the source frequency using a test meter or an oscilloscope. Participation in these programs is mandatory for all atomic emission rotrode spectrometer oil analysis laboratories, organic or under contract to a US military service for analyzing used oils from US government equipment.

a. Certification Program. Based upon laboratory facilities, personnel qualifications, and JOAP Correlation Program performance, laboratory spectrometers are categorized as certified or uncertified.

(1) Certified laboratories are authorized to provide oil analysis support to all authorized and approved customers, intraservice and interservice, as well as other DoD authorized customers. Uncertified laboratories are prohibited from providing oil analysis services to any customers unless the appropriate service program. Management office grants a waiver. This waiver must be in writing and shall normally limit the laboratory to intraservice support. A waiver granting authority for interservice support shall be supported by written concurrence of the program manager of the other supported service(s) on file with the program management office granting the waiver.

(2) The JOAP Certification Program is described in detail in Volume I.

b. Correlation Program.

(1) If a laboratory receives damaged correlation samples or does not receive samples by the 15th of the month, the laboratory shall notify the TSC of the problem immediately by telephone or e-mail.

(2) Perform complete spectrometer standardization. Immediately following the standardization, perform a daily standardization check with at least three standards prior to correlation samples analysis to ensure that the standardization was successful. If the results are not within the required tolerances, repeat the complete spectrometer standardization until the daily standardization checks are acceptable.

NOTE

Correlation printouts, including all standardization data, shall be retained for three months. This information is vital for troubleshooting instruments that score low in the program. The Program Managers may also request printouts as a quality assurance check.

(3) Ensure that the samples are analyzed on the spectrometer whose serial number is on the mailing label. Follow the specific spectrometer operators manual for any additional special standardization recommendations/requirements prior to the analysis of correlation samples such as optical alignment or a check of the source frequency using a test meter or an oscilloscope.

(4) Shake each correlation sample vigorously for one minute by hand just prior to analysis.

(5) Analyze each sample three (3) times and average the results.

(6) Report results on the results card, e-mail, or message to the nearest whole PPM.

Examples: 5.5 PPM = 6, 4.4 PPM = 4.

(7) Record “0” if a zero reading is obtained.

(8) Record R/M if one or more elements are inoperative.

(9) Leave elements not analyzed blank.

(10) Submit results to the TSC as soon as possible after receipt of the samples. Current month results are to be submitted by the 21st of the month. There is no late penalty for late submission. However, your results will not be used to help calculate the trimmed mean. JOAP certified laboratories should ensure that results from the previous month are received prior to submitting current month results. If a low score is achieved, then the problem can then be hopefully resolved prior to submitting additional results. Results can be sent by e-mail, regular mail, message traffic and facsimile. E-mailing the correlation data to corr@joaptsc.navy.mil is preferred as the data can then be downloaded directly into the correlation database. A receipt confirmation will be sent. If regular mail, message, or facsimiles are used for sending data, be sure to use two of these methods to ensure receipt by the TSC. If sending data by e-mail, be sure to attach the data using the standard form supplied by the TSC. An example of the message format is in Figure 3-2.

Phone:	DSN	922-5627, ext 115 or 121
	Commercial	(850) 452-5627, ext 115 or 121
FAX:	DSN	922-2348
	Commercial	(850) 452-2348

(11) Comply with any other special instructions received with the correlation samples.

(12) Score Computation.

(a) General. Correlation scores for all participating laboratory spectrometers are based on reproducibility 1 and reproducibility 2 results. A correlation test results report is sent each month for all spectrometers enrolled in the program. If either reproducibility 1 (R1) or reproducibility 2 (R2) fails the criteria for any of the required elements, points are subtracted as provided below. Each sample pair accounts for 50 possible points for a total of 100 points. Results are rounded off (i.e., one R1 failure equals 3.33 points for a JOAP instrument, 96.67 equals 97 percent score). Table 3-1 lists the 15 JOAP elements and points assigned for the types of spectrometers.

(b) Late Results.

1. Non-submission (NS). If the score sheet sent by the JOAP-TSC indicates N/S for the current month and results were submitted, contact the TSC as soon as possible and send in the results by the best and quickest means available. Be aware that all means of transmittal are subject to not actually arriving at the TSC. That is why it is recommended to send the data via at least two methods unless you receive an e-mail confirmation of receipt. If results were not submitted, please submit them as soon as possible. For JOAP Certified labs, non-submission of data can jeopardize JOAP certification.

2. Reported Maintenance (RM). Laboratories unable to analyze their correlation samples due to an inoperative spectrometer should report this fact to the JOAP-TSC prior to the data submission cutoff date. The JOAP-TSC will place these laboratories in an RM status for that month. RM status laboratories must ensure repairs are expedited and that results are submitted as soon as the spectrometer is operational. Table 3-2 lists all JOAP fluids currently used in equipment monitored in the JOAP.

SAMPLE MESSAGE FORMAT FOR REPORTING CORRELATION RESULTS

FROM: LABORATORY

TO: DIRJOAP TSC PENSACOLA FL

UNCLAS

SUBJ: CORRELATION TEST RESULTS FOR (Month)

1. DATE RECEIVED AND DATE ANALYZED (4 FEB 04/7 FEB 04)

2.

SAMPLE	Fe	AG	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	B	Mo	Zn
1	21	14	47	16	20	15	53	30	5	7	7	19	4	5	7
2	17	12	40	13	16	13	49	25	4	6	6	16	3	5	6
3	9	1	1	9	5	1	15	8	3	3	3	0	3	10	4
4	10	2	1	8	4	1	12	7	2	3	3	0	3	11	3

(Round off results to nearest whole PPM)

3. SPECTROMETER MODEL AND SERIAL NO. (FAS-2C O015)

4. STANDARDS USED FOR STANDARDIZATION/EXP DATE (i.e. 0 PPM NWL165 /D12-100 JUN 06 100 PPM CES584 MAY 06 / D3-100 PPM NCW503 JUN 04)

5. DISC ELECTRODE MFG AND LOT/BATCH NUMBER: (i.e. CARBON OF AMERICA 241-00-17)

6. ROD ELECTRODE MFG AND LOT NUMBER: (i.e. BAY CARBON LOT 0400 BATCH 331)

7. OPERATOR AND SUPERVISOR: (i.e. SSGT RAY JOHNSON / MSGT MIKE WILLIAMS)

8. COMMENTS: (list any pertinent comments)

Figure 3-2. Sample Message Format for Reporting Correlation Results

NOTES

If a laboratory is unable to conduct analysis for one or more elements for a given month due to instrument malfunction and appropriate maintenance corrective actions have been initiated and reported to the JOAP-TSC, an RM code will be entered in place of the score(s) that would normally be entered for the element(s). Laboratories are prohibited from analyzing oil samples for operational equipment for the element(s) for which the spectrometer was placed in an RM status. (See Vol I for additional information concerning RM status.) The JOAP-TSC will coordinate closely with the service program managers to resolve possible adverse affects on certification status and interservice support. A message request for maintenance help to the JOAP-TSC or some other agency, with info copy to the TSC, does not constitute requesting R/M status unless a specific request for R/M status is included in the message. Either call the TSC or send an e-mail specifically requesting R/M status and try to provide the TSC with a “get well” date.

TABLE 3-1. CORRELATION ELEMENTS AND SCORE WEIGHTING SCHEME

Element	Symbol	No Data or Fails Reproducibility 1 or 2	
		JOAP AE Rotrode	AA/ICP/etc.
Iron	Fe	3.33	5.55
Silver	Ag	3.33	5.55
Aluminum	Al	3.33	5.55
Chromium	Cr	3.33	5.55
Copper	Cu	3.33	5.55
Magnesium	Mg	3.33	5.55
Sodium	Na	3.33	-
Nickel	Ni	3.33	5.55
Lead	Pb	3.33	-
Silicon	Si	3.33	5.55
Tin	Sn	3.33	-
Titanium	Ti	3.33	5.55
Boron	B	3.33	-
Molybdenum	Mo	3.33	-
Zinc	Zn	3.33	

TABLE 3-2. JOAP FLUIDS

The following fluids are the types now used in the Joint Oil Analysis Program for all JOAP engines, transmissions and components.

STOCK NUMBER	PRODUCT	SPECIFICATION	NATO	TYPE
9150-01-152-7060	LUB OIL	ASTO750		S
9150-00-985-7232	HYDRAULIC FLUID	MIL-H-17672	H573	
9150-01-113-2045	HYDRAULIC FLUID	MIL-H-19457	H580	
9150-01-080-5961	HYDRAULIC FLUID	MIL-H-22072	H579	S
9150-00-111-6255	HYDRAULIC FLUID YELLOW	MIL-H-46170	H544	S
9150-01-131-3325	HYDRAULIC FLUID RED	MIL-H-46170	H544	S
9150-00-223-4134	HYDRAULIC FLUID PETRO	MIL-H-5606	H515	S
9150-01-290-2943	HYDRAULIC FLUID	MIL-H-6083	C635	S
9150-00-149-7431	HYDRAULIC FLUID	MIL-H-83282		
9150-00-235-9061	LUB OIL COMPOUND	MIL-L-15019		S
9150-00-942-9343	LUB OIL STEAM	MIL-L-17331	0250	M
9150-01-177-3988	LUB OIL ENG 10 GRADE	MIL-L-2104	0Z37	M
9150-01-178-4726	LUB OIL ENG 30 GRADE	MIL-L-2104	0238	M
9150-00-189-6730	LUB OIL ENG 40 GRADE	MIL-L-2104	N/C	M
9150-00-188-9864	LUB OIL ENG 50 GRADE	MIL-L-2104		M
9150-01-178-4725	LUB OIL ENG 15W/40	MIL-L-2104	01236	M
9150-01-048-4593	LUB OIL GEAR 75	MIL-L-2105	0186	M
9150-01-313-2191	LUB OIL GEAR 80/90	MIL-L-2105	0226	M
9150-01-035-5393	LUB OIL GEAR 85/140	MIL-L-2105	0228	
9150-00-111-3199	LUB OIL PRESERV.	MIL-L-21260	C640	
9150-00-111-0209	LUB OIL PRESER. 30	MIL-L-21260	C642	
9150-01-293-7696	LUB OIL PRESER. 15-40	MIL-L-21260		
9150-00-111-0211	LUB OIL PRESER. 50	MIL-L-21260	644	M
9150-00-168-6889	LUB OIL A/C	MIL-L-22851	0128	S
9150-00-985-7099	LUB OIL A/C	MIL-L-23699	056	M
9150-00-186-6682	LUB OIL ENG 10 GRADE	MIL-L-46152		M
9150-00-186-6689	LUB OIL ENG 30 GRADE	MIL-L-46152		M
9150-01-278-1356	LUB OIL ENG S/30	MIL-L-46152		M
9150-01-177-2762	LUB OIL ENG 10/30	MIL-L-46152		M
9150-01-177-2763	LUB OIL ENG 15/40	MIL-L-46152		M
9150-00-402-2372	LUB OIL ENG	MIL-L-46167	0183	M
9150-LP-000-1012	OIL LUB (1100 GR)	MIL-L-6082	0113	S
9150-00-782-2627	LUB OIL A/C TURBINE	MIL-L-7808	0148	S
9150-01-209-2684	LUB OIL HELO	MIL-L-85734		S
9150-01-210-1938	LUB OIL HELO	MIL-L-85734		M
9150-00-181-8229	LUB OIL SHIP	MIL-L-9000	0278	M
9150-00-664-4449	OIL COMPRESSOR XC 20/50 PHILLIPS	W-L-825	0283	

TABLE 3-2. JOAP FLUIDS (Cont)

Correlation Fluid	Identification	*Type
MIL-L-9000	Diesel engine lubricating oil	M
Mobil Jet 254	Coast Guard turbine engine oil	S
Phillips XC 20/50	Aircraft piston engine lubricating oil	M
VV-L-825	Refrigerant compressor lubricating oil	M

*M - Mineral
*S - Synthetic

SECTION IV

PHYSICAL TEST LABORATORY OPERATING REQUIREMENTS

4.1 GENERAL.

a. Purpose. This section outlines the requirements for physical property testing of used lubricant from engines, transmissions and hydraulic systems. Physical property testing is a diagnostic tool used to determine the physical condition of used lubricants. It is not intended to replace normal maintenance practices.

b. Scope. Physical property tests described in this manual are designed to determine whether used oil is contaminated or deteriorated by testing the oil for the following: viscosity, moisture/water content, flash point (fuel dilution), acidity, dispersancy, insolubles/total solids and particles/debris. The physical test requirements in this section are applicable to activities operating nonaeronautical equipment as directed by appropriate authority within the individual services and may also be applicable to selected items of aeronautical equipment as directed. The physical test may be used individually or in conjunction with spectrometric oil analysis as directed by appropriate authority within the individual services.

4.2 Laboratory Operating Requirements. The following paragraphs contain information regarding space and staffing requirements, as well as equipment recommended for operation of a JOAP laboratory performing physical property tests.

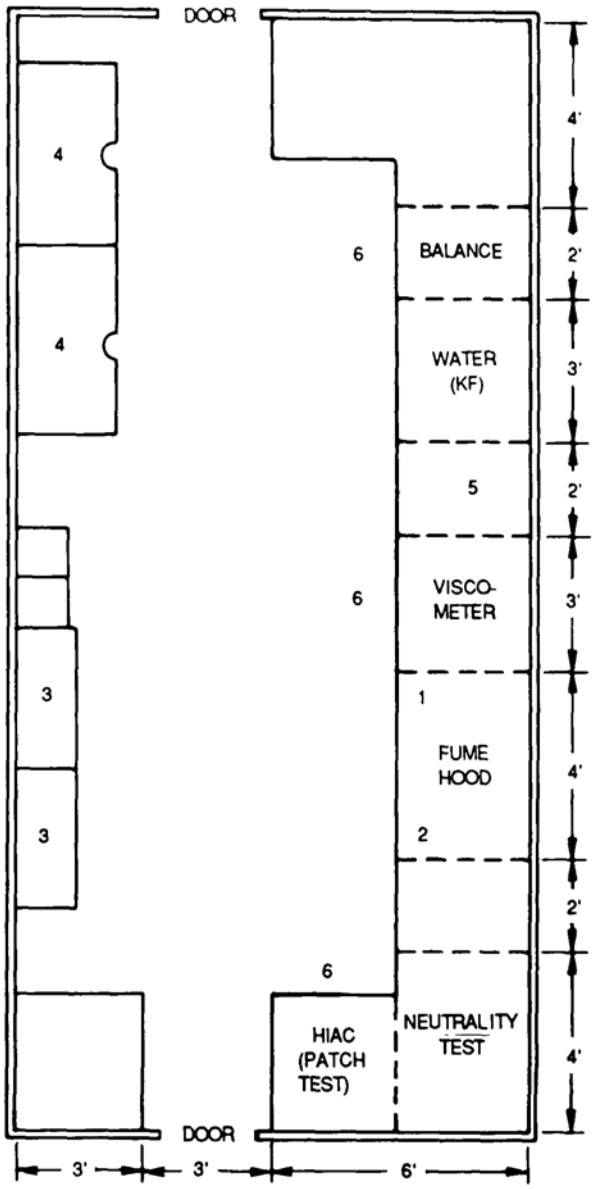
a. Laboratory Space Requirements. Recommended space requirements shown in figure 4-1 are to be used as guidelines only, since operational requirements and facility availability vary widely among service activities. The area required for a spectrometric testing facility is not included in figure 4-1. Activities experiencing problems with space requirements should contact the appropriate oil analysis program manager.

b. Laboratory Environmental Requirements. Each laboratory shall be environmentally controlled for operational efficiency. Proper ventilation and exhaust capabilities (for crackle, water (KF), and flash point) shall be provided to conform to safety requirements. Physical property test equipment is designed to operate over a wide range of environmental conditions. Refer to equipment operation, maintenance manuals and local base policies for specific equipment requirements. A portable fire extinguisher shall be readily accessible in all testing areas.

c. Staffing Requirements.

(1) Number of Personnel. The number of personnel required for a laboratory will vary depending on assigned workload, use of civilian or military personnel, use of manual versus automated data recording, and the type and location of the laboratory. In general, one full-time employee is required for every 800 analyses per month with automated data recording (this includes spectrometric and physical property testing). All Army laboratories must employ two certified evaluators full-time. One full time certified AOAP evaluator must be present at all times during the operation of the laboratory.

(2) Training. All laboratory personnel performing the duties of operator and/or evaluator for nonaeronautical equipment must receive appropriate training as determined by the appropriate service oil analysis program manager. The training may be obtained through attendance at service-approved courses and/or on the job training (OJT). Certification of physical testing operators/evaluators is an individual service prerogative in accordance with applicable service guidelines. Army requirements for certification of laboratory personnel are in Appendix N.



LEGEND

1 CRACKLE TEST
2 FLASH POINT
3 2 EA 36" X 18", STORAGE CABINETS FOR PARTS, SUPPLIES, ETC.
4 DESK AND CHAIR
5 BLOTTER/TOTAL SOLIDS
6 CHAIRS OR STOOLS

NOTE 1: THE BALANCE, KF EQUIPMENT VISCOMETER, PATCH TEST (PARTICLE COUNT) EQUIPMENT, ETC., ARE POSITIONED ON BENCH-TOPS OF LABORATORY FURNITURE. SUPPLIES, EQUIPMENT, ETC., MAY BE STORED BENEATH WHEN NOT IN USE. ALSO, ABOVE THIS EQUIPMENT ARE WALL CABINETS FOR STORAGE OF SUPPLIES, ETC.

NOTE 2: SPACE FOR A SPECTROMETRIC TESTING FACILITY IS NOT INCLUDED ON THIS LAYOUT.

Figure 4-1. Typical Physical Test Laboratory Layout

4.3 Laboratory Testing Requirements (Army). Figure 4-2 outlines the Army sample analysis requirements to be followed for engines, transmissions, and hydraulic system samples.

a. Engines. The laboratory shall conduct at least the following screening tests on engine samples.

(1) Spectrometric analysis - Spectrometric results shall be reviewed to determine whether a critical condition requiring maintenance action or a non-critical condition, such as oil contamination, exists. In either case, a resample shall be requested for verification. A critical condition may be discovered by high wear-metal concentrations or abnormal trend indications. A non-critical condition could be detected by high silicon concentrations indicating contamination of the oil by dust/dirt. Spectrometric values may also be reviewed for additive levels for elements such as zinc, boron, copper, and magnesium.

(2) Viscosity.

(3) Blotter.

(4) Water test, Crackle or Karl Fischer (KF).

(5) Fourier Transform Infrared (FT-IR) Oil Analysis Spectrometer.

b. Transmissions. The laboratory shall conduct the following screening tests on transmission samples:

(1) Spectrometric analysis.

(2) Viscosity.

(3) Water test, -Crackle or Karl Fischer.

(4) Fourier Transform Infrared (FT-IR) Oil Analysis Spectrometer.

c Hydraulic Fluids. The following tests are provided as a means of screening hydraulic fluid samples taken from equipment and may be used as directed by the appropriate service program manager.

(1) Spectrometric analysis.

(2) Viscosity.

(3) Water by Karl Fischer Titration. If water contamination exceeds the guidelines, the laboratory shall recommend flushing the system and replacing the fluid.

(4) Water by Crackle Test. If water is present, the laboratory shall recommend flushing the system and replacing the fluid.

(5) Automatic Electronic Particle Counting. If the particle count exceeds published guidelines, the laboratory shall recommend flushing the system and replacing the fluid.

(6) Fourier Transform Infrared (FT-IR) spectrometric analysis. If water contamination, oil additive depletion levels, or lubrication degradation exceed the specified guideline, the laboratory will recommend flushing the system and replacing the fluid to include servicing/replacing the oil filter.

NONAERONAUTICAL EQUIPMENT LUBRICANT SAMPLE
ANALYSIS REQUIREMENT GUIDE*

I. ENGINES

A. Spectrometric

1. Pass - Go to I.B.
2. Fail - See wear-metal guidelines for specific equipment.
   a. Critical - Resample to verify.
      (1) Wear Metals - abnormal or high range.
      (2) Oil contamination by dirt or dust - Si increase.
   b. Noncritical - Resample to verify, then change oil.
      (1) Oil contamination by dirt or dust - Si increase.
      (2) Additive depletion - Zn, Mg, or Cu decrease.
      (3) Coolant Problem - B or Na increase by 20 PPM or more.

B. Viscosity

1. Pass - Go to I.C.
2. Fail - See viscosity guidelines.
   a. Low - Fuel dilution or wrong oil. Verify by flash point test and change oil. If repeat problem, make maintenance recommendation for fuel dilution.
   b. High - Soot, sludge, water or wrong oil. Verify by blotter and water tests and change oil.

C. Blotter

1. Pass - Go to I.D.
2. Fail – Refer to paragraph 5-2.b.
   a. Contaminated oil - Soot or water is present. Verify by water (crackle or KF) test and change oil.
   b. Additive depletion - Spot has poor dispersency. Verify by spectrometric analysis (large decrease in Zn, Mg, or Cu) and change oil.

D. Crackle Test for Water

1. Pass - Go to I.E. if quantitative degree of water content required (optional).
2. Fail – Refer to paragraph 5-9.a.
   a. Free water - Change oil.
   b. Coolant leak - Verify by spectrometric (B or Na increase by 20 PPM or more) and change oil.
   c. Dissolved water - Verify by KF test and consult guidelines.

E. Karl Fischer Test for Water

1. Pass
2. Fail – Refer to paragraph 5-4.b.

F. Fourier Transform Infrared (FT-IR) Spectrometric Analysis Results

1. Pass
2. Fail - See FT-IR method number guidelines and analysis readings. Refer to paragraph 5-4.
   a. Free water - Change oil and service filters.
   b. Contaminated oil - Soot, Oxidation, Glycol, and Fuel Readings exceed established guidelines, recommend oil changes or inspect and initiate repairs of faulty systems.

Figure 4-2. Nonaeronautical Equipment Lubricant Sample Analysis Requirement Guide (Sheet 1 of 2)

II. TRANSMISSIONS

A. Spectrometric
1. Pass - Go to II.B.
2. Fall - See wear-metal guidelines for specific equipment.
a.Critical - Resample to verify.

(1) Wear Metals - abnormal to high range.
(2) Oil contamination by dirt or dust - Si Increase.

b. Noncritical - Resample to verify, then change oil.

(1) Oil contamination by dirt or dust - SI Increase.
(2) Additive depletion - Zn, Mg, or Cu decrease.
(3) Water or moisture condensation - Na increase.

B. Viscosity
1. Pass - Go to II.C.
2. Fail - See viscosity guidelines.
a. Low - Wrong oil, change oil.
b. High - Sludge, water or wrong oil. Verify by water test and change oil.

C. Water test - Crackle or Karl Fischer
1. Pass
2. Fail – Refer to paragraph 5-9.

D. Fourier Transform Infrared (FT-IR) Spectrometric Analysis Results
1. Pass
2. Fail - See FT-IR method number guidelines and component analysis warnings. Refer to paragraph 5-4.
a. Submitting unit to correct the faulty system initiate Critical - Recommend corrective maintenance actions.
b. Non-critical - Change oil and service filter.
(1) Oil contamination by dirt or dust.
(2) Additive depletion.
(3) Water or moisture condensation - Sodium (Na) increase.

Ill. HYDRAULIC SYSTEMS

The following tests are approved methods of testing hydraulic fluid condition and may be directed by services as required. These tests may be performed singly or in combination as required. (Army laboratories shall use spectrometric, viscosity and water testing as a minimum.)

A. Spectrometric
B. Viscosity
C. Water testing, Crackle or Karl Fischer Method
D. Electronic Particulate Count
E. Colorimetric Patch Testing
F. Fourier Transform Infrared (FT-IR) Spectrometric analysis for additive depletion and lubrication degradation contaminants in the components servicing the oil system. Refer to paragraph 5-4.
1. Pass
2. Fail - See prescribed guidelines for specific components.
a. Water: Change oil and service or replace component filters.
b. Chlorine: Change oil and service or replace component filters.

*Sequence of test provided as a guide, not as mandatory requirements.

Figure 4-2. Nonaeronautical Equipment Lubricant Sample Analysis Requirement Guide (Sheet 2 of 2)

(7) Patch test contamination analysis. If the test results exceed the class level allowed for the type equipment, the laboratory shall recommend cleaning the system and replacing the fluid.

d. Grease. The laboratory shall perform ferrographic analysis of samples taken from AH-1 series helicopter swashplates and scissors and sleeve assemblies. Samples from other components may be analyzed as directed by the AOAP Program Manager.

4-4. U.S. Air Force Special Tests.

a. The following instructions apply to suspected problems with jet engine oil. Common problems are contamination from let fuel, hydraulic fluid, water or loss of viscosity.

(1) Ensure samples are taken properly.

(2) Send two 5 dram oil sample bottles. If possible, retain a larger sample bottle for possible further testing requirements. Ensure they are tightly sealed, taped and adequately packed. Include a DD Form 2026 with all pertinent information. Give reason for test(s) and point of contact with DSN number. If analysis requirement is immediate, send by overnight express. If not, send first class to the following address:

WL POSL
ATTN DR ROBERT WRIGHT
BLDG 490 AREA B
1790 LOOP ROAD N
WRIGHT PATTERSON AFB OH 45433-7103
DSN: 785-4230
Commercial: (937) 255-4230

b. The following instructions apply to suspected problems with hydraulic fluid. Common problems are contamination from particulates, water and other fluids.

(1) Refer to MIL-HDBK-200 for area laboratory locations.

(2) If further information is required, a point of contact is WL-POSL at the numbers provided above.

SECTION V

PHYSICAL TEST LABORATORY OPERATING PROCEDURES

5-1. Total Acid Number (TAN)

a. Scope. This method, based on ASTM-D974, determines total acid number in petroleum products due to processes such as oxidation.

b. Summary of Method. In the procedure, a weighed amount of lubricant sample is dissolved in a mixture of toluene and isopropyl alcohol and p-Naptholbenzein indicator added. The mixture is then titrated with potassium hydroxide of known normality, until a color change is observed. The acidity, or Total Acid Number (TAN), of the sample is then calculated based on the milliliters of potassium hydroxide required to neutralize the known weight of sample.

c. Equipment/Apparatus/Materials

(1) Balance

(2) Erlenmeyer Flasks: 250 ml capacity

(3) Auto Zero Buret 25 milliliter capacity

(4) Toluene, TT-T 548, 6810-00-290-0048

(5) Isopropyl alcohol, O-C-265, 6810-00-227-0410

(6) P-Napthholbenzein

(7) 100 ml graduated cylinder

(8) 0.1 N Alcoholic potassium hydroxide (KOH)

(9) Laboratory apron

(10) Laboratory goggles

(11) Laboratory gloves

d. Operation/Procedures

(1) Prepare titrating solvent. Mix together 500 ml of Toluene, 495 ml of Isopropyl Alcohol and 5 ml of water. Add 0.50 grams of p-Naphtholbenzein.

(2) Tare an Erlenmeyer flask by placing it on the balance and adjusting the readout to 0.

(3) Add sample to the flask until approximately 20 grams of sample has been added. If the sample Is dark, use less of the sample. Sample size may be decreased to as small as 2 milliliters for really dark samples. Some POE oils have leak-detecting dye in them and require a smaller sample.

(4) Record the weight of the sample to two decimal places.

(5) Add 100 milliliters of the toluene/isopropyl alcohol titrating solvent and mix by swirling the sample to ensure the sample is completely dissolved. The mixture should appear orange and homogeneous at this point.

(6) Fill the automatic buret with the 0.1N alcoholic potassium hydroxide (KOH) solution.

(7) Ensure the KOH solution is at the 0 line of the buret.

(8) Add the KOH solution in small increments to the sample mixture. Swirl the flask after each addition and note the color of the mixture. Add in decreasing increments as green swirls start to appear.

(9) STOP when a distinct color change from orange to green that lasts for 15 seconds is observed color should be a grass green, possibly overlaid with brown but not a yellow brown.

(10) Record the amount of KOH used

(11) Prepare a blank by adding 100 milliliters of titrating solvent to another flask

(12) Titrate the blank following steps 5 through 10.

(13) Record the milliliters of KOH that is required to obtain a color change in the blank.

(14) Calculate TAN as follows:

(a) Subtract the milliliters of KOH required to titrate the blank in step 12 from the ml of KOH required to titrate the sample recorded in step 10. Record this number as net ml KOH.

(b) Compute TAN by multiplying net ml of KOH by 5.61 then dividing the result by the grams of sample.TAN (mg KOH/gm) = (net ml KOH) x 5.61 grams of sample

(15) Record the TAN and enter into OASIS.

NOTE

Ensure that all waste disposal is in accordance with local procedures.

5-2. Blotter Spot Test

a. Scope. This method provides a qualitative test for amount of insoluble contaminants and/or dispersant ability of used lubricants from diesel engines.

b. Summary of Method. After vigorous shaking, one drop of the used lubricant is placed in the center of filter paper. The oil spot is allowed to develop for 15 minutes, and the resulting spot is evaluated for total contaminants, coolant contaminants, and dispersant effectiveness.

c. Definitions.

(1) Dispersancy. Dispersancy is a measure of the ability of the oil to support debris. Dispersancy additives in most modern lubricants keep contaminants suspended in the oil rather than allowing them to be deposited on engine surfaces.

(2) Contaminants. Contaminants are soluble and insoluble materials that accumulate in used oils from many sources and, that if allowed to accumulate beyond recommended guidelines, may become harmful to the equipment. Some examples are fuel, oxidation products, soot, dust, wear debris, water and coolant.

d. Equipment/Apparatus/Materials.

(1) Filter paper (circles or sheets).

(2) Wire. Approximately 1/16th inch diameter wire (paper clip).

e. Standards/Standardization/Calibration. It is recommended that the operator prepare blotter spots of new oils to become familiar with normal spot sizes and patterns. Although wire size is not critical, it is important that the same size wire is used each time to drop the oil on the filter paper.

f. Operation/Procedures.

(1) Shake sample vigorously to ensure homogeneity.

(2) Using a suitable wire, place one drop of the oil sample in the center of the filter paper.

(3) Allow 15 minutes for the oil spot to spread and dry.

(4) Evaluate the oil spot for the following characteristics: solids contamination, dispersancy, and coolant contaminants.

g. References/Guidelines.

(1) Solids Contamination. Distinctive patterns develop after placing the oil on the filter paper. Evaluation of solids contamination becomes obvious after experience is gained for a given type of equipment. Solids contamination is evaluated as being light, medium, or heavy. Care should be exercised if solids suddenly disappear and an oil or oil filter change has not been reported. This condition can indicate a loss of dispersion and a “drop out” of solids that cannot be detected by any of the available test methods. When heavy solids are confirmed or in the case of solids “drop out”, a recommendation to change the oil and the oil filter should be issued.

(2) Dispersancy, Dispersancy is evaluated as good, fair, or poor. The spots for oils with good dispersion are characterized by fuzzy or lacy patterns, with solids carried well out in the paper. Generally, the greater the size of the spot and spread of the solids as compared with the initial spot, the better the dispersion. As the oil’s dispersion is reduced, the spot becomes smaller. The spots for oils with poor dispersion have sharp and distinct peripheries and the spots after 15 minutes are not much larger than the initial spots. A recommendation to change oil should be issued if dispersion is poor.

(3) Coolant Contaminants. Water and other coolant contaminants will reduce or destroy dispersant additives. Spots that form are similar to those described for the dispersion guidelines. In addition, these spots will often appear to be wet long after normal spots are dry.

h. Reports. Record test results as follows.

(1) Total Contaminants - (1) Light, (2) Medium, (3) Heavy.

(2) Coolant Contaminants - (1) Not Detected, (2) Present.

Dispersion- (1) Good, (2) Fair, (3) Poor.

Using the numerical codes above, the best quality oil would be rated 1,1,1, while the worst possible case is 3,2,3. When numerical coding is used, it is not necessary to save the actual blotter spot record, since data can still be trended.

5-3. Ferrographic Analysis Procedures

Army CH-47D Helicopter Swash plate/Scissors and Sleeve Assemblies

a. Scope. This procedure is used to determine the size, shape and type of wear-metal particles being generated by a piece of equipment as well as the mode of wear (e.g. spalling, rubbing and cutting) producing the particles.

b. Summary of Method. The grease sample is diluted with a fixer solution to break down the bonding material of the grease. The liquid is then allowed to flow across a substrate mounted over a magnetic field gradient. The magnetic field aligns the particles in strings along the slide and the fixer solution is passed across the substrate to remove the residual grease. After drying, the substrate is analyzed under a Ferroscope. Laboratory grease evaluation procedures are contained in volume III.

c. Equipment/Apparatus/Materials. The equipment required is the analytical Ferrograph and Ferroscope.

d. Standards. None

e. Operation/Procedures

WARNING

Repeated or prolonged contact with liquid tetrachloroethylene or inhalation of vapors can cause skin and eye irritation, dermatitis, narcotic effects, and liver and kidney damage. After prolonged skin contact, wash the contacted area with soap and water. Remove contaminated clothing. If vapors cause irritation, get to fresh air. For prolonged over-exposure, get medical help. When handling liquid in vapor-degreasing tanks with hinged cover and air exhaust, or at air-exhausted workbench, wear approved gloves and goggles if contact with liquid is likely. When handling liquid at open, unexhausted workbench, wear approved respirator, gloves, and goggles. Dispose of liquid-soaked rags in approved metal containers.

(1) Measure 1 cubic centimeter (cc) of grease and place it into a 16 x 150 millimeter (mm) test tube. Add approximately 7 milliliters (ml) of tetrachloroethylene and shake until thoroughly dissolved.

(2) Remove the glass substrate from the package. With the dot in the lower left hand corner, position the substrate so that the top edge is elevated and resting on top of the magnet assembly. The drain tube supports the bottom edge of the substrate.

(3) Cut a 4 inch long piece of Tygon tubing and two pieces of turret tubing, one piece 2 inches long and one piece 8 inches long. Cut both ends of the turret tubing at a 45 degree angle and insert an end of each piece into the Tygon tubing. Place the 2 inch long piece of turret tubing in the delivery arm with the 45-degree angle open end facing the drain tube.

(4) The sample and rinse vials are supported at least 3 ½ inches above the peristaltic pump. The pump itself is not used. The end of the 8-inch piece of turret tubing is inserted into the sample vial, supported by a double-notched stopper (one notch for the turret tube and one to equalize pressure).

(5) A screw clamp is placed on the Tygon tubing. A slight suction is applied at the delivery arm end of the tubing and the clamp is loosened long enough to allow the sample to flow halfway through the tube. The clamp is tightened, the suction removed, and the delivery arm is lowered until the exit end of the turret tube touches the substrate. The delivery arm is then backed off slightly.

(6) The clamp is released very slowly allowing the sample to flow evenly down the substrate. When the volume in the sample bottle reaches approximately ¼ inch, the Tygon tube is clamped and the end of the turret tube is placed in the rinse vial. The clamp is then released and the substrate rinsed with fixer solution. Allow several air gaps in the turret tube by opening and closing the clamp several times to ensure that the oil does not back up into the rinse.

(7) Allow the substrate to dry. Remove the substrate by lifting upon the exit end and pulling it straight out of the holder so as not to break the completed Ferrogram. Number the Ferrogram and the Ferrogram cover with the component serial number and sample number. This can be done using thin typewriter correction tape or a glass-marking pen.

(8) The Ferrogram is then analyzed using the Ferroscope. The wear-metal debris is compared to the guideline photographs for degrees of severity. The results are recorded on the Ferrograph worksheet (see Appendix O), and filed by component serial number along with the substrate. Worksheets and substrates will be kept on file for a minimum of one year.

Supplemental Ferrographic Oil Analysis Procedures (Army).

This is a supplemental procedure used by the Army in the analysis of suspect aeronautical oil samples. Suspect oil samples are defined as those for which one or more of the following diagnostic indicators are observed: chip light; vibration; metal on screens or filters; oil of unusual color, odor, or high solids content; and oil samples having abnormal spectrometric trends or wear-metal content.

a. Scope. This procedure captures information relative to the size, shape, and types of wear-metal particles and debris too large to be detected by spectrometric analysis.

b. Summary of Method. The oil sample is diluted with a fixer solution to increase the rate of flow. The sample is then analyzed using the Direct Reading (DR) Ferrograph and appropriate guidelines, to quantify both large and small wear particles. If the established DR guidelines are exceeded, the development of a Ferrogram and its examination under the Ferroscope is required.

c. Equipment/Apparatus/Materials. The equipment required is the DR Ferrograph, analytical Ferrograph or Ferrograph Machine III (FMIII), and the Ferroscope.

d. Standards. None.

e. Operation/Procedures.

WARNING

Both the fixer reagent and filtered oil contain a nonflammable chlorinated hydrocarbon. Its vapor however is harmful if breathed. Ensure adequate ventilation. Avoid contact with skin. Do not take internally. Serious injury may result if these cautions are not followed.

f. Direct Reading (DR) Ferrograph.

(1) Press the on/off switch on the rear of the DR unit to the on position. At this time the “INSERT TUBE LED” lights, and both windows display 0.0. This is a standby state during which the DR warms up. NOTE: The DR should be turned on at least 30 minutes before testing is begun.

(2) Heat the sample oil to approximately 149° F (65° C) and vigorously shake the sample in the original container until all sediment is homogeneously suspended in the oil.

(3) Turn the drain pump knob so that the white indicators line up.

(4) Using the dispenser assembly on the fixer reagent bottle, pump exactly 2 ml of fixer reagent/solvent into a new test vial.

(5) Using a pipette dispenser, add exactly 1 ml of sample lubricant to the same test vial and mix thoroughly.

(6) Place the vial in the holder and prepare the DR for testing by:

(a) Remove the precipitator tube from its shipping bag.

(b) Carefully raise the clamp assembly and place the glass section of the precipitator tube in the groove provided. Be sure not to touch the glass tube with your fingers. This could interfere with zeroing the instrument (see paragraph (9)). As you slide the tube in, note the small lever at the rear as you position the tube (you will hear a slight click).

(c) When the precipitator tube is correctly positioned the “INSERT TUBE LED” goes off and the “PRIME LED” lights: Gently lower the clamp to lock the tube into position on the magnet.

(d) Place the Tygon end of the tube on the inlet nipple.

(e) Run the opposite length of the tube around the tube guide at the left of the DR. It fits behind a lip.

(f) Run the tube through the two spring supports up to the sample vial. It is better to have the excess length near the vial and a relative length down to the guide.

(g) Place the opposite end of the tube into the vial. This should touch the bottom of the vial so that the entire sample will be drawn out during the test.

(h) Make sure that the waste bottle is placed in the well, and place the drain tube permanently attached to the outlet nipple into the waste bottle.

(7) Confirm that the “INSERT TUBE LED” is off, and that the “PRIME LED” is on. If the opposite occurs, readjust the precipitator tube against the actuator arm.

(8) Press the PRIME pushbutton. This action causes the PRIME LED to go off and both the DL ZERO and DS ZERO LEDS to come on for approximately 2 seconds (at this time the DR circuitry automatically zeros on the empty precipitator tube). When zeroing is complete, the DS LED goes off, and only the DL LED is on, indicating the DR is functioning correctly.

(9) Create a suction in the precipitator tube by slowly turning the drain pump knob in a clockwise direction. This action draws the mixed fluid from the sample vial. When the fluid level is drawn at a level below the sample vial, the siphoning action takes over, and the oil flows by itself. Stop turning when the white line on the knob lines up with the other line of the DR. When the fluid passes the second light path in the test area, the auto-zero sequence is initiated. Again, both the DL and DS LEDS are on. When the DR has zeroed on the sample, the 2 LEDS go off; the windows display 0.0; and the RUN LED lights. This indicates that the test is in progress and typically requires about 5 minutes to complete. As the solution flows over the test area, the display increments from 0.0, indicating that residual wear particles are dropping into the 2 light paths. When the liquid stops flowing, record the readings.

(10) Turn the drain pump knob slowly in a clockwise direction after all the oil has passed over the test area. This action empties the pumping system into the waste bottle.

(11) Remove the precipitator tube from the test area.

(12) Discard the precipitator tube, sample vial, and pipette tip before doing another test.

g. Ferrogram preparation. There are three different methods of preparing ferrogams; the standard method, the fast method that employs the older model Analytical Ferrograph, and the new method that employs the newer model FMIII.

h. The Standard Method.

(1) Remove the Ferrogram substrate from the sealed bag and protective envelope.

CAUTION

Avoid touching the surface of the substrate with the fingers. Always handle the substrate by the edge.

(2) Install the substrate in the substrate-holding fixture by retracting the spring-loaded positioning pin and inserting the substrate into the holding fixture as far as possible. When positioning the substrate, make sure that the black dot appears in the lower left-hand corner.

(3) Remove the turret tube from the sealed bag and cut one end at a 45 degree angle. This will become the exit end of the tubing.

(4) Press the exit end of the turret tube with the 45 degree angle facing the operator into the delivery arm holding groove. Notice the index mark on the delivery arm and observe the distance from the index mark to the end of the arm. Now extend the turret tube an equal distance beyond the end of the delivery arm.

(5) Press the turret tube into the exit notch on the downstream side of the pump.

(6) Release the pump turret arm locking screw by turning the knurled nut counterclockwise. Open the pump turret arms, thread the tube around the turret and then partially close the turret arms.

(7) Press the turret tube into the pump entry tube clamp on the upstream side of the pump and secure it by turning the knurled eccentric clamp lever counterclockwise. Tighten the turret arms.

(8) Inspect the drain tube to make sure no sections of it are liquid filled. Draw out any liquid with a cotton swab.

(9) Insert the drain tube into the drain tube holder and rotate the drain tube holding fixture counterclockwise until it is centered on the substrate.

(10) Lower the notched end of the drain tube until the tip touches the substrate.

(11) Prepare the sample by first heating it to 149°F (65°C) and then shaking vigorously until all sediment is homogeneously suspended in the oil.

(12) Discharge 5 ml of fixer reagent into a sample vial (to be used as a wash), and place the vial in the rack slot nearest the magnet assembly.

(13) Discharge 1 ml of fixer reagent into a second sample vial and place it in one of the empty vial rack slots. Add 3 ml of oil sample to the vial containing 1 ml of fixer reagent and mix thoroughly. This can be done with a mechanical shaker or by hand if care is taken to cover the mouth of the vial with a non-contaminating material or stopper.

(14) Place the sample vial back into the rack. Because of the influence of the field strength of the magnet, place the vial containing the sample mixture in the position farthest away from the magnet assembly.

(15) Install the spring clip assembly on the oil sample vial.

(16) Insert the suction end of the turret tube into the bottom of the sample vial and press the tube into the spring clip.

(17) Lower the delivery arm until the exit end of the tube touches the substrate. Then, back off the delivery arm approximately 1 mm so that the liquid does not drip, but flows freely onto the substrate.

(18) Place the power switch to the ON position, set the timer to 15 minutes, and depress the red timer START button to start the sample cycle.

(19) When the sample vial is empty, reset the timer to 10 minutes and depress the red timer START button to start the wash cycle.

(20) Remove the spring clip and turret tube from the empty vial and transfer both to the vial containing the fixer reagent wash solution.

(21) Introduce three air gaps into the flow in the turret tube by removing the end of the turret tube momentarily from the wash solution and then reinserting it back into the solution. This prevents the oil from diffusing back into the wash solution.

(22) Immediately after the pump shuts off, lift the turret tube off of the ferrogram by raising the delivery arm.

(23) When flow through the drain tube has stopped (approximately 1 minute) lift the drain tube holder with the drain tube in it, and rotate it 90 degrees clockwise.

(24) Allow sufficient time for the ferrogram to dry; do not remove the ferrogram until all of the fixer reagent has evaporated.

(25) Release the spring-loaded positioning pin and lift the ferrogram up vertically.

CAUTION

Do not drag the ferrogram across the magnet as this could disturb the particles on the ferrogram.

(26) Label the ferrogram and ferrogram cover with the component serial number and sample number. This can be done using typewriter correction tape or a glass marking pen.

(27) Discard the turret tube and the sample and fixer reagent vials.

i. The Fast Method.

(1) Measure 5 ml of sample and place into a 16x150 mm test tube. Add approximately 7 ml of fixer reagent/solvent and shake until thoroughly mixed.

(2) Follow steps (3) through (4) of the Standard Method above.

(a) Follow step (2) from the standard method above.

(b) Cut a 4” long piece of Tygon tubing, a 2” long piece of turret tubing, and an 8” piece of turret tubing. Cut the ends of the turret tubing at a 45° angle to the axis of the tubing. Insert an end of each piece of turret tubing into the Tygon tubing. Place the 2” long piece of turret tubing into the delivery arm with the 45° angle open end facing the operator.

(c) Follow step (4) from the standard method above.

(3) The sample and rinse vials are supported 3 ½ inches above the peristaltic pump. The pump itself is not used. The free end of the turret tubing is inserted into the sample vial, supported by a double-notched stopper (one notch for the turret tube and one to equalize the air pressure).

(4) A screw clamp is placed on the Tygon tubing section. A slight suction is applied at the delivery arm end of the tubing and the clamp is loosened long enough to allow the sample to flow halfway through the tube. The clamp is tightened, the suction removed, and the delivery arm is lowered until the exit end of the turret tube touches the substrate. The delivery arm is then backed off slightly.

(5) The clamp is initially released very slowly allowing the sample to establish a path down the substrate. Once the path is established, the sample is allowed to flow at a faster rate. When the volume in the sample vial reaches approximately ¼ inch, the tube is clamped and the end of the turret tube is placed in the rinse vial. The clamp is then released and the substrate rinsed with the fixer solution. Allow several air gaps in the turret tube by opening and closing the clamp several times. This will ensure that the oil does not back up into the rinse.

(6) Follow steps (25) through (27) for the Standard Method above.

j. New Method (FMIII). Automatic Cycle: The automatic cycle button initiates the flow of liquid across the ferrogram at a controlled rate and will automatically switch to a rinse cycle and a drying cycle to give you a properly prepared ferrogram. Machine set up instructions and the semi-automatic and fixer cycles are described in the manufacturers users manual.

NOTE

The instructions provided below describe the processing of a single sample. The design of the FMIII provides the ability to process two samples simultaneously if desired.

(1) Using the dispenser assembly on the fixer reagent bottle, pump exactly 1 ml of fixer reagent into a new test vial.

(2) After heating the sample to 149°F (65°C), using a pipette dispenser, remove slightly more than 1ml of sample lubricant from a sample bottle.

(3) Add exactly 1 ml of sample lubricant to the same sample vial.

(4) Repeat steps (2) and (3) until you have a total of 3 ml of sample lubricant in the sample vial.

(5) Mix these solutions thoroughly.

(6) Place the sample vial under the sample head assembly and seal it into position by pushing the bottom of the vial into the detente. Swing the delivery arm/sensor assembly outward over the magnet assembly cover.

(7) Place the notched end of the FMIII sample tube through the sample head assembly all the way to the bottom of the vial.

(8) Place the other end of the FMIII sample tube through the delivery arm/sensor assembly until the sample tube bottoms out onto the surface of the magnet assembly cover. This will properly locate the right height for the FMIIII sample tube when being placed into operating position.

(9) Unpack a glass substrate from its protective envelope.

(10) are fully holding the substrate by the edges, place the entry end of the substrate on the lip of the magnet assembly cutout with the exit end resting on the vacuum drain assembly (the exit end is defined by the black dot).

NOTE

The black dot viewed on the left hand side indicates the substrate is in the proper position for sample lubricant to flow down the non-wetting barrier.

(11) Push down the vacuum drain assembly into operating position.

(12) Swing the delivery arm/sensor assembly over the glass substrate and center it by the detente for proper position.

(13) Press the auto cycle button. This action causes the SEMI-AUTOMATIC CYCLE LED switch to go off and the SAMPLE LED to go on initiating the pumping action in the sample vial. Soon the sample lubricant will go through the sample tube and deposit wear debris on the glass substrate with the excessive fluid and fumes being vacuumed away by the vacuum drain assembly. Once all the sample fluid is gone indicated by our sensor, the pumping action will still occur removing any residual sample lubricant for about two minutes. The FIXER LED will come on indicating fixer is now washing the glass substrate for about 8 minutes.

NOTE

The delay time and fixer cycle can be adjusted. See manufacturers users manual. Afterwards, the fixer wash will stop and the vacuum drain will still be on, removing any residual fixer and fumes until the ferrogram is dry. The COMPLETE CYCLE LED and the sound of beeper indicate this.

(14) Check to make sure that the ferrogram is dry by swinging the delivery arm/sensor assembly outward, and visually inspecting the ferrogram for any remaining fixer.

(15) Carefully pull the vacuum drain assembly upwards. Position your fingers so that you are controlling the ferrogram by the edges and carefully lift straight up.

NOTE

Do not move ferrogram side-to-side near the magnetic field. This may relocate the wear debris and give misleading information.

(16) Place the ferrogram into its protective envelope and mark with the component serial number and sample numbers.

(17) Remove the FMIII sample tubing and the sample vial from the FMIII and discard them.

k. Evaluation. At this point the ferrogram is ready for optical examination using the Ferroscope operating instructions for the Ferroscope are found in the manufacturers users manual. The sample has already been determined to be suspect based on spectrometric results and DR readings. The evaluation process then is primarily concerned with determining the size, shape, and type of wear being generated. Techniques and guidelines for the ferrogram evaluation process are found in the Wear Particle Atlas prepared for the Advanced Technology Office, Support Equipment Engineering Department, Naval Air Engineering Center, Lakehurst, NJ. A copy of the Wear Particle Atlas is furnished with each ferrograph system.

l. Recording Results. The results are recorded on the ferrograph worksheet (Appendix O) and filed by component serial number along with the substrate. Worksheets and substrates will be kept on file for a minimum of 1 year.

m. Ferrography is performed on aeronautical fine filtration equipped components or when units report debris found during routine inspection. Also, if abnormal wear particle analysis readings are obtained from the oil sample then further testing is required.

n. Oil analysis of the servicing oil is the first step in the analysis process using the atomic emission spectrometer wear particle readings that are noted on the component historical record. The second step is to prepare a ferrogram for which the oil has been pre-heated to 60 degrees Centigrade, using a pipette and dispenser to withdraw 1 ml of the component's oil sample, which is then diluted, with 1 ml of Fixer oil. Using a 100 ml glass vial, shake vigorously. Procedures for Direct Read (DR) III instrument are prescribed in the instrument's manual. Enter the component results on the DR Analysis Report Register Appendix 'O' and the unit's submitted DD Form 2026/DA Form 5991-E, Oil Analysis Request. The component analysis results from the spectrometric and AR analysis readings are used to determine if further ferrographic tests are necessary. If no further ferrographic test is deemed necessary, evaluation is based on spectrometric and physical property test results.

5-4. Fourier Transform Infrared (FT-IR) Analysis.

a. Scope. FT-IR or Fourier transform infrared spectroscopy is an analytical measurement method used to characterize and identify the structure and relative quantity of organic lubricant molecules. The FT-IR can detect water, fuel, anti-freeze, by-products formation (oxidation, nitration, sulfates), foreign fluid contamination, lubricant breakdown and additive depletion.

b. Summary of Method. Oil is drawn by vacuum into a transmission cell that is transparent to infrared (IR) light. As the infrared light beam is transmitted through the cell, the oil and its contaminants absorb some of the light; the remaining light exits to a detector producing an infrared transmission spectrum. The instrument software creates an absorption spectrum to classify specific and repeatable peaks corresponding to the molecular bonding characteristics of the oil. This software extracts information for each lubricant.

c. Equipment/Apparatus. The BIO-RAD Oil Analyzer is currently used for FT-IR analyses in the JOAP. Refer to the BIO-RAD Oil Analyzer Operator's Manual and the Win-IR Software Quick Reference Guide for operation and maintenance of the FT-IR spectrometer.

d. Materials.

(1) Wash beaker with wash solvent (n-heptanes or hexane)

(2) Wash bottle with wash solvent

(3) Waste beaker

e. Standards/Standardization/Calibration. Use the calibration function in the oil analysis mode to check alignment, voltages, cleanliness, water vapor, and cell path-length. The software will issue warnings for any parameter out of limit. If any function is beyond preset limits, instrument operation cannot continue until the condition is corrected.

Following are the recommended Win-IR timing parameters for oil analyzers with and without the auto sampler:

AUTOSAMPLER SPECIFIC PARAMETERS

Maximum Load Time (seconds)	90
Wash Time (seconds)	12
Drying Time (seconds)	20
Fill-to-Scan Delay Time	0
Maximum Retries	2
Consistent Loads	2
Auto start Wash/Dry	0

GENERAL PARAMETERS

Number of Scans	20
Rescan Background (Minutes	2
Right Monitor Window (Wave numbers)	3000
Left Monitor Window (Wave numbers)	1500
Start Scanning at Absorbance	1.4
Valid Sample (Absorbance)	2.1
Cell Clean (Absorbance)	3
Background Clean (Absorbance)	2

f. Operation/Procedures. The sample is taken directly from the sample container. The JOAP FTIR-instruments running all versions of the BIO-RAD Win-IR software are configured to run 10 analysis methods that correspond to different oil classes and/or oil applications with different limits. The methods are listed below:

Method Name	**Lubricant Type (example)**
Run_All_Test	Unknown
Petroleum_Ground	Diesel Crankcase (Mil-L-2104)
Synthetic_Turbine	Polyol Ester (Mil-L-23699)
Syn-Ground_Hyd	Ground Equipment Synthetic Hydraulic (Mil-H-6083)

Syn_Ground_Hyd (M1)	Fire Retardant Hydraulic (Mil-H-46170)
Petroleum_Hydraulic (10W)	Ground Equipment Petroleum Hydraulic (Mil-L-2104, 10W)
Syn_Aero_Hyd	Aircraft Hydraulic (Mil-H-83282)
Mil-L-17331	Steam Turbine (Mil-L-17331)
Mil-L-9000	Marine Diesel Crankcase (Mil-L-9000)
Syn_Aero_Hyd (350)	Aircraft Hydraulic (Mil-H-83282, 350 PPM limit for water)

The Petroleum Diesel Engine Oil FT-IR method is called “petroleum ground”. It is designed primarily for analyzing Mil-L-2104 type lubricants. Many diesel engine lubricants and some gear oils (Mil-L-2105) and transmission oils fit this application. Polyalphaolefins (PAO) and synthetic/petroleum blends should be analyzed using this method. A similar method is used to analyze marine diesel crank case Mil-L-9000 fluid but with different limits.

The Gas Turbine Oil FT-IR method is called “synthetic_turbine”. This method is designed primarily for Mil-L-23699, Mil-L-7808 and DoD-L-85734 type lubricants. These lubricants are polyol esters.
Listed below are the methods developed for hydraulic fluids along with the primary fluid and examples of equipment use:

Method Name	**Primary Fluid**	**Equipment Example**
Syn-Ground_Hyd	Mil-H-6083	M109 A6
Syn_Ground_Hyd (M1)	Mil-H-46170	M1A1
Petroleum_Hydraulic (10W)	Mil-L-2104, 10W	M578, 113A3
Syn_Aero_Hyd	Mil-H-83282	Helicopter hydraulic systems
Mil-L-17331	Mil-l-17331	Steam Turbine
Syn_Aero_Hyd (350)	Mil-H-83282	UH60 hydraulic systems

(1) Turn on the instrument and allow it to warm up for 30 minutes.

(2) Open the Win-IR software, the default screen is the “Used Oil” User Mode.

(3) Calibrate the instrument at the beginning of each work day/shift. (Note: The pump must be running to calibrate. This is to remove any oil/solvent that may have run back into the cell.) Press **“Calibrate”**. The system will check the calibration, alignment, cell cleanliness, take a background, ensure background integrity, and measure the cell path-length. Once completed, the screen will display the results. The following is a typical screen display.

Calculated Cell Path-length: _____ (typically 0.1mm, range 0.09 to 0.14mm)

Signal voltage: _____ (typically -6 volts, range -5 to -7 volts)

Alignment Quality: _____ (typically 15%, range 10% to 50%)

CH Absorbance Intensity: _____ (typically less than 0.2, range 0 to 0.2)

Results should be within the limits specified. Keep a log of these results. If the cell is dirty, a message will appear: **“Warning - Cell Requires Cleaning!”** Clean cell and **“Calibrate”** again. If problems continue to occur, check with the supervisor. See **“Operator Mode Error Messages and Actions”** in the Bio-Rad Oil Analyzer Operator’s Guide for the Hardware and Software for other problems.

(4) After internal calibration, click on **“OK”**. The original User screen returns. Now click on **“Analyze”**. A final check of the cell will be made and then the **“Sample Information Entry Form”** appears.

Laboratory ID Number: _ _ _ _ _

TEC:_ _ _ _

Component Model #: Undefined

Component Serial Number: _ _ _ _ _ _ _ _ _ _ _

End Item: Undefined

End Item Serial Number: _ _ _ _ _ _ _ _ _

Fluid Type: Undefined

Time Since Fluid Change: _ _ _ _

Check Info **Cancel**

Fill in the items with the spaces by clicking on them or press the **Tab** key to move down the screen. Do not press Enter. The other items will auto-fill when **"Check Info"** is pressed (if the TEC code is valid.) If the TEC is unknown, type **YYYY** for the TEC. A screen will occur asking you to chose the correct lubricant type e.g. synthetic aeronautical. If known, arrow down to the correct fluid and hit Enter. If unknown, the **"scan and search"** may be chosen. In this mode, the FT-IR scan will be performed. After the scan, a library of spectra will be searched to find the best match. The name of the lubricant matched will be given on the report along with the quality of the match presented as a percentage.

(5) The "Sample Information Entry Form" screen will re-display once. "Check Info" is pressed, with an extra button "Analyze Sample":

Check Info *Analyze Sample* *Cancel*

Check all the entered information against the sample submission one more time, then either use the mouse to click on the **"Analyze Sample"** button or just hit Return. The system will now wait for the sample to appear in the cell.

(6) Load the sample cell by pressing the pump rocker switch to the right position, marked **FILL/RINSE,** place the sample bottle under the sample probe (tubing) such that the end is completely immersed below the level of the oil sample.

When the cell is filled, the system will **"Beep"** twice and the message **"Stop Pumping"** will appear. (Or stop when oil exits the bottom tubing.) NOTE: For aeronautical synthetic lubricants with low viscosity, release the pressure on the pump or keep the sample probe in the oil sample bottle. The backpressure on the pump will continue to sip the oil through even though the pump is turned off.

(7) Allow the FT-IR to collect data. The number of scans will count down in the bottom right hand corner of the screen and the name of the sample will appear at the top of the screen. Once the system has acquired and signal averaged the spectrum, a message **"Please Empty Cell"** will appear.

(8) Press the rocker pump switch to the left **"EMPTY"** position. Hold the waste beaker under the sample probe. Once the cell is empty, the system will **"Beep"** twice and the message **"Please Clean Cell"** will occur.

(9) Rinse the sample probe with solvent from the wash bottle while still holding the waste beaker underneath.

(10) Now press the rocker pump switch to the right **"FILL/RINSE"** position. Rinse the sample probe (tubing) with wash solvent and pull the solvent through the system. Continue rinsing until the solvent exiting the bottom tubing appears clean. Leave the pump running to pull air through the system. The solvent should be exiting into a waste container. NOTE: Viscous fluids e.g. ground equipment, will clean faster and easier with an air/solvent mixture to "scrub" the walls of the tubing rather than just plain solvent.

(11) Observe the display in the bottom left corner of the screen and continue the cleaning process until the displayed absorbance is less than 0.30. The system will continuously check the cell cleanliness. Once clean, the system will return to the **"Sample Information Entry"** screen.

(12) Repeat steps (6) through (11) for additional samples.

(13) Shut down the system by clicking the button labeled **"Cancel"** in the **"Sample Information Entry"** screen.

(14) Release the pressure on the pump tubing to extend the tubing life.

(15) Shut off the pump (center position). The screen will go blank after 10 minutes.

(16) Do not turn off power to the FT-IR. The heat from the system will assist in keeping the internal KBr beam splitter from fogging and extend the life of the desiccant.

g. Safety Precautions. The solvent, N-heptane, is flammable. Store in a flammable locker and dispose of the oil/solvent waste according to local regulations. (N-heptane is a petroleum distillate.) Gloves and lab coat should be worn, especially for any oil spill cleanup.

5-5. Fuel Dilution Determination in Used Lubricating Oils.

a. Scope. This method covers the determination of oil dilution by diesel fuel or gasoline in engines and is to be conducted when screening tests indicate the presence of fuel contamination. Two methods are available for determining fuel dilution, the flashpoint method and the fuel sniffer method.

b. Summary of Methods.

(1) The Setaflash Tester low/high temperature, closed cup models, is used to determine fuel dilution of used lubricating oils in diesel or gasoline fueled engines by measuring flashpoint depression.

(2) The Fuel Sniffer measures fuel dilution by using a surface acoustic wave sensor to determine the percent fuel in the sample by analyzing the air in the top of the sample bottle.

c. Equipment/Apparatus/Materials.

(1) Flashpoint method

Setaflash Testers. One of the following is used, depending on oil tested.

(a) Model 01SF Lo Temperature, closed cup, used for measuring fuel dilution in lubricating oils of gasoline engines.

(b) Model 03SF, Hi Temperature, closed cup, used for measuring fuel dilution in lubricating oils of diesel engines.

(2) Fuel Sniffer, manufactured by Spectro, Inc.

d. Standards/Standardization/Calibration. Prepare calibration standards of diesel fuel or gasoline in MIL-L-2104 (OE 30 weight) or in MIL-L-9000 (grade 9250) oil at concentrations of 0, 5.0, and 10.0 percent by volume. Fuel standards should be made of the same fuel available to the majority of customers of the oil lab. Standards should be prepared a minimum of once each month and stored in tightly capped glass bottles.

e. Preparation of Sample. No special sample preparation is required; however, particulate matter should be allowed to settle as much as possible and syringe needle should be immersed in top part of sample in an effort to prevent syringe plugging from large particulates.

f. Operating Instructions.

(1) Setaflash method

NOTE

Detailed instructions are also found in ASTM Test Method D-3828.

(a) Filling Gas Supply System. It is recommended that the Setaflash tester be connected to the laboratory gas supply wherever possible.

SAFETY NOTE

Connection to the laboratory gas supply must NOT be made with flexible tubing. Connect ONLY with stainless steel or copper tubing and permanent attachments.

(b) The following applies only when liquefied petroleum gas (LPG) must be used.

1. Fully charge the tank ONLY when the instrument is at ambient temperature. Do not recharge the tester tank with the pilot test jet lit nor in the vicinity of any ignition source.

CAUTION

The Setaflash Tester contains LPG which may present a safety hazard unless directions are followed explicitly.

2. Shake the container of LPG to make sure it contains fuel. If empty, it will exhaust the remaining fuel from the Setaflash tester integral tank. Hold the cylinder with the valve nozzle straight down. The valve nozzle requires an adapter that is supplied with the container. Do not twist or bend the nozzle on the cylinder as this may damage its main valve.

3. Press the nozzle firmly into the valve of the Setaflash integral tank. A hissing sound indicates that fuel is entering the tank.

4. When the tank is full, a spray-back occurs. Remove the container from the tank valve immediately.

5. Wipe off excess fuel from the tank or adjacent areas with absorbent paper.

6. Regular laboratory gas may be used with an adapter - SEE SAFETY NOTE ABOVE.

(c) Determination of flashpoint by FLASH/NO FLASH method.

1. Inspect sample well and lid/shutter for cleanliness, and freedom from contamination.

2. Switch instrument to SUPPLY.

3. Turn the temperature dial fully clockwise causing the RED signal light to glow.

4. When the thermometer reads approximately 295°F (140°C), slowly return the temperature dial to the point at which the signal light is just extinguished.

5. The sample well temperature is stable when the signal light slowly cycles ON/OFF. Slight adjustments may be necessary to obtain precise temperature. Numbered divisions are used as a guide to temperature settings.

6. Charge the syringe with 4 ml of sample, transfer to the filling orifice, taking care not to lose any sample.

7. Set the timer by rotating the knob clockwise to its fullest extent. DO NOT FORCE AGAINST THE STOP.

8. Meanwhile, open the gas control valve and light the pilot/test flame. Adjust the test flame size with the pinch valve to match the 4mm dial gauge ring.

9. When the time has elapsed, slowly and uniformly open and close the slide completely over a period of 2 ½ seconds - watch for flash at 300°F (150°C). Report results as less than or more than 300°F (150°C) as applicable.

10. Close the Gas Control Valve.

11. To prepare for the next test, unlock the lid and shutter assembly. Lift to hinge stop. Soak up sample with tissues to remove any traces of contamination (if necessary use moistened tissues). Allow the sample well to cool below 212°F (100°C) before using moistened tissue. Clean the underside of the lid and filling orifice. A pipe cleaner may be of assistance in cleaning the orifice.

12. Any further cleaning necessary may be carried out by complete removal of the lid and shutter assembly. To remove this, disconnect the silicon rubber gas tube and slide the assembly to the right. Unscrewing the retaining nut by hand and removing the plunger assembly should also clean the syringe.

(2) Fuel Sniffer

(a) Scope. The Fuel Sniffer offers a new capability for engine condition monitoring. It can be used in the laboratory or in the field to give rapid and accurate measurements of fuel contamination in engine oils. The Fuel Sniffer is a non-destructive test that requires only a small oil sample. The results of the analysis are reported in percent dilution.

(b) Summary of Method. Oil samples should be collected in glass or plastic bottles. The quantity of oil collected should be a representative sample and at least 25 ml. The sample should remain capped and properly labeled before use. It is important that the type of fuel being used in the engine is noted, as this will affect the calibration standard used. The Fuel Sniffer is menu driven. Interaction with the Fuel Sniffer software, LCD and sample inlet is accomplished through the control panel. The sample inlet is a 1/8-inch Swagelok compression fitting. The tubing that connects the Fuel Sniffer to the sample bottle attaches at this location using a 1/8-inch Swagelok nut provided on the tubing assembly. Turn clockwise to attach the tubing.

CAUTION

Do not over-tighten. The fluid is drawn into the unit, and a measurement of percent fuel from 0 to 10% is provided.

(c) Equipment/Apparatus/Materials. Spectro, Inc manufactures the Fuel Sniffer. They can be reached at:

Spectro, Inc., 160 Ayer Road, Littleton, MA. Ph (978) 486-0123, Facsimile (978) 486-0030, e-mail: sales@spectroinc.com

Fuel Sniffer Specifications

Dimensions:	9 cm x 20 cm x 28 cm (3.5" x 8" x 11")
Weight:	2.7 Kg (6 pounds)
External Power:	85 to 265 VAC, 47 to 440 Hz
Sensor:	SAW Chemical Microprocessor
Display:	LCD, with LED backlight
Serial Output:	RS232C @ 9600 Baud
Measurement Range:	0 to 10% fuel dilution
Measurement Time:	60 seconds
Accuracy:	+/- 0.2%
Data Log Memory:	500 measurements

The Fuel Sniffer is designed for general-purpose laboratory use. The Fuel Sniffer is **not** designed for use in areas containing explosive atmospheres and should not be operated in these environments. It is recommended that a clean and dedicated circuit be provided in an earth ground configuration to power the Fuel Sniffer. A 110 or 220V power cord is supplied for this purpose.

CAUTION

Always connect the IEC plug into the back of the Fuel Sniffer before plugging into the main power source.

(d) Standards/Standardization/Calibration. To perform a calibration of the Fuel Sniffer, a calibration standard must be prepared. It is recommended to calibrate the Fuel Sniffer on a daily basis to ensure accurate results. The Fuel Sniffer requires only one reference calibration point due to the SAW sensor linear response. The standard concentration must be prepared at the 5% level, which is the midpoint of the dynamic range. The Fuel Sniffer does not allow the user to use any other value. If any other level of dilution is used above or below this standard, the instrument will either over or under estimate actual readings respectively.

WARNING

The oil sample bottle should be approximately ¾ full. Do not fill the sample bottle to the top. There must be a headspace between the sample and the top of the bottle for a proper measurement and to avoid the possibility of contaminating and damaging the Fuel Sniffer's sensor with the sample.

NOTE

To ensure a representative calibration sample, the standard should be mixed and allowed to equilibrate for at least one hour for diesel fuel and at least four hours for more volatile gasoline fuel or jet fuel.

CAUTION

Using a standard immediately after preparation will cause the instrument to under report values.

The flask should remain uncapped during the equilibration period to ensure a representative calibration sample. This is done to "off gas" the light end hydrocarbons that are present in fresh fuel samples. This is consistent with an actual engine oil sample, since it would have been exposed to heat during operation that drives off the light end gases. Hence using a standard immediately after preparation will cause the instrument to under report actual measured values because the light end gases have been included in the standard calibration. The following sequences of LCD screens illustrate the calibrate fuel dilution mode. The sample bottle clamp and seal must be connected by way of the sample tube to the "Sample Connect" before starting a measurement. By pressing the start button, the analysis cycle will begin, and the red calibrate LED will illuminate.

CALIBRATE FUEL DILUTION PRESS START OR ⇓⇑

CALIBRATE FUEL DILUTION CALIB, IN PROGRESS, WAIT

CALIBRATION SATISFACTORY PRESS SELECT TO CONTINUE

Upon a successful calibration, the calibrate LED will turn off and the user must press "Select" to return to the main menu choices.

(e) Operation/Procedures. Basic operation is covered here. Please refer to the manufacturer's manual for more detailed information concerning theory of operation, accessories, data transfer, parts, maintenance, and troubleshooting.

1. Software Overview. The Fuel Sniffer is a menu driven instrument. The LCD display presents a series of menus, which allow operation of the instrument. The software prompts the user through each step to make a successful measurement analysis. There are four pushbuttons on the front panel, "Select", "Down Arrow", "Up Arrow", and "Start" which are used to input information. Each menu function is discussed in detail.

2. Start-Up Screens. Upon power up, the LCD will indicate the following displays:

MICROSENSOR SYSTEMS INC. FDM METER VERSION 3.1.5

AUTOTEST UNDERWAY PLEASE WAIT

AUTOTEST SATISFACTORY PRESS SELECT TO CONTINUE

Upon successful completion of the power-up, the Fuel Sniffer will respond with a series of five tones and the front panel LED'S will each flash from top left to bottom right sequence with each audible tone. By pressing the "Select" button, the Fuel Sniffer will respond with the following main operating menu.

PROGRAM SELECTION PRESS ⇓⇑ FOR MENU

By pressing either "arrow" button, the Fuel Sniffer will display the menu selections. The primary Fuel Sniffer menus are below.

MEASURE FUEL DILUTION PRESS START OR ⇓⇑

CALIBRATE FUEL DILUTION PRESS START OR ⇓⇑

TRANSFER DATA TO OUTPUT PRESS START OR ⇓⇑

SET TIME AND DATE PRESS START OR ⇓⇑

3. Measuring fuel dilution.

a. Basic information. This mode allows the measurement of fuel dilution in oil samples. The results are reported in percent fuel dilution on the LCD. Each sample analysis requires 60 seconds to complete. The Fuel Sniffer must be in position on its stand with the sample inlet tubing connected to the tubing connector on the control panel. The Fuel Sniffer should be allowed to warm up and stabilize for at least 15 minutes after the power On/Off toggle switch has been turned to On.

b. Procedure. Loosen the two screws that hold the sample bottle diameter adjustment bar and reposition so that the sample bottle is centered on the platform. Tighten the screws to hold the bar in position. Set the sample platform to the correct height by loosening the two captive adjustment screws. Set the table so that the sample bottle just clears the bottom of the sample cover with the sample bottle lever in the up position (towards the Fuel Sniffer). Tighten the adjustment screws. Place the sample bottle in position on the sample table. Move the sample bottle lever into the down (towards the operator) position. There should be some resistance as the lever is moved into the down position such that the sample bottle will be locked in place.

c. Analysis start. By pressing the start button, the analysis cycle will begin and the green measure LED will illuminate. The Fuel Sniffer will begin a pumping sequence to first purge the headspace, then reverse flow pulling the headspace sample into the detector and then reversing the flow purging the detector expelling the sample in preparation for the next measurement.

d. Results. The results will be reported in percent fuel dilution over the calibrated range of 0 to 10%. The user must acknowledge the result and push "Select" to begin the next measurement cycle. The following sequences of LCD screens illustrate the measure fuel dilution mode.

MEASURE FUEL DILUTION PRESS START OR ⇓⇑

MEASURE FUEL DILUTION MEAS. IN PROGRESS, WAIT

0.0% FUEL DILUTION PRESS SELECT TO CONTINUE

MEASURE FUEL DILUTION PRESS START OR ⇓⇑

Please refer to the complete Spectro, Inc. "System Description and Operations Manual" which comes with each unit or is available through e-mail by request from the JOAP-TSC at: tsc@joaptsc.navy.mil

The information contained in this manual was included with the permission of Spectro, Inc.

5-6. Microscopic Analysis

a. Scope. This method covers the microscopic examination of debris filtered from suspect spectrometric oil samples to determine the significance of debris with respect to wear, contamination, and component condition. Currently, this method is applicable to all US Army aircraft but may be specified for use on other equipment by the appropriate service oil analysis program manager. A precise methodology for the characterization and classification and the importance or implications of results of insoluble debris analysis has not been established.

b. Summary of Method. A measured quantity of the suspect oil sample is mixed with solvent and filtered through a 0.45-micrometer membrane filter. The insoluble debris and filter membrane are carefully rinsed with solvent to remove oil and then allowed to air dry. The dry membrane is transferred to a petri slide and the debris examined under a low-power microscope. The debris observed are characterized and related to the component's condition with respect to wear and contamination.

c. Definitions.

(1) Suspect Oil Sample. An oil sample from equipment for which one or more of the following diagnostic indicators are observed: chip-light, vibration, metal on screens or filter, oil of unusual color, odor, or solids contents, and oil having an abnormal spectrometric trend or level.

(2) Insoluble Debris. Refers to insoluble solid materials filtered from suspect oil samples that may consist of wear debris, corrosion products, and non-metallic debris generated by the component, or contaminants from external sources.

d. Equipment/Apparatus/Materials.

(1) Millipore Filtering Equipment Set.

(2) Microscopic Equipment Set

(3) Solvent. Biotek Hisolv or other high flash solvent is used as the solvent depending on local availability. Before use, the solvent shall be filtered through a 0.45-micrometer membrane filter.

e. Operation/Procedures.

(1) Loosen the cap on the suspect oil sample bottle and place the bottle in an oven at 65± 5 °C (149° ± 9 °F) for 30 minutes.

(2) Prepare the vacuum filtering apparatus by installing a 0.45 micron membrane filter and start vacuum.

(3) Remove the warm sample from the oven, tightly cap, and shake vigorously. Pour 10 ml of the sample into a 100 ml graduated cylinder with a stopper. Add 90 ml of pre-filtered solvent, install stopper and mix well.

(4) With the vacuum still applied, carefully remove the spring clamp and upper section of the filter funnel carefully wash the edges of the filter membrane with a gentle stream of solvent using care not to wash debris off the filter membrane. Continue wash until membrane and debris are free of oil. Allow the membrane to dry. Transfer the membrane to a petri slide.

(5) Inspect the debris using the microscope, identify the metal or alloy and record the findings.

5-7. Particle Counter Testing

a. Scope. The information concerning hydraulic fluid testing contained in this section is applicable to aircraft and other equipment hydraulic systems using MIL-H-5606, MIL-H-83282 and MIL-H-46170 hydraulic fluid. These instructions may require modifications, including sample dilution for equipment using higher viscosity hydraulic fluids. During normal operation, hydraulic systems may become contaminated with metallic and nonmetallic particles. Particulate contamination may result from internal wear, failure of system components,or incorrect maintenance and servicing operations. Hydraulic system contamination analysis provides a method of determining the particulate contamination level of a hydraulic system and detecting the presence of free water or other foreign substances.

b. Summary of Methods.

(1) The two primary methods of analyzing hydraulic fluids currently in service use are the patch test method, using the Contamination Analysis Kit P/N 571-414 (08071) and the automatic electronic particle counting method, using electronic particle counters such as the HIAC 8000 Contamination Test Center. Both the HIAC 8000 Contamination Test Center and the Contamination Analysis Kit P/N 571-414 (08071) have been approved for Navy fleet use and may be authorized for Army and Air Force use by proper authority.

(2) Due to differences in their basic method of operation, test results obtained using automatic particle counters and the Contamination Analysis Kit P/N 571-414 (08071) may not always be in precise agreement. Although both pieces of equipment are authorized for use and either may be utilized, it is important that the reasons for differing test results be fully understood.

(3) Automatic particle counters optically sense particles contained in the fluid sample and electronically size and count them. Most particle counters are calibrated so that the smallest particle counted will have an effective diameter of 5 microns. Particles smaller than 5 microns, although always present, will not affect the particle count.

(4) The contamination Analysis kit, P/N 571-414, uses a patch test method in which the fluid sample is filtered through a test filter membrane, causing it to discolor proportional to the particulate level. The test filters used have a filtration rating of 5 microns absolute however, they will also retain a large percentage of those particles less than 5 microns in size. The contamination standards provided with the contamination analysis kit are representative of test indications that will result if the fluid sample has a particle size distribution (number of particles versus size) typical of that found in the average military aircraft. Samples from aircraft having typical particle size distributions will, therefore, show good correlation if tested using both particle count and patch test methods.

(5) Some operating hydraulic systems may, as a result of peculiar design characteristics, produce a particle size distribution different from that normally found in typical aircraft. Fluid samples from this equipment generally contain an abnormally large amount of silt-like particles smaller than 5 microns in size. Experience has shown this condition is usually the result of inadequate system filtration or the use of hydraulic components having abnormally high wear rates. It is fluid samples of this type that may produce different results when tested using both particle counting and patch test methods. The differing test results are caused by the particle counter not counting those particles smaller than 5 microns, whereas many of them will be retained by the patch test filter membrane and cause it to discolor a proportional amount.

(6) When conflicting test results are encountered due to the reasons discussed, the equipment tested shall be considered unacceptable if it fails either test method. The equipment should then be subjected to decontamination. It is important to recognize, however, that the differing test results may be indicative of system deficiencies and justification for requesting an engineering investigation of the equipment. Poor correlation between particle counts and patch tests can also result from improper sample taking procedures, incorrect particle counter calibration, or faulty test procedure. These possibilities must be carefully investigated should a correlation problem be encountered.

c. HIAC Contamination Test Center, Model 8000 is approved for use in accordance with NAVAIR 01-1A-17. Operators of this equipment are required to have copies of operators manuals furnished with the equipment. NAVAIR 17-20SX-146 provides calibration procedures for the HIAC Contamination Test Center. Periodic calibration is required in accordance with NAVAIR 01-1A-17 or after repairs which could affect the calibration (see operators manual, calibration procedures).

d. Colormetric Patch testing using the Contamination Analysis Kit P/N 571-414. The Contamination Analysis Kit, P/N 571-414 (08071), is the principal equipment currently used for determining contamination levels in military aircraft hydraulic systems and hydraulic ground support test and servicing equipment. The contamination analysis kit equipment employs a “Patch Test” method in which a hydraulic fluid sample of known volume is filtered through a filter membrane of known porosity. All particulate matter in excess of a size determined by the filter characteristics is retained on the surface of the membrane, causing it to discolor an amount proportional to the particulate level of the fluid sample. Refer to NAVAIR 17-15E-52 and NAVAIR 01-1A-17 for additional information concerning the contamination analysis kit.

5-8. Viscosity Measurements of Used Lubricating Oils

a. Nametre Method.

(1) Scope. This method is used by the Army and is performed on all non-aeronautical engine, transmission, and hydraulic samples.

(2) Summary of Method. Used oil samples are allowed to stabilize at room temperature. The viscometer’s transducer tip is then immersed in the sample to the level indicating line, and when the reading stabilizes, the viscosity is read directly from the digital readout panel. The used lubricant quality is then determined by comparison with viscosity guidelines for lubricants of the same type and grade or results from the analysis of the first sample after oil change for the specific item of equipment.

(3) Equipment/Apparatus/Materials.

(a) Viscometer, Nametre Model 7.006 Direct Readout Viscometer.

(b) Thermometer, ASTM 28F.

(4) Standards/Standardization.

(a) Standards required for viscometer calibration and daily standardization checks are:

Cannon Standard Number Nominal Viscosity at 771 °F (250 °C)

S-6 6.75 centipoises x g/cm^3

S-60 93.40 centipoises x g/cm^3

S-200 430.00 centipoises x g/cm^3

They are available from Cannon Instrument Co., P.O. Box 16, 2139 High Tech Road, State College, PA 16804-0016; phone numbers are 1-800-676-6232 or 1-814-353-8000.

(b) On receipt of standards, the laboratory shall provide the Joint Oil Analysis Program Technical Support Center (JOAP-TSC) with information from the standard bottle label. The JOAP-TSC will then provide the laboratory with a table of viscosity values expected for that particular standard at a range of temperatures.

CAUTION

The transducer tip is a sensitive and delicate device and should be treated with care. The tip should be cleaned with soft absorbent paper between determinations and with a standard safety; solvent after the final measurement is made.

(5) Calibration.

(a) When the viscometer is in use, it will be calibrated daily using Cannon S-6, S-60, and S-200 standards. A quotient index (QI) shall be calculated by dividing the measured value for the standard by the table value for the standard at room temperature. If the Q1 is between 0.95 and 1.05, no adjustment is required for that standard; if not, the instrument requires calibration.

(b) Separate daily calibration logs for each standard shall be maintained by the laboratory. The room temperature, measured value, table value, QI, and date of analysis shall be entered on these logs.

(c) Standardization Check. Once the viscometer is calibrated, only standardization checks are required throughout the day. When the viscometer is unused for a portion of the day or when switching between different weight oils, a sample of the Cannon standard with the viscosity that most nearly matches that of the samples to be analyzed shall be analyzed to verify that the viscometer is still calibrated correctly. If the QI for the standardization check sample is out of limits, the viscometer must be recalibrate.

(d) Preparation of Sample. Sample should be at room temperature 75° ± 2°F or 24° ± 1°C). Agitate the sample of used oil in the original container until all sediment is homogeneously suspended in the oil. Make sure all air bubbles caused by agitation have been removed from the sample before making the viscosity measurement.

(e) Analysis. Immerse transducer tip in oil up to the line on the sheath. When the digital readout stabilizes, record the viscosity in centipoises xg/cm^3.

(f) Guidelines. Table 5-1 shows the viscosity guideline limits for various grades of used MIL-L-2104 lubricating oils. Samples with viscosities below the minimum guidelines require testing for flash mint for fuel dilution. Samples with viscosities above the maximum guidelines require blotter and water testing.

TABLE 5-1. VISCOSITY GUIDELINES FOR MIL-L-2104 LUBRICATING OIL

N_m Units: Centipoises Xg/cm^3

Temp,	Grade 10		Grade 30		Grade 50*		Grade 15W-40	
°F	N_m Min	N_m Max	N_m Min	N Max	N_m Min	N_m Max	N_m Min	N_m Max
65	108	307	124	349	296	845	141	344
66	105	299	121	341	289	824	136	333
67	103	292	119	333	282	803	133	321
68	100	284	116	325	276	783	129	311
69	98	277	114	318	270	764	125	300
70	96	270	112	311	263	745	121	290
71	94	263	109	304	257	726	118	281
72	91	256	107	297	251	708	115	272
73	89	250	105	290	245	691	111	263
74	87	244	102	283	240	673	108	254
75	85	238	100	277	234	657	105	246
76	83	232	98	271	229	640	103	238
77	81	226	96	264	223	624	100	231
78	79	220	94	258	218	609	97	224
79	77	214	92	253	213	594	94	217
80	75	209	90	247	208	579	92	210
81	74	204	88	241	203	565	89	204
82	72	199	86	236	198	551	87	197
83	70	194	84	230	194	537	85	191
84	69	189	83	225	189	524	83	186
85	67	184	81	220	185	511	81	180
86	65	179	79	215	181	498	78	175

87	64	175	78	210	176	486	76	170
88	62	170	76	205	172	473	75	165
89	61	166	74	201	168	462	73	160
90	60	162	73	196	164	450	71	155
91	58	158	71	192	161	439	69	151
92	57	154	70	187	157	428	67	147
93	55	150	68	183	153	418	66	143
94	54	146	67	179	150	407	64	138
95	53	142	65	175	146	397	63	135
96	52	139	64	171	143	387	61	131
97	50	135	63	167	139	378	60	127
98	49	132	61	163	136	368	68	124
99	48	128	60	159	133	359	57	120
100	47	125	59	156	130	350	56	117

* Grade 50 oil is being phased out of the DoD inventory and is being replaced with Grade 15W40.

b. Brookfield Method using Small Sample Adapter with #18 spindle (see paragraph c. below for operation without the Small Sample Adapter).

(1) Scope. This method is used by the US Navy and is performed on various non-aeronautical equipment fluid samples.

(2) Summary of Method. The Syncro-Lectric Viscometer is a rotational viscometer which measures torque necessary to overcome the immersed element, which is a spindle attached to a beryllium copper spring. The degree to which the spring is wound is proportional to the viscosity of the fluid at the test temperature for any given speed and spindle.

(3) Apparatus. Viscometer, Brookfield Syncro-Lectric-Models LVF, LVDV-E, LVDV-1+, LVDV-2+, small sample adapter with the #18 spindle, and water bath capable of temperatures between 10 degrees Celsius and 60 degrees Celsius.

(4) Standards. The standard recommended for viscometer calibration, Fluid #50, is available from Brookfield Engineering Labs, Inc., 11 Commerce Blvd., Middleboro, Massachusetts, 02346, U.S.A., 800-628-8139.

(5) Procedure

(a) Assemble the Model A laboratory stand. Place the upright rod into the base (refer to assembly instructions in the manufacturer's manual). The rack gear and clamp assembly should face the front of the base. The upright rod is held in place with the jam nut, which is attached from the bottom of the base. Tighten this nut with a suitable wrench. Attach leveling feet.

(b) Insert the mounting handle on the back of the viscometer into the hole on the clamp assembly. Be sure that the clamp screw is loose.

(c) Tighten the clamp screw. Adjust the viscometer to be as close to level as possible while tightening the clamp screw.

(d) Level the viscometer. The level is adjusted using the three leveling screws on the base. Adjust so that the bubble level on top of the viscometer is centered within the circle. Check level periodically during use.

(e) Ensure water bath is filled to the level recommended by the manufacturer.

(f) Connect the tubing from the water bath to the inlet and outlet connectors on the water jacket of the small sample adapter.

(g) Adjust the water bath temperature.

(6) Instrument Start-up. (LVDV-E, LVDV-1+, LVDV-2+)

NOTE

Before a reading can be taken, the viscometer must be auto-zeroed. This action is performed each time the power switch is turned on. The display window on the viscometer displays a guide through the procedure.

(a) Turn the power switch (located on the rear panel) to the ON position. This will result in the following screen display:

```
BROOKFIELD

RV    VISCOMETER
```

The model type will be displayed in the upper right-hand corner of the screen
(DV-1+, DV-2+, etc..

After a few seconds, the following screen appears:

```
BROOKFIELD

  VERSION 5.0
```

(b) After a short time the viscometer will instruct you to remove the spindle and that any key be pressed. The viscometer will begin to auto-zero itself.

NOTE

Ensure that the viscometer is level before initiating auto-zero.

(c) After the viscometer has completed it's auto-zeroing, follow the directions to replace the spindle and press any key. Pressing any key at this point will result in the display of the default screen.

```
CP 0.0       S01

0.0RPM       %  0.0
```

The display will vary slightly depending upon the status of the last spindle entry.

1. Pressing the SELECT Spindle key will cause the characters on the top line of the display to begin to blink.

2. By pressing the up or down arrow keys, the characters will start to cycle through the different types of spindles. When the desired spindle is reached, press the Select Spindle key once again. This will cause the characters to stop blinking and the new spindle will be accepted for use in the viscometer calculations.

(d) Speed Selection can be accomplished by pressing the **Select Speed** key. Once the key is depressed, scroll through the different speeds by pressing the **Up** or **Down** arrows. Pressing the **Select Speed** key again after the desired speed was reached will allow the viscometer to accept the new speed for it's calculations.

(7) Calibration Procedure.

NOTE

The laboratory shall annotate on the viscosity standard bottle a 1-year shelf life, expiration date effective the day the standard is initially opened. At the 1-year expiration date, the laboratory shall discard the outdated standard in accordance with local directives and replace it with a more current one.

(a) Warm up the viscometer in accordance with the Instrument Start-up procedure.

(b) Put the proper amount of standard (8 ml) in the sample chamber, allowing the fluid to cover the spindle with chamber in place.

(c) Place the number 18 spindle on the viscometer and attach the extension link, coupling nut, and free hanging spindle.

(d) Ensure the temperature of the water bath is at the temperature at which the standard's known viscosity was determined.

(e) Place the sample chamber into the water jacket.

CAUTION

The coupling shaft is a left-hand thread, and proper care must be taken in order not to damage the viscometer bearings.

(f) Allow 3 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.

(g) Measure the viscosity and annotate the viscometer's reading on the QA chart (see Table 5-2). The factor of the spindle and fluid accuracy determines the total tolerance of the fluid. Table 5-3 provides the various factors for spindles.

NOTE

Instrument tolerance is equal to spindle factor. If the spindle factor is 10, then the viscometer's tolerance will be 10.

BROOKFIELD VISCOMETER QUALITY ASSURANCE CHART

DATE	
TEMPERATURE	
VISCOMETER MODEL	
MANUFACTURER:	BROOKFIELD
PART NUMBER	
LOT NUMBER	
CERTIFIED VISCOSITY	
EXPIRATION DATE:	(1 YEAR AFTER OPENING)

SPINDLE LV 1								
RPM	FACTOR	% TORQUE	MIN ACCEPT	ACTUAL READING IN Cp	MAX ACCEPT	INTRUMENT ACCURACY	FLUID ACCURACY	TOTAL TOLERANCE
30	2							
12	5							
6	10							

SPINDLE LV 2								
RPM	FACTOR	% TORQUE	MIN ACCEPT	ACTUAL READING IN Cp	MAX ACCEPT	INTRUMENT ACCURACY	FLUID ACCURACY	TOTAL TOLERANCE
30	10							
12	25							
6	50							

SPINDLE 18								
RPM	FACTOR	% TORQUE	MIN ACCEPT	ACTUAL READING IN Cp	MAX ACCEPT	INTRUMENT ACCURACY	FLUID ACCURACY	TOTAL TOLERANCE
30	1							
12	2.5							
6	5							

TABLE 5-2

SPINDLE FACTOR					
	SPINDLE NUMBER				
RPM	18	LV1	LV2	LV3	LV4
60	0.5	1	5	20	100
30	1	2	10	40	200
12	2.5	5	25	100	500
6	5	10	50	200	1M
3	10	20	100	400	2M
1.5	20	40	200	800	4M
0.6	50	100	500	2M	10M
0.3	100	200	1M	4M	20M

TABLE 5-3

Example: Spindle factor for spindle 18 at 30 rpm is 1 and fluid accuracy is +/- 1% of the known viscosity (for Standard at 45 centipoise, fluid accuracy is +/- .45 cp). Total tolerance would equal +/- 4.5 cp of standards known viscosity. (1 + .45 = 1.45)

CAUTION

The spindle must rotate at least five (5) times before readings are taken.

(8) Sample Procedure.

(a) Preparation of Sample. Agitate the used oil sample in the original container until all sediment is homogeneously suspended in the oil.

NOTE

Ensure that the viscometer speed is at 12 rpm for all testing.

(b) Warm up the viscometer in accordance with the Instrument Start-up procedure.

(c) Put the proper amount of used oil (8 ml) in the small sample chamber, which will allow the spindle to be completely immersed in the oil.

(d) Put the number 18 spindle in the used oil and attach the extension link, coupling nut and free hanging spindle.

(e) Adjust water bath temperature to 104 degrees Fahrenheit.

(f) Allow 3 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.

(g) Place the sample chamber in the water jacket.

CAUTION

Protect alignment by taking care to avoid putting side thrust on the shaft.

(h) Measure the viscosity and record the viscometer reading.

NOTE

On LVF model viscometers, multiply the dial reading by the spindle factor to obtain the centipoises of the fluid.

Centipoise = dial reading * spindle factor

355cp = 35 (DR) * 10 (SF)

CAUTION

The spindle must rotate at least five (5) times and torque value must be above 10% before readings can be taken.

(i) If desired, convert centipoise to centistokes by dividing by specific gravity:

Centistokes = Centipoise/Specific Gravity

The average specific gravity of in-service diesel lubricating oil is approximately 0.92; synthetic gas turbine oil is 1.0. Refer to TABLE 5-4 below for the specific gravity of various oils used.

SPECIFIC GRAVITY	OIL TYPE
0.92	MIL-L-9000G MS-9250
0.880	MIL-L-17331 MS-2190 TEP
1.0	MIL-L-23699
0.880	MS- 2075TH
0.863	MS-2110TH
0.867	MS-2135TH
0.859	MIL-H-5606
0.834	MIL-H-83282
1.40	MIL-H-19457 FYRQUEL

TABLE 5-4

(9) Cleaning. Clean the small sample chamber with cleaning solvent and wipe dry with a non-abrasive cloth.

CAUTION

Electron should be used with adequate ventilation. Prolonged breathing of vapors should be avoided. The solvent should not be used near open flame or heat, as the products of decomposition are toxic and very irritating.

NOTE

The black insulating bottom of the sample chamber should not be exposed to strong solvents such as methanol, toluene, ammonia, and 111-trichloroethylene. Do not totally immerse the chamber in any cleaning solution. Improper cleaning may result in separation of the black insulation from the chamber.

c. Brookfield Method without Small Sample Adapter.

(1) Scope. This method is used by the US Navy and is performed on various non-aeronautical equipment fluid samples.

(2) Summary of Method. The Syncro-Lectric Viscometer is a rotational viscometer which measures the torque necessary to overcome the immersed element, which is a spindle attached to a beryllium copper spring. The degree to which the spring is wound is proportional to the viscosity of the fluid at the test temperature for any given speed and spindle.

(3) Apparatus. Viscometer, Brookfield Syncro-Lectric-Models LVF, LVDV-E, LVDV-1+, LVDV-2+, Small Sample Adapter with the #1 and 2 spindle, 100 ml beaker, oven and a digital thermometer capable of temperature ranges between –40 to 250 degrees Fahrenheit.

(4) Standards. The standard recommended for viscometer calibration, Fluid #50, is available from Brookfield Engineering Labs, Inc., 11 Commerce Blvd., Middleboro, Massachusetts, 02346, U.S.A., 800-628-8139.

(5) Procedure

(a) To assemble the Model A laboratory stand, place the upright rod into the base (refer to assembly instructions in manufacturer's manual). The rack gear and clamp assembly should face the front of the base. The upright rod is held in place with the jam nut, which is attached from the bottom of the base. Tighten this nut with a suitable wrench. Attach the leveling feet.

(b) Insert the mounting handle on the back of the viscometer into the hole on the clamp assembly. Be sure that the clamp screw is loose.

(c) Tighten the clamp screw. Adjust the viscometer to be as close to level as possible while tightening the clamp screw.

(d) Level the viscometer. The level is adjusted using the three leveling screws on the base. Adjust so that the bubble level on top of the viscometer is centered within the circle. Check level periodically during use.

NOTE

Before a reading can be taken, the viscometer must be auto-zeroed. This action is performed each time the power switch is turned on. The display window on the viscometer displays a guide for the procedure. Refer to Paragraph 5-8.b. (6) for complete instructions.

(6) Calibration Procedure.

NOTE

The laboratory shall annotate on the viscosity standard bottle a 1-year shelf life, expiration date effective the day the standard is initially opened. At the 1-year expiration date, the laboratory shall discard the outdated standard in accordance with local regulations and replace it with a more current one.

(a) Warm up the viscometer in accordance with the Instrument Start-up procedure.

(b) Place the number 1 or 2 spindle on the viscometer. In order to use the smaller beaker, the spindle guard cannot be used. Take care not to bump the spindle.

CAUTION

The coupling shaft is a left-hand thread, and proper care must be taken in order not to damage the viscometer bearings.

(c) Put the proper amount of standard in a 100 ml beaker allowing the fluid to reach the groove imbedded on the spindle.

(d) Allow the fluid to reach the temperature at which the standard's known viscosity was determined.

(e) Measure the viscosity and annotate the viscometer's reading on the QA chart (Table 5-2). The factor of the spindle and fluid accuracy determines the total tolerance of the fluid. Table 5-3 shows the various factors for spindles.Example: Spindle factor for spindle 18 at 30 rpm is 1 and fluid accuracy is +/- 1% of the known viscosity (for Standard at 45 centipoise, fluid accuracy is +/- .45 cp). Total tolerance would equal +/- 5.5 cp of standards known viscosity (1 + .45 = 1.45).

CAUTION

The spindle must rotate at least five (5) times before readings are taken.

(7) Sample Procedure

(a) Warm up the viscometer in accordance with the Instrument Start-up procedure.

(b) Place the number 1 or 2 spindle on the viscometer. To determine the proper spindle, a known range of viscosity should be determined for the fluid (see TABLE 5-5).

NOTE

Ensure the spindle speed is set at 60 RPM.

SPINDLE	RANGE
LV-1	15-20K
LV-2	50-100K
SCV4-18	1.2-30K

TABLE 5-5

CAUTION

The coupling shaft is a left-hand thread, and proper care must be taken in order not to damage the viscometer bearings.

(c) Put the proper amount of used oil with in the container, allowing the fluid to reach the groove imbedded on the spindle.

(d) Place the sample in the oven and allow the fluid to reach 104 degrees Fahrenheit.

(e) Measure the viscosity and annotate the viscometer's reading.

CAUTION

The spindle must rotate at least five (5) times before readings are taken.

(f) Convert centipoise to centistokes by dividing by specific gravity, and record the viscosity of the sample.

NOTE

On LVF model viscometers, multiply the dial reading by the spindle factor to obtain the centipoises of the fluid.

Centipoise = dial reading * spindle factor

355cp = 35 (DR) * 10 (SF)

Centistoke= Centipoise/Specific Gravity

The average specific gravity of in-service diesel lubricating oil is approximately 0.92; synthetic gas turbine oil is 1.0. Refer to TABLE 5-4 for the specific gravity of various oils used.

(8) Cleaning. Clean the spindle with cleaning solvent and wipe dry with a non-abrasive cloth.

CAUTION

Electron should be used with adequate ventilation. Prolonged breathing of vapors should be avoided. The solvent should not be used near open flame or heat, as the products of decomposition are toxic and very irritating.

5-9. Water Contamination Tests

a. Crackle Test

(1) Scope. Water contamination refers to the presence of free water or coolant in used lubricants originating from faulty cooling systems, condensation caused by improper operation, or careless contamination of the oil system or storage containers. This test is a qualitative determination of free water in used lubricating oils, and is performed on non-aeronautical samples.

(2) Summary of Method. Water held in suspension by emulsifiers becomes audible (crackles) and visible as bubbles and steam when drops of oil are placed on a heated surface of approximately 300° to 350°F (150° to 177°C).

(3) Equipment/Apparatus/Materials.

(a). Hot Plate, thermostatically controlled. For shipboard use, the hot plate shall be an explosion proof, variable temperature control model.

(b) Thermometer. Surface thermometer (PTC, Spot Check R Model 572F, Fisher Scientific Catalog Number 15-170D, 18° to 260°C (50° to 500°F) or equivalent).

(4) Operation/Procedures.

WARNING

Testing must be conducted in a fume hood. Persons performing test must wear protective goggles and clothing and avoid direct contact with hot plate surface reaction.

(a) Heat hot plate to surface temperature of 300 to 350°F (150° to 177°C).

(b) Shake sample vigorously.

(c) Drop one or two drops of oil on the heated surface of the hot plate and observe the reaction.

(d) Record the reaction as positive (1), meaning bubbles were present; or negative (0), meaning bubbles were not present.

(e) Wipe off the hot plate surface between samples.

(5) References/Guidelines.

(a) General. The crackle test indicates whether water is present. If the exact amount of water is desired, the Karl Fischer test for water shall be conducted as specified in paragraph 5-9. b. below.

1. The blotter spot will often indicate water/glycol content by poor dispersancy and a spot that remains wet longer than normal.

2. Spectrometric analysis can indicate the presence of coolant by the levels of sodium and boron, which are used as additives in coolants. If no new oil has been added to the system, an increase of 20 parts per million or more of one of these elements is reason to suspect coolant contamination.

3. Free water from condensation or external contamination will not be accompanied by high levels or sudden increase in sodium or boron. An exception to this is the analysis of marine diesel engine samples. When water is present in these samples, there will frequently be an increase in sodium levels because seawater is used as the engine coolant.

4. In addition to these tests, attention should be given to the oil's appearance. A gray color or visible emulsion in the oil may be an indication of water or coolant contamination.

b. Karl Fischer Water Test (KF) With the Aquatest 2010

(1) Scope. Karl Fisher (KF) titration is an accurate method of measuring moisture that utilizes the quantitative reaction of water with iodine, which can be measured electrolytically at the anode. One molecule of iodine reacts quantitatively with one molecule of water. Consequently, 1 mg of water is equivalent to 10.71 coulombs. Based on this principle, the water content in the sample can be determined by the quantity of electricity required for the electrolysis.

(2) Summary of Method. After the instrument is prepared for use, operation is accomplished in three quick steps: 1) depress the FILE key and verify all the parameters are set in accordance with Table 5-3 and the weight of oil being tested. (2) introduce a measured quantity of sample; and (3) wait for the results of the sample to be displayed and/or printed with the amount of moisture present.

(3) Equipment/Apparatus/Materials.

(a) Aquatest 2010

Manufacturer:

Photovolt Instruments Inc.
6325 Cambridge St. Suite 3
Minneapolis, MN 55416
Phone: (800) 222-5711

(b) Syringes. Ten milliliter capacity syringes are used for replacing titrator solutions and one microliter or ten microliter syringes are used for sample induction with a 4 ½ inch needle.

(4) Preparation of Sample. No special sample preparation is required; however, particulate matter should be allowed to settle as much as possible and syringe needle should be immersed in top portion of sample in an effort to prevent syringe plugging from large particles.

(5) Operation/Procedures. Aquatest 2010 analysis for detection of water in oil.

(a) Proper Use.

1. Do not use this product for any purpose other than for which it was intended.

2. When storing or moving the instruments refer to operating manual for proper storing of this equipment.

3. Use only those accessories recommended by the manufacturer in order to avoid risk of fire, shock, or other hazards

4. Unplug all equipment exposed to rain, moisture, or strong impact and have the instrument inspected by qualified service technician before use.

5. Disconnect all equipment from the line power source during a lightning storm or before leaving unused for extended periods of time.

6. Unplug all equipment before cleaning. Then use a clean, dry, chemically untreated cotton cloth to wipe the unit. Use no cleaning fluids, aerosols or forced air that could over spray or soak into the unit and cause electrical shock.

(b) Setting up for operation.

1. The AQUATEST 2010 has Type T line voltage fuses in series with the power supply. These fuses are located on the rear panel. To replace the fuses, unplug the line cord and remove the fuse cover from the power-input module. Remove the fuse/selector cover. Do not remove or change the setting of the voltage selector. Pull out each fuse drawer and replace both fuses with two of the identical rating. Always change both fuses.

IMPORTANT NOTE

The AQUA TEST 2010 is shipped without fuses installed. Prior to applying power, verify that the appropriate fuses are installed and that the voltage selection switch is set to the correct voltage.

WARNING

For protection against fire, replace both fuses with two of identical rating. Refer to Table 5-6 for proper fuse ratings for the selected voltage.

Voltage Rating	Fuse Description
100/115	Type T, 0.4 amp. 250V, Slow Blow UL Listed
220/240	Type T, 0.2 amp 250V, Slow Blow IEC Approved

Table 5-6

2. The AQUATEST 2010 is designed to operate at nominal line voltages of 100/115/220/240 VAC, depending upon the setting of the voltage selection switch located on the back of the instrument. The red notch on the voltage selection switch indicates the selected operating voltage. To change the voltage, first unplug the line cord. Open the fuse drawer and check the fuse ratings compared to the desired voltage setting. Change the fuses if necessary. If the voltage is being changed from 110/115V to 220/240V or 220/240V to 110/115V, the fuses must be changed. Both fuses must be replaced together.

3. Using a flat bladed screwdriver, move the rotary dial so that the new voltage is indicated on the switch.

(c) Assembling the Titration Cell. The titration cell for the AQUATEST 2010 consists of a titration vessel, generator cartridge, sensing electrode, injection port, vent tube, stir bar, and gas port stopper. The titration cell is assembled as follows:

IMPORTANT NOTE

Before assembling the titration cell, all part must be properly lubricated with Photo volt Sealant to prevent seizing of parts to the generator vessel.

1. Place the stir bar into the vessel.

2. Lubricate the ground glass portion of the sensing electrode and insert into the proper port on vessel.

3. Place a septum inside the 2-pice injection port assembly and gently tighten the threaded portions.

4. Lubricate the ground glass portion of the gas port stopper and the rounded sides of the sample injection port.

5. The injection port can occupy one of two positions on the titration vessel. Select the preferred position for the injection port and insert the stopper into the remaining port.

6. Fill the vent tube with silica gel desiccant. A plug of glass wool may be used under and over the desiccant. Lubricate the slotted stopper and the ground glass joint at the bottom of the tube. Insert the vent tube into the proper port on the vessel. Insert the slotted stopper into the vent tube.

NOTE

The silica gel desiccant must be replaced periodically. If the blue indicating beads are no longer blue through more than 50% of the tube, replace the desiccant.

7. Remove the generator cartridge from the packing. Remove the foam insert. Lubricate the solid stopper and ground glass joint on the body of the generator. Assemble the pieces and insert into the proper port on the vessel.

WARNING

Proper personal protective equipment (PPE) should be used with all hazardous chemicals. Refer to the MSDS for the hazards involved with each chemical being used.

(d) Filling the vessel with KF Reagents. Selection of reagents is an important factor in the overall performance of a coulometric titration. Photovolt provides reagents designed to provide optimal performance in the analysis of the wide variety of materials. Photovolt Pyridine Free KF Reagent is the most popular reagent currently in use. Pyridine is replaced by a proprietary amine, which has a reduced odor and toxicity compared to pyridine.

WARNING

Dispose of Karl Fischer reagents, solvents and cleaning solutions in a proper manner. Refer to the MSDS sheets for the chemicals to identify chemical hazards. Follow all applicable regulations regarding disposal of chemical waste.

1. Remove the stopper from the gas tube port of the vessel and pour approximately 150 ml of Photovolt Coulometric KF vessel solution into the cell using a large polyethylene funnel supplied. Replace the stopper.

NOTE

Take care to avoid getting water into the vessel when filling with the reagents. Make sure the vessel is free from water.

2. Remove the stopper from the top of the generator.

3. Carefully crack the top off one 5 ml ampoule of Photovolt Coulometric KF generator solution.

4. Pour the full contents of the ampoule into the generator using the small polyethylene funnel supplied with the reagent.

5. Replace the stopper.

NOTE

For best results, maintain the level of the solution in the generator well below the level of the solution in the vessel.

6. Set the slide lever on the left side of the instrument approximately half way through its range to achieve a moderate rate of stirring. Avoid setting the lever to high to reduce “tumbling”. This action could damage the electrode.

7. When facing the AQUATEST 2010, connect the sensing electrode to the BNC connector on the right denoted by the letter D for detector. Connect the generator to the BNC connector on the left denoted by the letter G for generator.

(e) Achieving Set Point. Generally, after filling the vessel with solution, the AQUATEST 2010 will need to be equilibrated before beginning analysis of samples or standards. This process is referred to as “bringing to set point.” In most cases, the AQUATEST 2010 will come to set point in less than 10 minutes. The exact amount of time required for the process, generally depends upon how “wet” the vessel solution is during filling. A very small amount of water present in the vessel, before the addition of reagent, can add a great deal of time to the process. For this reason, it is best to ensure that the components of the vessel are reasonably free of moisture before assemble.

WARNING

The AQUA TEST 2010 sensing electrode can be damaged by exposure to high heat. DO NOT place the sensing electrode in an oven.

1. Turn on the power switch. The following message should be displayed:

S T B Y

Where the # # are present indicates potential.

NOTE

If the potential shows a negative value, this indicates that the vessel solution contains a large amount of free iodine. Excess iodine may be present in the vessel solution as a result of the reagent manufacturing process. If this is observed, add approximately 2 uL of pure water until the potential becomes positive.

2. Press the [STANDBY] key. The display indicates the titration rate (ug H2O/sec), current demand sign (*), status and total moisture, for example:

12 . 5 *	WET	765 .8 ug

After titration of residual moisture from filling the vessel with the solutions, the titration stops, the beeper will sound three times and the following will be displayed:

END

After a few seconds and if the background is above 0.1 ug H2O/sec., the display will read:

RDY

If the background is below 0.1 ug H2O/sec., the display will read:

DRY

If the indicated titration rate (background) is 0.2 (ug H2O/sec) or higher, moisture is still present or remains on the inner walls of the vessel. In this case press the [STANDBY] key again to stop the electrolysis and set the stirrer speed to zero. Lift the vessel and swirl it gently to mix any moisture in the vessel with the reagent. Do not shake the vessel hard enough to cause the solution to exit through the vent tube. After swirling, replace the titration cell, adjust the stirrer speed, and press [STANDBY] to restart electrolysis. Repeat this procedure a few times if necessary. Again wait for display to indicate [RDY].

NOTES

When the titration rate falls below 0.2 (ug H2O/sec), the AQUA TEST 2010 is ready for analysis of most samples or standards. Testing should not be conducted before this. The performance of the AQUA TEST 2010 can be verified through the injection of a small amount of pure water (2 ul of pure water injected from a 5 ul syringe is suggested).

(f) Programming the Aquatester for variety of oils. The conditions under which a sample measurement is performed can be selected through use of the [FILE] key. A sequential menu of setting will be displayed by pressing this key. Eight files can be programmed into the AQUATEST 2010 to perform test on a variety of oils.

1. Pressing [FILE] key will give the following display:

FILE#: X

Where X is the number of the presently active analysis file. To begin using a different file for a sample measurement, enter a number from 1 to 8 using the keypad. Press [ESCAPE] if the new file is not to be altered before analyzing a sample. To check the contents of the new file, press the [ENTER] key to display each of the settings. Pressing the [ENTER] key allows viewing of the contents of a file without changing

them. Entering a number into a field then pressing [ENTER] will change that setting. For a complete list of settings for each type of oil commonly used in the Navy refer to Table 5-7.

	A/C Reefer oils	23699	2190	2135	2110	Mil-h-5606	MIL-H-83282	MIL-H-19456	QA Check
File	*	*	*	*	*	*	*	*	*
Delay	.2	.2	.2	.2	.2	.2	.2	.2	.2
Min Time	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
Stop Time	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
End Point	.1	.1	.1	.1	.1	.1	.1	.1	.1
Print Form	2	2	2	2	2	2	2	2	1
Calc Form	3	3	3	3	3	3	3	3	0
Units	1(%)	2 (PPM)	2 (PPM)	1 (%)	1 (%)	1 (%)	1 (%)	1 (%)	
Prod	*	*	*	*	*	*	*	*	*
Test	*	*	*	*	*	*	*	*	*
Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
Volume	1	.25	1	1	1	1	1	1	
Density	1	1	0.88	0.867	0.863	0.859	0.834	1.4	

Table 5-7

***=Any entry 1 to 99 can be entered.**

2. Delay. A titration delay time is used when a sample requires an extraction time period in the vessel solution before it can be analyzed. It is also used to allow time for moisture to be carried into the vessel from the optional vaporizer accessory. After pressing the [START/STOP] key, the titration sequence will not begin until the selected time has elapsed.

3. Min. Time (Minimum Titration Time). The titration will proceed for a minimum time equal to this value regardless of the status of the sensing electrode circuit. This setting is used in the analysis of samples having only a trace of moisture where the peak moisture value may not exceed the detection threshold of the AQUATEST 2010.

4. Stop Time (Titration Maximum Stop Time). The titration will be forced to stop at the selected time regardless of the status of the sensing electrode circuit. By bypassing the normal endpoint detection algorithm, this function can be used to terminate a titration at a selected time,. The titration will stop if the detection algorithm senses that all of the moisture has been titrated before the stop time is reached.

5. End Point (End point Sensitivity). This setting is used to determine the endpoint of titration through the sensing electrode circuit. The sensitivity is increased. If the endpoint sensitivity is set at zero, the AQUATEST 2010 will continue to titrate indefinitely or until the Titration Stop Time is reached or until the Start/Stop key is depressed.

6. Print FRM (Print Format). There are four different print formats possible for reports generated by the AQUATEST 2010. As the value set for print format increases so does the information that the printout generates. A zero value for print format deactivates the printer and no printout will be generated. To printout a completed history with the average of all samples conducted since last time the test number has been reset to 1, press [MEMORY] and [PRINT] keys.

7. Calc. FRM (Calculation Report Form). Many calculations can be performed on the measured data to yield a final concentration value. The selection of calculation format determines how the final value will be calculated. A zero value entered into the calculation format setting forces all data to be presented in total ug H2O only. To get a complete list of Calculation values refer to Manufacturer's manual. It is recommend that moisture content when a liquid sample is taken by volume. (Calc Form 3).

8. Units. If an appropriate calculation formula is selected for the " Calc FRM" parameter, the AQUATEST 2010 will automatically prompt the user for units. Units determine whether the final value will be given in PPM (parts per million) or percent. Depending on the type of oil units 1 and 2 will most commonly be used.

9. Samples. The AQUATEST 2010 can accept and use information about the samples to be measured. Sample information is entered before starting a titration or after completed a measurement. Press [SAMPLE] key and the following should be displayed:

PROD: X

The product code number can be used to identify the sample being tested. It is printed on the analysis report when print format 2, 3 or 4 is selected. A product code number can be any number between 1 and 9999.

10. Test Number. The AQUATEST 2010 has a memory capacity for up to 99 sample measurements. The 99 measurements can split in any fashion among a series of product code numbers. Each product code number may have a different number of sample results.

11. Blank. The AQUATEST 2010 will display an upper case "B" when a blank value is to be entered. The blank value will be subtracted from the final result of moisture test. This is used to compensate for moisture that is introduced into the vessel from sources other than the sample. (For example, when using a cleaning solvent to dissolve a sample, the solvent usually contributes a small amount of moisture that must be subtracted from the final result).

12. Sample Volume. The AQUATEST 2010 will display:

VOLUME:

If liquid volume rather than mass are measured, the AQUATEST 2010 will prompt you to enter a volume in liters. Enter the value using the number keys then press [ENTER].

13. Specific Gravity (Or Density). Density must be entered in order for the AQUATEST 2010 to determine the end result. For a complete list of Navy oil specific gravity refer to Table 5-1 in the physical testing procedure for viscosity.

14. Set Clock. The "set clock" function allows the time and date to be set. Press [OPTION] key once followed by the right arrow key twice. The following message will be displayed:

SET CLOCK

Press enter key and the current date will be displayed in the following format:

DATE:YYYY/MM/DD

Use the number keys to change the date. Press the right arrow [>] key to past the slash mark or press the minutes (-) symbol. Press the [ENTER] key to set the value into the instrument clock.

15. Reagent Use. The AQUATEST 2010 maintains a running count of the amount of water that has reacted with the reagents in the vessel. This count is maintained even when the power is interrupted. The “reagent use” function should be reset each time that the reagents are changed. Press the [OPTION] key once, followed by the right arrow [>] key until the following display:

REAGENT USE

Press the enter key to view the current reagent usage. The display will read:

REAG USE: VVV-GGG

The (VVV) is the consumption value in mg H2O for the vessel solution and (GGG) is the consumption value of H2O for the generator solution.

a. When replacing both solutions press the [CLEAR] key to reset both values.

b. When replacing the vessel solution only. Enter zeros for the digits of the first value and press the [ENTER] key.

c. When replacing the generator solution only, use the arrow [>] key to the digits of the second number and enter zeros.

Refer to manufacturer’s specifications for the capacity data of the solutions.

(6) Standards/Standardization/Calibration

(a) A calibration check that verifies the accuracy of titration of the instrument and reagent can be performed, as needed, using de-ionized (DI) water.

(b) Place the Aquatest 2010 in the proper file for Q.C. verification (paragraph f., items 1-15).

(c) Setup sample, first press the [SAMPLE] button. Next enter the serial number for the product. Enter 1 for test and press [ENTER].

(d) Use a 50 micro-liter (ul) syringe. Clean the syringe by drawing 50 ul of test fluid. Discharge the fluid into a suitable waste container.

(e) Draw 50ul test fluid past the 50ul mark on the syringe. Place the needle in the upward position allowing the bubble to float to the top of syringe chamber. Discharge all air bubbles until fluid has reached the 50ul mark on the syringe.

NOTE

Do not inject fluid with visible bubbles. Start each injection when the display says that the titration rate is 0.20 or less.

(f) Press start on the Aquatest 2010 and inject 2ul into the generator vessel. Repeat step 3 times for a total 3 injections.

NOTE

An injection of 2ul should get a result of 1000 +/- 50ug. If erratic readings occur, replace generator and vessel solution after you place Aqua tester in standby.

(g) Print a data report and average of the 3 injections by pressing the [MEMORY] and then the [PRINT] button.

(7) Sample testing procedure.

(a) Condition syringe by drawing 1cc of oil into a 5cc syringe (for 23699 samples draw 0.5cc of sample into a 1cc syringe). Discharge oil into a suitable waste container. Repeat step "a" no less than 3 times to flush last oil residue from syringe.

(b) Draw 1.25cc of sample (for 23699 draw 0.5cc) into syringe. Invert syringe and ensure air bubbles rise to the top of syringe. With syringe inverted depress plunger to the 1cc mark (for 23699 depress to the .25cc mark) to remove air and excess oil. Wipe oil from end of needle.

(c) When the machine displays "RDY" press the "START" button, insert syringe below the solution level and inject sample. Remove syringe. When test is completed the results will be printed.

(8) Maintenance

(a) The Aquatest 2010 has been designed to provide years of operation under normal laboratory use. The appearance and operation of your Aquatest 2010 can be maintained by providing proper routine care.

1. Spills of reagents or sample on the outer surface of the case should be removed quickly using a slightly damp cloth. In the event of a large spill, immediately unplug the instrument until the excess liquid can be removed.

2. The desiccant in the vent tube should be changed when more than 50% of the blue indicting beads are no longer blue.

3. The injection port septum should be changed whenever it has been pierced to the extent that it will no longer maintain a good moisture tight seal.

4. Check the ground glass joints of the titration cell at least once a week by trying to rotate them. If they do not move smoothly, clean the joint and reseal with sealing grease.

5. When replacing reagents, always lubricate the ground glass joints with sealing grease.

6. If the instrument will not be used for an extended period of time (more than 3 to 4 weeks), the solutions should be removed and the titration cell rinsed with methanol. Never allow the reagents to evaporate totally from the titration cell.

(b) Maintaining the printer unit. The printer should be cleaned of paper dust periodically. Use a soft brush or clean compressed air to remove dust particles from the printer mechanism. Any accumulation of material in the printer housing can be removed with a vacuum.

NOTE

Do not insert sharp objects into the printer unit. Portions of the mechanism may fail to operate properly if they are scratched or cut.

(c) Cleaning the titration cell. The titration cell can be cleaned with methanol or ethanol to remove waste material. If samples are greasy, exolene, octanol, chloroform, or other solvents can be used as degreasing agents before final cleaning.

WARNING

Proper personal protective equipment (PPE) should be used with all hazardous chemicals. Refer to the MSDS for the hazards involved with each chemical being used.

It is not generally necessary to remove all traces of waste material from the cell. The Coulometric titration method can be used in the presence of many foreign substances. Wiping waste material with a soft paper towel should clean the sensing electrode. It can be rinsed with solvents.

NOTE

Never heat the sensing electrode or place it in a drying oven. The sealed glass envelope may crack.

(d) Cleaning and maintaining the generator. Over a period of time, contaminants may accumulate in the frit of the generator cartridge. Many of the contaminants can be removed by periodically rinsing the frit with dry reagent grade methanol or other solvents. When the contaminants build up to the extent that they begin to impair the performance of the Aquatest 2010, the instrument may display an error message.

(e) Reagents and equipment for cleaning the generator.

1. Alcohols. Methanol or ethanol, reagent grade, should contain a low amount of water. Alcohols are used to rinse the frit after nitric acid cleaning and water rinsing.

NOTE

Ketones such as acetone, aldehydes and very acidic or basic solvents should not be used to clean the components of the titration vessel. Some of these solvents can interfere with the Karl Fischer reaction when present at elevated levels.

2. Other solvents. A wide variety of solvents may be used to remove sample build up on the frit. Oils can best be removed with petroleum solvents – xylenes, toluene, chloroform, methylene chloride, etc. With other samples, the analyst is usually aware of solvents in which their samples are soluble. Use these solvents to remove any build up on the frit. Rinse the frit with water to remove the solvents before cleaning with nitric acid. The frit material and the platinum anode and cathode are relatively inert to most solvents and acids. Strong alkalis should be avoided especially when hot, for they may damage the frit.

3. Nitric acid. ACS reagent grade nitric acid is suggested for thorough cleaning of the frit. Technical grades can be used if ACS reagent grade is not available. Nitric acid is preferred to other acids and can be obtained from any chemical supply house.

4. Containers for cleaning the generator. Any acid and solvent resistant glassware or plastic-ware may use. Glass or polyethylene containers are suitable.

5. Vacuum apparatus. Some means of drawing a slight vacuum on the generator cartridge is necessary. The PHOTOPHOLT titration cell cleaning kit (part number 4091004), is quite useful for providing a sufficient vacuum. A plug for the vent hole is included with the kit.

6. Explosion proof oven. An oven can be used to dry the generator cartridge after rinsing with alcohol. Maintain the oven at 40-60 degrees Celsius. Use of a drying oven is optional.

(f) Cleaning procedure.

1. The Aquatest 2010 should be in [STANDBY] mode or the power should be turned off before unplugging the generator cartridge from the instrument.

2. Remove the generator cartridge and siphon or pour off the generator solution.

3. Rinse the generator cartridge with methanol followed by clean water to remove any remaining Karl Fischer solutions.

4. Insert a plug into the vent hole on the generator cartridge if vacuum is to be used to aid in the cleaning process.

5. Immerse the generator cartridge in a small container of 75% nitric acid and 25% water. Draw about 5-10 ml of acid into the generator cartridge. It will probably come through the frit very dark brown due to iodine's and other containments. Discard the darkened acid and draw more acid through the frit until it comes through clear.

6. Replace the acid container with one containing water and repeat the process of drawing water through the frit. Draw up enough water to completely remove all traces of the nitric acid.

7. Replace the water container with one containing the driest alcohol available (methanol is preferred) and repeat the process of drawing alcohol through the frit.

8. Place the generator cartridge in an explosion proof oven to dry.

WARNING

Dispose of Karl Fischer reagents, solvents and cleaning solutions in a proper manner. Refer to the MSDS sheets for the chemicals to identify chemical hazards. Follow all applicable regulations regarding disposal of chemical waste.

c. Distillation Test for Water in Petroleum Products and Bituminous Materials. (ASTM-D95)

(1) Scope. This test method covers the determination of water in petroleum products, tars, and other bituminous materials by the distillation method.

(2) Summary of Method. The material to be tested is heated under reflux with a water-immiscible solvent, which co-distills with the water in the sample. Condensed solvent and water are continuously separated in a trap, the water settling in the graduated section of the trap and the solvent returning to the still.

(3) Equipment/Apparatus/Materials. The apparatus consists of a glass or metal still, a heater, a reflux condenser, and a graduated glass trap. For detailed equipment requirements, refer to ASTM-D95, Section 6.

(4) Standards/Standardization/Calibration. Standardization of a given assembly of apparatus is accomplished when accurate readings are obtained from the addition of known amounts of water from a calibrated buret or pipet to a clear hydrocarbon oil, which is then tested in accordance with ASTM-D95, Section 9.

(5) References/Guidelines:

(a) ASTM-D86 Method for Distillation of Petroleum Products.

(b) ASTM-D1796 Test Method for Determination of Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure).

(c) ASTM-D4006 Test Method for Water in Crude Oil by Distillation.

(d) ASTM-D4007 Test Method for Water and Sediment in Crude Oil bj the Centrifuge Method (Laboratory Procedure).

(e) ASTM-E123 Specification for Apparatus for Determination of Water by distillation.

d. Pall TD513 Series Water Sensor

(1) Scope. This test method covers the determination of the total of dissolved water in hydraulic, transmission, and electronic cooling system fluids.

(2) Summary of Method. The Pall Water Sensor is a small portable device that provides an electronic display reading of percent dissolved water through the use of in-system, bottle, or dipstick probes.

(3) Equipment/Apparatus/Materials.

(a) Water Sensor

(b) Probes

(c) Battery Charger

(d) Isopropyl alcohol is required to clean the probes.

(4) Standards/Standardization/Calibration. A calibration validation procedure is used to ensure that the unit is operating properly and within calibration tolerances.

(5) References/Guidelines: Pall TD513 Water Sensor Manual

(6) Quick Use Instructions to monitor fluid water content.

(a) Charge Unit. Plug power adapter into a 110V wall outlet for 24 hours (see battery, page 6 of the manual).

(b) Connect sensor. Attach the sensor to the display cable by rotating the outer ring clockwise.

(c) Press “PWR” to turn unit “on”.

```
Measure?
Yes        Next
```

(d) Press “YES” to accept measurement mode.

```
I.D.#
Next   Yes   No
```

(e) Press “YES” to continue without entering a sample identification number.

1. Press “FLUID TEMP” to select a different fluid to be measured.

```
73F
H-83282
218
```

2. Press “NEXT WATER” to change fluid type.

```
Use PRF-
87252?
Yes    No
Next
```

3. Press “YES” to accept the fluid type. or

```
Fluid Selected
```

4. Press “NO” to go back to step (e) without changing the fluid type

```
73F
H-83282
218
```

```
Store this data?
Yes      No
```

(f) Press “YES” if proper measurement has been displayed

(g) Press “YES” to save measurement and return to step (c)

OR

```
Measure?
Yes
Next
```

(h) Press “NO” not to save and return to step (c)

```
Measure?
Yes
No
```

(i) Press “PWR” to turn unit off.

Note: The Pall Water Sensor information has been included in the JOAP Manual with permission from Pall Aerospace.

SECTION VI

US NAVY DIELECTRIC COOLANT TESTING

6-1. GENERAL.

a. Introduction. This section provides technical information required for dielectric coolant testing. It includes several individual test methods, which are utilized to perform analysis on coolant fluids, used in Naval aircraft. It is an abbreviated manual for use by trained operators and is not intended to replace applicable equipment manuals, test procedures or training. This manual is required reading for all personnel responsible for the installation, operation or support of the equipments described.

b. Objective. The primary objective of this section is to provide an abbreviated set of instructions for performing dielectric coolant testing at the intermediate level.

c. Application. This section is applicable to dielectric coolant testing utilized at the intermediate level of maintenance, ashore and afloat. The testing is required for maintenance and support of the F-18 APG-65, and AV-8 radar coolant systems and both the F-14 AWG-9 and AIM-54 coolant systems. The intermediate level dielectric coolant test sets are utilized to perform coolant fluid quality tests on site, at the location of the equipment. Two samples (color coded red and green) are taken at 30 day intervals for Support Equipment (SE), at 56 day intervals for the F-14 and at 84 day intervals for the F-18 and AV-8. Sample red is tested at the intermediate level for moisture, flash point and particle contamination (patch test). If sample red passes all three tests, then sample green will be forwarded to a higher capability laboratory where dielectric breakdown, volume resistivity and particle count tests will be performed. However, if sample red fails either of the three tests specified herein, sample green shall be discarded.

d. Coolant Fluid Contamination. Silicate ester fluids (i.e. Coolanol 25R) are very effective in transferring heat and providing high voltage insulation. However, they have two undesirable properties: a hygroscopic nature and poor hydrolytic stability. Being hygroscopic, the fluids readily absorb any moisture to which they are exposed, atmospheric moisture included. The lack of hydrolytic stability means that the fluid may combine with water to form undesirable by-products. These by-products include gel-like substances that can adversely affect equipment operation, when deposited in a critical area, and affect the flammability of the fluid itself. The fact that these substances, when present, tend to pick up minute amounts of particulate matter and ionic contaminants further creates a problem, in that their presence can also degrade the electrical insulating properties of the fluid. Coolanol fluid is being replaced by polyalphaolefin (PAO) dielectric coolant fluid, which does not exhibit these properties.

e. Fluid Inspection. Fluid inspection consists of the collection and test of fluid samples obtained from operating equipments. Inspections are performed in accordance with scheduled requirements and when coolant contamination is otherwise suspected. Fluid samples are collected in specially prepared sample bottles using procedures provided in applicable equipment manuals. Samples are tested utilizing the liquid coolant testing procedures provided in this manual.

f. Coolant Fluid Testing Requirements. Liquid coolant contamination control requirements have been established for all F-18, AV-8, and F-14 aircraft and for support equipment (SE) to assure that fluid is maintained within acceptable limits that will preclude its physical deterioration and to assure satisfactory equipment operation. Most important, there is a requirement for the periodic collection and test of fluid samples from all operating equipment, with tests performed to assure that the following physical properties are within the limits specified:

(1) Water content: Not to exceed 150 parts per million (ppm) in aircraft systems or 100 ppm in SE. Not to exceed 150 ppm in EOTS/CASS (AN/USM-629/AN/USM-636) Coolant Unit Assy (P/N 74D740194-1001).

(2) Flash point: Minimum of 275°F (Cleveland Open Cup).

(3) Particulate level: Not to exceed Navy Standard Class 5 in aircraft systems or Navy Standard Class 3 in SE. Not to exceed Navy Standard Class 5 in EOTS/CASS (AN/USM-629/AN/USM/636) Coolant Unit Assy (P/N 74D740194-1001.)

g. Coolant Fluid Analysis. Coolant fluid testing is generally accomplished at the depot level utilizing laboratory-type test equipment. The testing described in this manual is intended for utilization at the intermediate level to provide an immediate “Go or No Go” indication. More extensive testing will be accomplished at depot level facilities.

h. Decontamination Procedures. Aircraft or SE found to be unacceptably contaminated are decontaminated using procedures provided in the applicable maintenance manuals. The procedures vary but the basic technique used is to circulate the contaminated fluid through known serviceable fluid conditioners.

i. Related Publications.

(1) NAVAIR 01-1A-17 Aviation Hydraulics Manual.

(2) NAVAIR 17-15E-52 Operation and Intermediate Maintenance with Illustrated Parts Breakdown for Hydraulic Fluid Contamination Kit P/N 57L414.

(3) ASTM D-92 Test Method for Flash and Fire Points.

(4) ASTM D-1533 Test Method for Water in Insulating Liquids (Karl Fischer Reaction Method).

j. Training Description. All of the tests required for testing coolanol are included in the physical properties portion of the JOAP Operator/Evaluator Training School.

6-2. COOLANT TESTING PROCEDURES.

a. Introduction. This section provides general procedures for testing coolant samples. It is intended to assist the operator by providing procedural information relative to incoming inspection of the sample, sequence of testing, general test requirements and data reporting.

b. Incoming Sample Inspection. The bottles are made of polyethylene plastic and hold 8 fluid ounces when filled. The bottles are intended for one-time use and are discarded upon completion of the fluid analysis. Provided with each sample bottle is a coolant sample identification label (Figure 6-1). This label, when filled in and attached to the sample bottle, identifies the submitting activity and equipment sample.

c. Visual Inspection

(1) Prior to the sample analysis, the unopened sample bottle shall be visually inspected for proper filling and sealing, as well as evidence of gross contamination. Properly filled bottles will be almost completely filled with fluid extending up to the bottom of the threaded neck section. The purpose of completely filling the bottle is to minimize the quantity of air present, which could contain large amounts of atmospheric moisture, and to assure that adequate fluid is available to perform all of the required tests. Activities submitting coolant fluid samples in improper or inadequately filled bottles shall be advised to resample the equipment.

<table>
<tr><td colspan="13">COOLANT IDENTIFICATION LABEL</td></tr>
<tr><td colspan="13">SAMPLE I.D. (SOURCE, BUNO./SERIAL NO.)</td></tr>
<tr><td colspan="13">FILL OUT ACCURATELY AND COMPLETELY</td></tr>
<tr><td colspan="4">(CIRCLE ONE)
F-14 AIRCRAFT</td><td colspan="4">PGSE AND SE</td><td>AN/USM 629</td><td>F-18</td><td colspan="2">AV-8</td></tr>
<tr><td>AWG9</td><td>AIM54</td><td>RAIL</td><td>FAIRING</td><td>LAU9 3</td><td>LCSU</td><td>FMU</td><td>HD 957</td><td>DSM 130</td><td>APM 446</td><td></td><td colspan="2">APG 65</td></tr>
<tr><td colspan="6">SAMPLING DATE</td><td colspan="7">PREVIOUS SAMPLING DATE</td></tr>
<tr><td colspan="13">AIRCRAFT HOURS OR METER HOURS</td></tr>
<tr><td colspan="11">SUBMITTING ACTIVITY</td><td colspan="2">PHONE NO.</td></tr>
</table>

Figure 6-1. Coolant Identification Label

(2) Prior to sample analysis, fluid in the sample bottle shall be visually inspected for evidence of free water, turbidity or visible particles. This inspection is somewhat limited by the is positioned in front of a strong light source. Free water, when present, will collect in the bottom of the bottle and be readily visible. Allowing the bottle to stand stationary for at least 10 minutes prior to inspection will cause any dispersed water droplets to settle out, rendering them more visible. Free water is cause for rejection, and the submitting activity shall be requested to resample the equipment to confirm this indication.

(3) Gross particulate contamination, i.e., particles large enough to be seen with the unaided eye, will also be most visible when the fluid is allowed to stand motionless for a period of time. Like free water, such particles will generally settle to the bottom of the bottle. Gross particulate contamination is usually indicative of improper sampling technique. If present, the submitting activity shall be so advised and requested to resample the equipment.

(4) Fluid turbidity results in the coolant fluid appearing cloudy as opposed to its normal clear, transparent appearance. Turbidity is most visible when the fluid is agitated and may be indicative of large amounts of air, free water or suspended foreign matter. Allowing the fluid to stand stationary for a period of time will assist in identifying the probable cause. Turbidity caused by suspended semi-solid matter is of particular concern as it may be indicative of chemical degradation of the Coolanol fluid. The contamination byproducts of such degradation will also show up when performing the test for particulate contaminations using the patch test.

d. Testing Sequence.

(1) Coolant fluid analysis at the intermediate level consists of three separate tests. It is important that the individual tests be conducted in a specific sequence to minimize the effects of sample handling upon the test results. Table 6-1 illustrates the required testing sequence in chart form and should be referred to until a normal working routine is established.

The test for particulate contaminations using the patch test.

(2) The first test performed on any sample is water measurement utilizing the Photo volt Aquatest VIII. This test is highly affected by exposure of the sample fluid to the atmosphere, particularly in high humidity environments. The fluid sample bottle shall not have been opened prior to the time that fluid is removed for the water test, thus minimizing the effects of external moisture.

Water measurement is accomplished in accordance with detailed procedures provided in Section 5-3. In performing the test, fluid is removed from the sample bottle using a hypodermic syringe and transferred to the aquatest for analysis. A minimum of 2 analyses per sample, each requiring at least 2 milliliters (ml) of sample fluid, are analyzed to assure adequate repeatability of test results. The total amount of fluid required for the water analysis normally will not exceed 10 ME.

(3) Flash Point Analysis. Analysis for flash point is the second test performed on the coolant fluid sample. The analysis is accomplished using the Cleveland Open Cup flash point tester. Detailed operating procedures are provided in Section 6-4.

TABLE 6-1. SPECIFIC TESTING SEQUENCE

Testing Sequence	Key Requirements
Inspect bottle sample	Inspect for: Use of proper sample bottle. Sample bottle completely filled. Identification label properly filled out.
Record identification data	Record identification data on: Test data worksheet. Test data report form.
Visually inspect fluid	Inspect for: Free water. Visible particles. Turbidity.
Measure water content	in performing test: Perform three separate tests (if necessary). Use 2-ml samples for each test. Record test results on worksheet. (Two separate tests with results that do not differ more than 11 pprn are acceptable).
Measure flash point	in performing test: Use Cleveland Open Cup test set. Fill cup to fill mark. Record test results on worksheet.
Measure particle level	in performing test: Perform Patch Test Analysis using 100 ml samples. Use Contamination Analysis Kit. Record test results on worksheet.
Review test data	Review test data to: Determine fluid acceptability. Determine need for corrective maintenance advisory.
Prepare test report	Prepare test report providing: Numerical test results. Pass/fail notations. Appropriate maintenance advisories.

(4) Particulate Analysis. Analysis for particulate (solid particles) contamination is the third test performed on the coolant fluid sample. The analysis is accomplished using the Contamination Analysis Kit, part no. 57L414. Section 6-5 contains the procedures for analyzing coolant samples for particulates.

e. Test Data Reporting.

(1) The recording and reporting of test data resulting from the analysis of fluid samples is of the utmost importance. The information provided by the testing operator will in effect determine whether corrective maintenance will be performed on the equipment. To facilitate test data reporting, the use of specially prepared worksheets/forms (Figure 6-2) is recommended.

COOLANT ANALYSIS RECORD														
SUBMITTING ACTIVITY													TELEPHONE	
SAMPLE I.D. (BUNO/SER NO.)													DATE RECIEVED	
SAMPLING DATE				PREVIOUS SAMPLING DATE									OPERATING HOURS	
F-14 AIRCRAFT					PGSE AND GSE								F18	AV8
AWG-9	AIM54	RAIL	FAIRING	LAU93	LCSU	FMU	HD 957	DSM 130	PURF CART	ARM 446	AN/USM 629		APG 65	APG 65
MOISTURE					NAVY CLASS								MESSAGE NUMBER (IF APP)	
1		4												
2		5			SUITABILITY								JON (IF APPLICABLE)	
3		6												
AVG					FLASH POINT								NAME/DATE/TIME NOTIFIED	
REMARKS:														
					SAMPLE NUMBER								REPORT NUMBER CC —	

005002

e

Figure 6-2.Cooliant analysis Report

(2) Test results shall be entered into the Navy Oil Analysis Program Spectrometer Interfaced Data analyzer (NOAP-SIDA) computer. One copy is returned to the customer activity. Data entered into the NOAP-SIDA is forwarded by normal NOAP-SIDA data transmission procedures:

f. Maintenance Advisory. The purpose of the maintenance advisory is to allow the testing operator to provide the activity with the information for corrective action if necessary. Appropriate maintenance advisories from Table 6-5 will be included in the remarks section. The customer activity then will take the appropriate action.

6-3. MOISTURE ANALYSIS.

a. Introduction. The Aquatest VIII uses both the dead stop electrode and the coulometric generation of iodine in a closed vessel system. The coulometric addition of iodine makes the Aquatest an absolute instrument. When sample is added to the vessel reagent, the voltage rises across the sensing electrode to indicate the wet state. This triggers the coulometer and a constant current flow through the generator producing iodine in the vessel reagent. The iodine reacts with the water from the sample and the vessel solution. When all the water has reacted, the voltage at the sensing electrode drops. This signals the coulometer to stop. The electrical charge produced during the titration is measured coulometrically and is displayed as the total water content. Since the reagent in the vessel is returned to an initial state at the end of each sample addition, sequential analysis can be performed until the vessel reagent is exhausted.

b. Instrument Setup.

(1) Place the Aquatest VIII instrument on the laboratory bench in an area away from direct sunlight and sources of heat such as ovens.

(2) Handle the generator assembly (8, Table 6-2) by the Teflon collar.

(3) Holding the vessel cover (10) with the thumbscrews facing away from you, feed the generator plugs and wires through the larger threaded opening. While gently pulling the wires out of the way of the threads, insert the end of the generator that is open into cover.

NOTE

Never risk breaking the generator by over tightening it in the vessel cover. A gentle tightening will be satisfactory.

(4) Lightly and evenly grease the ground glass rim of the Pyrex vessel jar (12, Table 6-2) with the Photo volt special sealant (4). Check to see that the thumbscrew fasteners on the cover are fully unscrewed and extended.

(5) Place the magnetic stir bar (14) into the vessel jar.

(6) Carefully join the titration vessel jar and cover with the generator assembly. Twist the cover gently to spread the sealant. Finger tighten the cover thumbscrews to lock it onto the vessel jar, assuring the pawl on each thumbscrew grasps the lip of the vessel jar securely.

(7) Install a membrane septum. (7, Table 6-2)

TABLE 6-2. AQUATEST VIII REPLACEMENT PARTS

Item	Description	Part Number	Source
1.	Solution, Generator, Pyridine-Free (50 ml bottle)	2712801	Seradyn, Inc 1200 Madison Ave. Indianapolis, IN 46225-1600 (800) 222-5711
2.	Solution, Vessel, Pyridine-Free (Four 200 ml bottles)	0890106	Seradyn, Inc
3.	Aqua star Coulomat Single Solution (500 ml) (Alternate to items 1 and 2)	EM9255-1	VWR Scientific P.O. BOX 626 200 Center Square Road Bridgeport, NJ 08014 (800) 932-5000
4.	Grease, Special Sealing	2712205	Seradyn, Inc
5.	Electrode, Sensing, Aquatest 8, AC Circuitry (Dual platinum loops)	0412201	Seradyn, Inc
6.	Electrode, Sensing, Aquatest, DC Circuitry (Single platinum loop)	0412401	Seradyn, Inc
7.	Membranes, Sample Port (20 to a pkg and 3 caps)	0812202	Seradyn, Inc
8.	Generator Assembly (one-piece), Aquatest 8	1112801	Seradyn, Inc
9.	Three-piece Generator Assembly (complete)	1112813	Seradyn, Inc
10.	Vessel Cover (for 1112801)	1212802	Seradyn, Inc
11.	Vessel Cover (for 1112813)	1212805	Seradyn, Inc
12.	Vessel, Titration (alone)	2612201	Seradyn, Inc
13.	Cap, Generator	2612211	Seradyn, Inc
14.	Bar, Stir	2612250	Seradyn, Inc
15.	Pump; Vacuum (to clean generator)	2612254	Seradyn, Inc
16.	Syringe, Hamilton Series 7000, 5 micro liters, Gastight, 4-1/2 inch round point needle with Chaney Adapter	2612255	Seradyn, Inc
17.	Needle, nerve block, 19 gauges, 5 inches long	7522	Popper and Sons, Inc P.O. Box 128 300 Denton Ave. New Hyde Park, NY 11040 (516) 248-0300
18.	Syringe, glass multifit, luerlok, B-D (10 ml)	BD2132	See address in item 3.

(8) Lightly grease the ground glass collar area of the sensor electrode (5 or 6, Table 6-2). Insert the electrode into the small opening of the vessel cover. As you carefully and gently seal the collar into the cover, align the platinum circle rings at the end of the electrode such that they are parallel with the side area of the vessel jar closest to them.

c Pyridine Free Reagent Setup.

(1) In an exhaust hood or well ventilated area, remove the septum holder cap and membrane (7, Table 6-2) from the vessel cover, place the funnel supplied into the septum support, and add the entire contents of a bottle of vessel reagent (2). Remove the funnel and replace the septum and cap.

(2) Remove the generator cap (13). Using a glass syringe (18), add approximately 3-4 ml of pyridine-free generator solution (1) to the generator. Replace the generator cap.

NOTE

As an alternative, Aqua star Coulomat Single Solution (manufactured by EM Science) can be used in both the generator and vessel in the same amounts as the Photo volt pyridine-free reagents.

(3) Place the vessel jar onto the Aquatest VIll inside the plastic retaining ring.

(4) Plug the two banana plugs from the generator into the two banana jacks on back of the Aquatest VIll, black-to-black and red-to-red for proper polarity. Plug the sensing electrode plugs into the smaller two jacks; the larger of the two sensor plugs goes into the small red jack.

(5) Plug the power cable of the Aquatest VIII into an 110-VAC grounded receptacle.

NOTE

Assure the Aquatest VIII does not share its power line with devices capable of causing power line disturbances such as motors, compressors, refrigerators and ovens.

(6) Dip Switch settings should be 1,2,4,5,7,8 UP and 3,6 DOWN.

(7) Switch on power. The Aquatest will perform internal diagnostics, then display SELECT MODE.

NOTE

When the Aquatest VIII is first turned on, wait 30 minutes before performing a sample assay. This time allows the instrument and vessel assembly to stabilize in its new working environment. Photo volt pyridine-free reagent does not require the use of any neutralizing reagent.

(8) When SELECT MODE is displayed, press MONITOR.

(9) Press the first key on the left of the upper 4 keys that corresponds to SEN.

(10) At this time you will see wet/dry status which will usually show the reagent being at set point or slightly wet; this will be displayed on the Aquatest VIII as follows: WET… !∧ ... DRY.

(11) When the vessel is at set point, a caret on the dotted line will appear as follows: WET ... ∧ ... DRY. The instrument is ready to perform assays.

d. PPM Moisture Assay

(1) Press SET-UP.

(2) Press the fourth white function key under WT.

(3) Press the fourth white function key under NO to enter in a single sample weight.

(4) Press the fourth white function key under NO to allow manual entry of sample weight.

(5) Press CLR to remove the weight value stored in memory.

(6) Key in 1600 for PAO (1800 mg for Coolanol) as the weight of the sample and press ENTER. The aquatest VIII will beep as it stores the value in memory.

NOTE

In order for the Aquatest microprocessor to compute water content in ppm by weight, it must have the weight of the fluid sample. PAO fluid has a specific gravity of 0.8, weighing 0.8 grams per ml. The sample size of 1 ml represents a sample weight of 0.8 grams or 800 milligrams (mg). A sample size of 2 ml, therefore, represents a sample weight of 1600 mg.

(7) Again press SET-UP and this time press the first function key to choose UNIT.

(8) MCG PCT PPM will be displayed. Press the third function key to choose PPM.

(9) Press SET-UP. The third option is DLY: press the white pad. Next menu will display MCG TIME. Press the second pad correlating to TIME. Press the CLR key on the keypad and enter 0.3. This is 0.3 minutes or 18 seconds of a delay in the titration. Finally press ENTER. Now the instrument will delay the start of the titration by 18 seconds after the initial 7-second injection period has elapsed.

CAUTION

If the test set has not been used for 12 hours or more, initial test results may tend to be inaccurate. Perform two or three analyses, using spare coolant fluid, to allow test set to stabilize.

NOTE

Since the weight analysis is to be based on the weight transferred, care must be taken to remove all air bubbles from both the syringe and needle.

Careful wiping of the liquid clinging to the needle is required for precision. Do not draw the tissue all the way over the end of the needle. Wipe to just the edge of the needle tip and then stop. Blot the membrane septum between samples.

(10) Gently invert and swirl the sample bottle, so as to mix contents without generating excessive air bubbles. Remove the cap from the sample bottle. Using a clean, dry (see step (16).)

e. 10-ml glass hypodermic syringe (18, Table 6-2) fitted with 5-inch needle (17, Table 6-2), slowly draw approximately 1 ml of sample fluid from the sample bottle into the syringe. Withdraw the plunger past the 8-ml mark. Coat the interior walls of the syringe with the coolant fluid. Depress the plunger and expel the 1 ml of coolant into a waste container. Wipe needle clean.

(11) Using the same 10-ml glass hypodermic syringe fitted with 5-inch needle, slowly draw approximately 7 ml of sample fluid from sample bottle into syringe.

(12) With the needle pointed up, allow the air bubbles to rise to the tip. Place the wiping material above and over the needle point and slowly expel into wiping material any air trapped in syringe and any fluid in excess of 6 ml. Syringe should now contain exactly 6 ml of sample fluid and no air. Wipe the needle clean with wiping material.

(13) Press START Introduce sample immediately after ADD SAMPLE 7 SEC is displayed as follows: Insert needle through membrane septum (7, Table 6-2) on sampling port in vessel cover until it is below the level of the vessel solution, and discharge precisely 2 ml of fluid directly into the vessel solution. Remove the needle from sampling port. After 7 seconds, the display will show DELAY for 0.3 minutes and be automatically followed by titration.

(14) At the end of the titration, the weight that is in memory will be displayed as a confirmation test. If it is the right weight, merely press ENTER, and the result of the assay will be displayed in parts per million water.

NOTE

If the sample weight displayed after titration is incorrect, press CLR and enter the correct weight followed by ENTER.If you are assaying a number of samples of the same weight, you will only need to enter this weight once.Results of water analysis should be reported as an average of at least two runs. Results are considered to have good repeatability if they are within 11 ppm of each other. If they are not, perform a third run and report the average of the three runs.

(15) Repeat step d. (13) for the next injection of the same sample. If a different sample is to be injected, repeat step d. (10).

(16) Thoroughly clean the syringe, attached needle and plunger with filtered Dry Cleaning Solvent (2, Table 6-3) or isopropyl alcohol (3, Table 6-3) and allow it to air dry. If using flammable solvents, use an explosion proof oven and a temperature of 185°F or 85°C. For non-flammable solvents, if a hot air oven is available, place the syringe with plunger out of the barrel into the oven at 212°F or 100°C. After 5 minutes, remove the apparatus from the oven using protection for the hands and insert the plunger into the syringe barrel. Allow it to cool to room temperature (approximately 2 or 3 minutes). Syringe, needle, and plunger may also be cleaned in a solution of 2% Micro Cleaner (1, Table 6-3), rinsed well with hot tap water, and placed on in a hot air oven at 212°F or 100°C.

TABLE 6-3. SOLVENTS AND CHEMICALS

Item	Nomenclature	Specification or Part Number	Unit Issue	Source
1.	Micro Liquid Laboratory Cleaner	H-08790-00	Case of 12 1 qt btls	Cole - Parmer Instrument Company 7425 N Oak Park Niles, IL 60714 (800) 323-4340
2.	Solvent, Dry Cleaning	P-D-680 Type II	1 Gallon	Navy Stock
3.	Isopropyl Alcohol	TT-I-735	1 Gallon	Navy Stock
4.	Methanol	O-M-232	1 Gallon	Navy Stock
5.	Sodium Hydroxide, 0.5 Normal	SS270-4	4 Liters (bottle)	Fisher Scientific 711 Forbes Ave Pittsburgh, PA 15219-4785 (800) 766-7000
6.	Sodium Hydroxide, Pellets NSN 6810-00-234-8373	O-C-265	2.5 kg (bottle)	

f. Cleaning Generator.

(1) The bottom end of the generator assembly consists of a porous Pyrex glass frit. With use, the minute fluid passages in the frit will become clogged, retarding the transfer of generator solution to vessel solution during titration. This condition * may be indicated by the error display GEN OVERVOLTAGE and can be corrected by cleaning the frit. (* This display does not always occur.)

WARNING

Do not get sodium hydroxide (NaOH) solution in eyes on skin or on clothing: it causes severe burns. Do not take it internally. Wear gloves and wear goggles (or face shield) when handling.

When making up solution with NaOH pellets, continuously stir solution while adding compound: add it slowly to the solution to avoid violent splattering. Limit the heat rise to 50°F (10°C) per minute. Do not allow temperature of solution to exceed 194°F (90°C) when mixing.

Do not use on aluminum parts; reaction with aluminum forms large volumes of hydrogen gas. Flush area of spillage or leakage with water spray.

(2) The generator frit is cleaned by soaking it in a sodium hydroxide (caustic) solution (4, Table 6-3) and applying a vacuum to the top of the generator assembly. The vacuum pulls the caustic solution through the frit, opening up the pore structure. To clean frit, proceed as follows:

(a) Remove power from the Aquatest by switching the power off in back of the test set (power can be left on if so desired).

(b) Disconnect the generator and sensing electrode cables from the jacks.

(c) Loosen the three thumbscrews on the vessel cover and swing pawls away from the titration vessel. Use gentle twisting motion to loosen grease seal and remove cover.

(d) Remove generator cap from generator assembly and pour used generator solution into an approved waste container.

(e) Pour used vessel solution into the same waste container used in step e. (2) (d). Be careful not to pour out magnetic stir bar. Seal the waste container. Next transfer the magnetic stir bar from titration vessel onto a clean wiping cloth. Wipe and dry the stir bar with a clean disposable towel.

(f) Grasp Teflon mounting collar on generator assembly and remove from vessel cover by carefully unscrewing threaded section. Remove sensing electrode and wipe it clean.

(g) Using the empty titration vessel, stand generator assembly to be cleaned in empty vessel. Pour technical grade 0.5 Normal (0.5N) sodium hydroxide (NaOH) solution into the empty vessel jar until a level of approximately 2 inches is reached. To make up 0.5N NaOH, weigh 80g of pellets (6, Table 6-3) and dilute with 4 liters of tap water or deionized water if available.

(h) Pour additional solution into top opening of generator assembly, just enough to cover the frit.

(i) Allow generator assembly to soak 1 hour in the sodium hydroxide solution. Longer periods of soaking, if required, may be employed without damage to the generator. Periodically observe fluid level inside generator. An increase in level will indicate partial clearing of the frit; the open frit allows fluid to transfer from the vessel into the generator. Upon completion of soaking, discard used NaOH solution into an approved waste container, or dispose by approved methods.

(j) Expedite cleaning of porous frit after soaking procedure by the application of a vacuum (not to exceed 15 inches mercury (Hg)) to the generator assembly. Required vacuum can be obtained using the syringe and valve (15, Table 6-4) provided with Contamination Analysis Kit, part no. 57L414. Locally fabricate required adapters to connect vacuum source to generator, using modified rubber or cork stopper to connect vacuum line to open end of generator.

(k) Place fresh sodium hydroxide solution in emptied titration vessel, enough to partially cover the generator assembly when it is placed in the titration vessel. Apply vacuum to generator assembly until caustic cleaning solution flows freely from the vessel jar to the inside of the line. If required, pour excess fluid from generator assembly to waste. A filtering flask may be installed as a trap between the generator and the vacuum pump.

(l) When frit has been cleaned, remove generator assembly from vessel jar and discard caustic solution into an approved waste container, or dispose by approved methods. Rinse generator assembly and vessel jar using generous amounts of water, preferably hot.

(m) Return generator assembly to the vessel jar and partially fill vessel with tap or deionized water. Using vacuum procedure specified in steps (j) and (k), flush frit with water to remove residual caustic solution.

(n) Remove generator assembly from vessel jar and discard water.

TABLE 6-4. CONTAMINATION ANALYSIS KIT REPLACEMENT PARTS

Item	Description	Part Number (Millipore)	NSN
1.	Holder Assembly, Filter	XX6300120	Not Listed
2.	Funnel, Stainless Steel	XX6300121	Not Listed
3.	Support, Holder with Screen and Aluminum Base	XX6504708	6640-00-256-3351
4.	Support O-Ring, Buna-N (5/pkg)	YY4014267	5330-01-207-1482
5.	Base O-rings, (2) BUNA-N (1 0/pkg)	XX6300123	Not Listed
6.	Flask, Vacuum, Stainless Steel	XX63000129	6640-00-256-3354
7.	Bottle, Solvent Rinse, Plastic 500 ml (mod.)	XX6504704	8125-01-238-1382
8.	Holder, Swinnex Filter	XX6504707	6640-00-476-0682
9.	Bottle, Wash, Plastic, 500 ml	XX6504701	6640-01-076-5460
10.	Bottle, Sample, Plastic, 4 oz.	XX6504709	6640-01-193-0568
11.	Cylinder, Graduated, TPX, 100 ml	XX6504702	6640-01-165-5747
12.	Forceps, Stainless Steel	XX6200006	6640-00-426-0300
13.	Slides, Petri (100/pkg)	PD1504700	6640-00-431-6919
14.	Filter Membranes, Test, 47 mm (1 00/pkg)	SMWP04700	6640-00-967-0488
15.	Filter Membranes, Solvent, 25 mm (1 00/pkg)	SMWP02500	6640-00-152-1460
16.	Syringe and Valve	XX6200035	6640-00-086-5326
17.	Tube and Adapter, with Clamps	XX6504710	6640-00-256-3355
18.	Contamination Standards	XX6504713	6630-00-102-9187

WARNING

Methanol is flammable - do not use near open flames, near welding area, or on hot surfaces. Do not smoke when using it, and do not use it where others are smoking. Prolonged or repeated inhalation of vapor can cause eye irritation, drowsiness, and headache. Ingestion may be fatal or may cause eye damage. If vapor contacts eyes, immediately flush eyes with large amounts of water. Immediately remove solvent-saturated clothing. If vapors cause drowsiness, go to fresh air. When handling or applying liquid at air-exhausted workbench, wear approved goggles and gloves. When handling or applying liquid at unexhausted workbench, wear approved respirator, goggles and gloves.

(o) Remove residual water from generator assembly by pulling methanol (4, Table 6-3) through generator with vacuum, as described in steps (j) and (k), and then drying in explosion-proof oven (if available) at 150° to 185°F (65° to 85°C) for a period of 2 hours. If no oven is available, allow to air dry before use. Alternatively, generator assembly may be dried in a hot air oven, after step e.(2)(n) at 212°F (100°C), omitting the use of methanol. Store generator in dessicator, if available, until needed.

(p) In some cases, because of lack of equipment, it may not be possible to clean the frit in shipboard laboratories. In these cases the laboratory should be retained and subsequently taken to a shore-based laboratory where cleaning can be accomplished.

g. Calibration.

NOTE

The Aquatest VIII does not require calibration. However, a calibration check procedure is provided so that the user can quickly confirm that the instrument is indeed triturating water accurately. User calibration check is generally done every 6 months or as needed (whenever erroneous results are suspected).

(1) Set Aquatest to MCG mode (see paragraph d. (7)-(8)).

NOTE

In preparation for the following, fill a beaker or other clean container with a small amount of tap or deionized water. Set adapter on syringe (16, Table 6-2) to 1.0 micro liter mark on syringe barrel. Pump syringe several times while the needle is submerged in water to remove air. Remove septum membrane from sample port to enable needle (shorter length) to be below the vessel solution.

(2) Press START. Introduce sample immediately after ADD SAMPLE 7 SEC is displayed as follows: Insert needle of a gas-tight 5 micro liter syringe (16, Table 6-2) with built-in Chaney adapter directly through the sampling port in the vessel cover until it extends below the level of the vessel solution and discharge precisely 1.0 micro liter of water into the vessel solution. After a brief moment, remove syringe and needle from sampling port and replace membrane. After 7 seconds, the display will show DELAY and be automatically followed by titration. Establish that you obtain 1000 +/-50 micrograms of water. Repeat additions as necessary to determine precision (standard deviation less than or equal to 50 mcg is acceptable). Flush needle several times with water prior to storing to remove chemicals from Aquatest that will cause corrosion.

h. Replacement parts. For replacement parts, refer to table 6-2.

WARNING

Check local/state regulations before disposing of toxic wastes. Most local sewage disposal regulations prohibit the discharge of toxic wastes into natural waterways.

i. Disposal of Wastes. For handling and disposal concerns, refer to the Material Safety Data Sheet of the particular chemical or solvent.

6-4. FLASH POINT ANALYSIS.

a. Introduction. This section provides procedures used in determining the flash point of coolant fluid samples using the American Standard Test Method for Flash and Fire Points by Cleveland Open Cup (ASTM D 92). For detailed set up and equipment operation, refer to the applicable manual for the test equipment being used.

(1) Flash point is the lowest temperature at which application of a test flame causes the vapor of a specimen to ignite under specified conditions of test.

(2) Fire point is the lowest temperature at which a specimen will sustain burning for 5 seconds.

b. Summary of Method. The test cup is filled to a specified level with the sample. The temperature of the sample is increased rapidly at first and then at a slow constant rate as the flash point is approached. At specified intervals a small test flame is passed across the cup. The lowest temperature, at which application of the test flame causes the vapors above the surface of the liquid to ignite, is taken as the flash point.

c. Procedure.

CAUTION

The operator must exercise and take appropriate safety precautions during the initial application of the test flame, since samples containing low flash material may give an abnormally strong flash when the test flame is first applied. Assure that all flammables are removed from the immediate area prior to performing this procedure.

(1) Support the test apparatus on a secure level table in a draft-free room or compartment. Shield the top of the apparatus from strong light to permit ready detection of the flash point. Tests made in a laboratory hood, or in any location where drafts occur, cannot be relied upon. During the last 30°F before anticipated flash point, care must be taken to avoid disturbing the vapors in the test cup by careless movements or breathing near the cup.

(2) Wash the test cup with detergent in hot water. i.e., 2% solution of Micro Cleaner (1, Table 6-3) to remove any oil, traces of gum or residue remaining from a previous test. Rinse well with hot water. Wipe dry with disposable towel. Place on heating element of flash tester to remove last traces of water. Cool to at least 100°F below expected flash point prior to use.

(3) Support the thermometer in a vertical position with the bottom of the bulb ¼ inch from the bottom of the cup and locate it at a point halfway between the center and side of the cup on a diameter perpendicular to the arc of the sweep of the test flame and on the side opposite the test flame burner arm.

NOTE

The immersion line engraved on the thermometer will be 5/64 inch below the level of the rim of the cup when the thermometer is properly positioned.

(4) Fill the cup so that the top of the meniscus of the sample fluid is exactly at the filling line. If too much sample has been added to the cup, remove the excess with a medicine dropper. If there is sample on the outside of the apparatus, wipe off and clean thoroughly with a disposable towel. Destroy any air bubbles on the surface of the sample.

CAUTION

Meticulous attention to all details relating to the test flame applicator, size of the test flame, rate of temperature increase and rate of passing the test flame over the sample is necessary for good results and repeatability.

(5) Light the test flame and adjust it to a diameter of 1/8 to 3/16 inch which is the size of the comparison bead if one is mounted on the apparatus.

(6) Apply heat initially so that the rate of temperature rise of the sample is 25° to 30°F per minute. When the sample temperature is approximately 100°F below the anticipated flash point (275°F), decrease the heat so that the rate of temperature rise of the last 50°F before the flash point is 9° to 11°F per minute.

(7) Starting at least 50°F below the flash point, apply the test flame when the temperature read on the thermometer reaches each successive 5°F mark. Pass the test flame across the center of the cup, at right angles to the diameter, which passes through the thermometer. With a smooth continuous motion, apply the flame either in a straight line or along the circumference of a circle having a radius of at least 6 inches. The center of the test flame must move in a horizontal plane, not more than 5/64 inch above the plane of the upper edge of the cup and pass in one direction only. At the time of the next test flame application (each successive 5°F mark), pass the flame in the opposite direction. The time consumed in passing the test flame across the cup in each case shall be about 1 second.

(8) Record as the observed flash point the temperature read on the thermometer when a flash appears at any point on the surface of the oil, but does not confuse the true flash with the bluish halo that sometime surrounds the test flame.

(9) After cooling, test cup may be cleaned as in step c. (2).

d. For handling and disposal safety concerns, refer to safety summary at front of manual and to the Material Safety Data Sheet of the particular chemical.

6-5. CONTAMINATION ANAYLSIS KIT.

a. Introduction. This section provides detailed information on a method utilized to determine the level of particulate contamination in coolant fluid samples. It provides a detailed operating description of Contamination Analysis Kit, part no. 57L414 (08071) and its required operating procedures. Information is also provided that will assist the operator in maintaining the equipment and accomplishing minor repairs.

b. General Description of Equipment.

(1) Contamination Analysis Kit, part no. 57L414 (see Table 6-4) is the principal equipment used for determining contamination levels in naval aircraft hydraulic systems and related support equipment (SE). The equipment is compatible with the fluids utilized in liquid coolant systems and can be used to determine particulate levels in these fluids as well.

(2) The analysis kit employs a patch test technique in which a specific volume (100 ml) of sample fluid is filtered through an analytical filter disk of known porosity. All particulate matter in excess of a size determined by the filter characteristics is retained on the surface of the filter, causing it to discolor in an amount proportional to the particulate level of the sample fluid. The typical color of contamination in any given system will remain fairly uniform, and the degree of filter discoloration may be correlated with a level of particulate contamination. By visually comparing the test filter with the Contamination Standards representative of known contamination levels, a judgement can be made of the contamination level of the system. Free water will appear either as droplets during the fluid sample processing or as a stain on the test filter.

(3) The major component of the analysis kit is a filtration assembly consisting of a stainless steel funnel, filter holder and vacuum flask. The funnel is attached to the upper half of the filter holder, in which the filter disk is installed. The lower part of the filter holder is seated in the top opening of the vacuum flask, and an air-tight seal established by means of an 0-ring. A hand-operated vacuum pump is provided, which can be connected to a port on the vacuum flask and used to evacuate it.

(4) When processing a fluid sample, a new unused filter disk is first installed in the filter holder. One hundred milliliters (100 ml) of sample fluid is then measured out, using a graduated cylinder, and poured into the funnel. Using the hand pump, a vacuum is produced in the flask, pulling the fluid sample through the filter disk.

(5) Upon completion of the filtration process, a quantity of filtered solvent is introduced into the funnel and serves to rinse the filter disk free of any residual sample fluid, leaving only the particulate matter that is deposited on the filter surface.

(6) The Contamination Analysis Kit contains all the equipment and materials, solvent excepted, required to perform the test described. In addition to those items described, the kit also includes sufficient filters to perform 200 tests, sample collection bottles, solvent rinse bottles, filter storage slides and a Contamination Standard. The 4 ounce sample collection bottles, intended for use in hydraulic fluid analysis, are not utilized when sampling liquid coolant systems.

c. Unpacking. The Contamination Analysis Kit is a portable self-contained unit. All component parts are supplied in a fitted fiberglass carrying case that serves also as a transportation case. No special unpacking is required.

d. Facility Requirements. The test kit was designed for field use and has no special facility requirements.

e. Electrical Requirements. Electrical power is not required for operation of this equipment.

f. Preparation for Use.

NOTE

Accurate determination of coolant contamination levels requires proper technique and the use of known clean equipment and materials. Any foreign matter, which is allowed to contaminate the fluid sample or testing equipment, will cause erroneous results. Careful attention to the detailed procedures here in will assure that the effects of external contaminants are minimized.

WARNING

Dry Cleaning Solvent is combustible - do not use near open flames, near welding areas, or on hot surfaces. Prolonged contact of skin with liquid can cause dermatitis. Repeated inhalation of vapor can irritate nose and throat and can cause dizziness. If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause dizziness, go to fresh air. When handling liquid, wear approved gloves and eye protection. Use in a well-ventilated area and keep containers covered when not in use.

g. Required Materials. In addition to the kit components, a suitable solvent and a waste container are needed to analyze fluid samples. Dry Cleaning Solvent (2, Table 6-3) is the only authorized solvent, but may result in damage to plastic components of the kit.

h. Rinse Bottle Preparation.

(1) The solvent rinse bottle is used to dispense filtered solvent material when clearing residual coolant fluid from the test filter. To prepare the rinse bottle for use, proceed as follows:

NOTE

Two plastic bottles (7, 9, Table 6-4) provided in the analysis kit are identical except that one (7) has a shorter spout to accommodate the Swinnex filter unit (8). One bottle (7) is used to dispense filtered solvent when performing analysis. The other bottle (9) is used to flush fittings at aircraft sampling points to prevent external contamination of the sample fluid.Blue separator disks separate packaged filter membranes. Remove separators before installing the filter membrane in the equipment.

The 25 mm filter membrane does not need to be replaced after every test or usage of the equipment. The filter serves to remove particulates from the solvent being dispensed and may be used until saturated with dirt, as indicated when unusually high pressure is required to dispense fluid.

Should it be observed that fluid is being dispensed with unusually light pressure being applied, immediately disassemble the filter assembly and check for possible filter rupture.

(2) The Swinnex filter assembly consists of two threaded half sections and an internal support screen. Place one 25 mm filter membrane (15, Table 6-4) on the girded plastic surface using forceps (12). Position the perforated support screen on top of the filter membrane and reassemble the two halves of the assembly finger tight.

WARNING

Dry Cleaning Solvent is combustible - do not use near open flames, near welding areas, or on hot surfaces. Prolonged contact of skin with liquid can cause dermatitis. Repeated inhalation of vapor can irritate nose and throat and can cause dizziness. If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause dizziness, go to fresh air. When handling liquid, wear approved gloves and eye protection. Use in a well-ventilated area and keep containers covered when not in use.

CAUTION

Certain plastic components of the analysis kit, notably the graduate (11, Table 6-4) and the petri slides (13) are damaged by prolonged exposure to Dry Cleaning Solvent (2, Table 6-3). Such exposure therefore should be limited. The tip of the wash bottle may be damaged if the Swinnex filter holder is forced on too tight.

(3) Fill the 500 ml plastic bottle (7, Table 6-4) having the short spout with Dry Cleaning Solvent. Replace the screw cap.

(4) Attach the Swinnex filter unit to the rinse bottle (7, Table 6-4) with the short spout. Close hole in the cap with a finger, squeeze bottle, and filtered solvent will be dispensed as required. Sufficient drying time must be allowed and the other applicable precautions observed for Dry Cleaning Solvent.

NOTE

When using a Swinnex filter, if air becomes trapped between the filter and the inside nozzle of the rinse bottle, the flow will stop. To eliminate the air-lock, remove the filter from the outlet spout and purge air before filtering. If clogging persists, replace the filter.

If the rinse bottle (7) is damaged, the other plastic bottle may be modified by carefully cutting off the tip with a sharp knife or razor blade so that the Swinnex filter unit will fit. The damaged bottle may then be used for flushing of fittings and sampling points.

i. Fluid Analysis Procedures.

(1) Fluid analysis is accomplished by drawing the fluid sample through a 47 mm diameter, 5 micron filter membrane (disk) (14, Table 6-4), using the vacuum filtration equipment provided. Process the fluid sample as follows:

(a) Remove filter holder assembly (1) from its storage position in the kit. Stainless steel funnel (2) and holder support (3) are assembled and stored in an inverted position in the stainless steel vacuum flask (6). To prepare for use, the funnel assembly and holder support assembly must be removed fro installed in the flask assembly.

NOTE

A Thin film of coolant fluid applied to the external O-ring seals (4/5, Table 6-4) on the filter holder will aid in its insertion and subsequent removal. If difficulty is encountered in removing the filter holder assembly from flask, insert the back end of forceps (12) into the slot (present on some assemblies) and pry the holder from the flask.

(b) Using tube and adapter (17, Table 6-4), connect the vacuum port on syringe (16) to the small opening located on the side of the filter holder assembly (1) base. The tube and adapter are normally left connected to the syringe but may be removed for cleaning or replacement.

CAUTION

Evaporation of the filtered solvent may result in the condensation of atmospheric moisture on the funnel surface. This can cause inaccurate indications of free water in the sample. Carefully inspect for condensation. If present, move equipment to an air-conditioned workspace.

(c) Using the filtered solvent dispenser (see step h. (4)), wash down the inside wall of the stainless steel funnel to flush away any surface contamination present. Ensure funnel screen is also cleaned with filtered solvent.

(d) Remove funnel from filter holder by rotating the outer knurled ring in a counterclockwise direction until disengaged, and lift upward. Using forceps, carefully remove a single 47 mm filter membrane (14, Table 6-4) and place it on top of the wire mesh filter holder assembly. Ensure that the blue separator disks are not installed with the filter membrane. Place the support screen gasket between test filter membrane and stainless steel funnel. Reinstall funnel on filter holder assembly and secure by rotating the outer knurled ring in a clockwise direction until fully seated.

(e) Using the filtered solvent dispenser (see step h.(4)), repeatedly rinse the inside of graduated cylinder (11, Table 6-4) to remove all possible contaminants. Pour out any residual solvent into an approved waste container. Measure out approximately 15 ml of filtered solvent, using the cleaned graduate, and pour into the stainless steel funnel to prewet the filter membrane.

(f) Shake the bottle of sample fluid to be processed to distribute its particulate content. Remove cap from sample bottle and pour exactly 100 ml of fluid into graduate (11, Table 6-4). Pour contents of graduate into the stainless steel funnel (2) on top of the previously introduced filtered solvent. Allow contents of the graduate to drain completely into the funnel.

(g) Using the filtered solvent dispenser, wash down the inside surface of the graduated cylinder with clean solvent until the graduate contains approximately 100 ml of fluid.

(h) Operate syringe and valve (16, Table 6-4) in a slow pumping manner, drawing a vacuum, until sustained filtration of the fluid is indicated by a steady drop of fluid level in the funnel. As soon as the fluid level in the funnel has dropped enough to allow addition of approximately 50 ml of solvent, pour half of the contents of the graduated cylinder into the funnel as filtration continues. If necessary, operate the syringe again to maintain sufficient vacuum for filtration.

(i) Carefully observe the filtration process in the funnel and the decreasing fluid level. When the fluid level drops to the narrow neck of the funnel, pour the remaining contents of the graduate into the funnel. Pour contents so as to wash down the inside of the funnel, assuring that solvent is not poured directly onto the filter membrane.

(j) When filtration is complete, inspect the filter surface. If the central area shows a yellowish color, indicating that the filter membrane still has a residue of coolant fluid, direct a stream of clean solvent from the filtered solvent dispenser against the walls of the funnel until the fluid reaches the top of the tapered portion. Operate the syringe again to initiate filtration and allow all of this fluid to pass though the filter.

NOTE

Free water, when present in the fluid sample, may be seen as droplets on the surface of the test filter membrane immediately after completion of filtration. Immediate observation is essential as the droplets remain on the filter surface for only a short period of time.

(k) Upon completion of filtration, disengage funnel from the filter holder assembly and remove the test filter by grasping the membrane edge with forceps. Deposit the filter in an uncovered petri slide *(*13*,* Table 6-4*)* and allow to dry thoroughly in still air before applying cover to the slide.

NOTE

After using Dry Cleaning Solvent (2, Table 6-3*)* the filter must be dried thoroughly prior to placing in petri slide. The solvent, or its fumes, will craze and cloud the polystyrene petri slides.

j. Test Filter Evaluation.

(1) After the fluid sample is processed, the resultant test filter membrane should be visually compared with the Contamination Standards (18, Table 6-4*).* Determine the particulate contamination level by comparing the shade and color of the test patch with those of the Contamination Standards. If the test patches displays a rust or tan color, use the tan standard patch. If the test patch is gray in color, use the gray standard patch.

(2) Follow operating instructions contained in the Contamination Standards. Tan patches occur when rust or iron chlorides are formed in the system or the system contains abnormal amounts of silica (sand). Gray patches are typical of systems containing normal proportions of common wear materials and external contaminants.

NOTE

Test patches may be encountered that show evidence of a white colored precipitate or deposit. This material is the by-product of chemical reaction between water and the coolant fluid. Contamination standards for determining acceptability of such patches are presently not available and individual judgement must be based on local experience.

(3) Upon completion of test filter evaluation, record test results on the Coolant Analysis Record (Figure 6-2). The maximum acceptable particle level for coolant fluid samples originating from aircraft equipment is Navy Standard Class *5.* Fluid samples from related SE shall not exceed Navy Standard Class *3.* Visible free water present in either the sample bottle or on the surface of the test filter (at completion of filtration) is cause for rejection of the system under test. A stain on the test filter membrane may be an indication of the presence of free water. Ensure that observed water is not a result of atmospheric condensation during the sample processing. When a stain is seen on the test filter, a second fluid sample from the system under test should be obtained and processed so that water content can be confirmed prior to system rejection.

TABLE 6-5. MAINTENANCE ADVISORIES

Abnormal Indications	Equipment Sampled	Corrective Maintenance
Excessive Water	Aircraft System or Component	Decontaminate using SE. Resample
	Ground Support Equipment	Replace Hydro pack filter if present. Operate closed loop to decontaminate fluid. Resample.
Excessive Particle Level	Aircraft System Component	Check condition of contaminate remover (indicator button). Replace if required. Decontaminate using SE. Resample
	Ground Support Equipment	Check condition of particle filter(s) contaminate (pressure lamp or gage.) Replace filter element if required. Operate closed loop (if capability exists)* to decontaminate. Resample.
Low Flash Point	Aircraft System	Decontaminate using SE. Resample.
	Ground Support Equipment	Operate closed loop (if capability exists)* to decontaminate. Resample. Flushing may be required.

*If closed-loop capability does not exist, it may be necessary to flush out old fluid.

k. Maintenance Requirements. Equipment maintenance includes the unscheduled repair or replacement of defective items. Consult NAVAIR 17-15E-52 Operation and Intermediate Maintenance with Illustrated Parts Breakdown when effecting repairs and for maintenance consisting of cleaning, lubrication, and adjustments.

l. Calibration Requirements. Equipment calibration is provided by the Contamination Standards furnished with the equipment. To maintain their accuracy, the standards should be protected from stains and handling damage. Procure replacement standards when those provided with the equipment are determined to be no longer serviceable.

m. Related Publications. The following publications provide additional information relative to the operation and, maintenance of the Contamination Analysis Kit and should be consulted as required:

(1) NAVAIR 17-15E-52 Operation and Intermediate Maintenance with Illustrated Parts Breakdown for Hydraulic Fluid Contamination Analysis Kit Part No. 57L414.

(2) NAVAIR 01-1A-17 Aviation Hydraulics Manual.

n. Replacement Parts. For replacement parts refer to table 6-4.

o. Disposal of Waste Solvents. For handling and disposal safety concerns, refer to the Material Safety Data Sheet (MSDS) of the particular chemical or solvent.

6-6. NAVY (SHIPS) PHYSICAL PROPERTIES PROCEDURES.

NAVY (Ships) PHYSICAL PROPERTY TEST LIMITS BY TYPE OIL AND USE

SUBMARINES

USED AS A DIESEL LUBE OIL

M-L-900OG
MS-250

Spectrometric Required

Test	**Limits**
Water (by Karl-Fisher)	0.02% or 200 PPM Max.
Viscosity (at 100°F) report Centistokes (CS)	100 CS Min. 225 Ma. in.
Acidity (Surface and Sub)	Blue = Pass, Green or Yellow Fail
Fuel Dilution: Always perform when Viscosity is less than 130 CS, at 100°F, or odor of fuel is present.	0 - 2%, Acceptable 2 - 5%, Marginal/Warning Greater than 5.0%, Fail

USED AS A LUBE OIL

MIL-L-17331
MS-2190 TEP

Spectrometric Required

Test	**Limits**
Water (by Karl-Fisher) High Press Air Compressor	.017% or 170 PPM Max.
Low Pressure Blower (for Subs)	0.05% or 500 PPM Max.
Propulsion LUBE Oil	0.05% or 500 PPM Max.
Neutralization Number	0.5% Max.

REFRIGERANT COMPRESSOR OIL

VV-L-825
MS RCO-2 (TYPE 11)

R-12. Refrigeration Plants

Spectrometric Required

Test	**Limits**
Water (by Karl-Fisher)	0.01 %or 100 PPM Max.
Neutralization Number	0. 1 % Max.

R-1 14 Air Conditioning Plants
Spectrometric Required

Water (by Karl-Fisher)	0.01 % or 100 PPM Max.
Neutralization Number	.07% Max.

HYDRAULIC FLUIDS

MIL-L.17672
MS 2075TH; MS 211 OTH; MS 2135TH
MIL-L-17331 MS 190 TEP

Spectrometric Required ONLY FOR ABOVE WATER LIMITS, to determine SALT or FRESH water contamination.

	Particle Count (ISO)		Water (Karl-Fisher)	
	Overhaul Reqm'ts	Operating Reqm'ts	Single Sample	Average
Ship/System	Number of Particles Per Milliliter			
	Over 15 m	Over 15 m	% Volume	%Volume
AGSS555	80(IS013)	160(IS014)	0.05	0.05
DSRV 1 and 2	80(IS013)	320(IS015)	0.05	0.05
Other Submarines (SS, SSN, SSBN, NR-I, NKTV)				
Internal (Main, vital Ships Service, Independent Steering & Diving Missile Support) Systems	160(IS014)	320(IS015)	0.05	0.05
External Systems	320(IS015)	640(IS016)	0.10	0.05

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SECTION VII

US AIR FORCE B-2 COOLANT TESTING PROCEDURES

7-1 Introduction. This section defines the procedures, requirements, equipment and material needed for sampling and testing Silicate Ester-Based Dielectric (SEBD) coolant fluid used in operating systems such as radar cooling in the Environmental Control System of the B-2 Bomber.

7-2. General.

a. The equipment cooling system of the B-2 aircraft incorporates three liquid cooling subsystems and five circulated air subsystems. The liquid cooling subsystems consist of the Ethylene Glycol-Water Subsystem (EGW), DMS/LC Subsystem and the Liquid Cooling Subsystem (LCS).

b. The Liquid Cooling Subsystem (LCS) is composed of two independent closed cooling loops located in the left-hand and right-hand forward center section of the aircraft. The left side LCS loop (normally the transmitting radar side) is identical to the right side LCS loop (normally in standby). Each closed loop circulates liquid coolant through each of the radar packages to maintain the components at a controlled temperature. The fluid is then circulated through a three-fluid (coolant-EGW) heat exchanger for heat dissipation via the EGW coolant loop to the sink heat exchanger.

c. Each loop supplies liquid coolant at a flow rate of 4.0 GPM to the liquid cooling passages of 55.0 degrees Fahrenheit and a maximum pressure of 175.0 psig. The maximum volume of fluid in each loop is 4.76 gallons.

d. The LCS transports heat from both radar transmitters and antennas. The transmitters require a heat transport fluid with both high dielectric properties and thermal transport characteristics. The heat transfer fluid is a silicate ester-based dielectric (SEBD) coolant fluid, Coolanol 25R or Flocool 180.

e. As the fluid cycles throughout the aluminum system lines, metal particles may be generated by the relative motion between metallic parts within the mechanical system. Friction and continuous wearing away of contacting surfaces will increase the amount of particulate contamination. As particulate size and quantity increase, the physical and chemical characteristics of the EGW and Coolanol 25R fluids may also be impacted. This document defines the requirements for sampling and testing coolants such as EGW and SEBD coolants in the operating systems of the vehicle, in filtering and fluid supply service carts, and in other liquid servicing equipment.

7-3. Equipment.. Equipment identified to each specific test shall be maintained per manufacture's requirements. Records of maintenance and calibration of the equipment shall be maintained. Testing facilities shall be free of contaminates detrimental to test performance and shall be cleaned at intervals deemed necessary to maintain the cleanliness of the area.

7.4. Test Sequence. To minimize the quantity of fluid needed to perform the coolant fluid tests and to minimize the effects of sample handling, testing should be conducted in the following sequence:

	Paragraph
Appearance	7-7
Dielectric Strength	7-8
Particulate Contamination	7-9
Volume Resistivity	7-10
Water Content	7-11

TABLE 7-1. COOLANT TEST REQUIRMENTS

The SEBD coolant will be tested for the following:

A. Appearance	No evidence of separation, contamination or precipitates
B. Dielectric strength	300 volts per mil, minimum
C. Particulate contamination per 100 milliliters, particulate size 10 thru 200 microns >200 microns (Including fibers)	Automatic counts 32,000 maximum.
D. Volume resistivity	Automatic Count 5 maximum 4 X 10^{10} OHMS per centimeter
E. Water content	150 parts per million maximum.

7-5 Laboratory Safety.

a. Standard lab safety procedures should be followed. All chemicals should be treated as potentially hazardous and handled with care. Petroleum ether and methanol, which will be used to clean the sample containers on the instruments are flammable and should not be exposed to a flame, spark or high heat. Safety goggles and gloves impervious to organic solvents should be worn at all times. An eye wash station, fire blanket and fire extinguisher should be readily accessible at all times. Material Safety Data Sheets (MSDS) for all chemicals should be accessible to lab personnel while working in the lab. Never work in the lab alone-ensure there is someone else within easy calling distance.

b. Waste chemicals should be disposed of in approved marked waste containers. While the waste organic chemicals used in these procedures may be mixed in a single waste container, it may be more convenient to use one container for SEBD waste chemicals and another for EGW wastes. Remove waste chemicals from the lab on a regular basis.

7-6. Testing.

7-7. Appearance.

a. Prior to the sample analysis, the unopened sample bottle shall be visually inspected for proper filling and sealing, as well as evidence of gross contamination. Properly filled bottles will be almost completely filled with fluid extending up to the bottom of the threaded neck section. The purpose of completely filling the bottle is to minimize the quantity of air present, which could contain large amounts of atmospheric moisture, and to assure that adequate fluid is available to perform all of the required tests. Activities submitting SEBD coolant samples in improper or inadequately filled bottles shall be advised to resample the equipment.

b. Gross particulate contamination, i.e., particles large enough to be seen with the unaided eye, will also be most visible when the fluid is allowed to stand motionless for a period of time. Like free water, such particles will generally settle to the bottom of the bottle. Gross particulate contamination is usually indicative of improper sampling technique. If either is suspected, the submitting activity shall be advised and requested to resample the equipment.

c. Fluid turbidity results in the SEBD fluid appearing cloudy as opposed to its normal clear, transparent appearance. Turbidity is most visible when the fluid is agitated and may be indicative of large amounts of air, free water or suspended foreign matter.

Allowing the fluid to stand stationary for a period of time will assist in identifying the probable cause. Turbidity caused by suspended semi-solid matter is of particular concern as it may be indicative of chemical degradation of the SEBD fluid. The contamination by-products of such degradation will also show up when performing the test for particulate contamination

d. Prior to sample analysis, fluid in the sample bottle shall be visually inspected for evidence of free water, turbidity or visible particles. This inspection is somewhat limited by translucent plastic bottles but can be remedied by using a glass bottle or positioning the plastic bottle in front of a strong light source. Free water when present, will collect in the bottom of the bottle and be readily visible. Allowing the bottle to stand stationary for at least 10 minutes prior to the inspection will cause any dispersed water droplets to settle out, rendering them more visible. Free water is cause for rejection and the submitting activity shall be requested to resample the equipment to confirm this indication.

7-8. Dielectric Strength.

a. Introduction. This procedure describes the method for performing dielectric strength of silicate ester base dielectric coolant fluid with the Hipotronics Model 0C60D, digital Oil Dielectric Test Set. All personnel should review the manufacture's instruction manual prior to using the equipment.

b. Equipment and Materials. Model 0C60D Oil Dielectric Test Set, Hipotronics Inc.

c. Equipment Information and Test Procedures. The referenced test set provides the means of applying, measuring, and displaying the value of the voltage required to electrically stress insulating liquids such as SEBD to a point where the insulating qualities break down and allow an electrical current to flow between and electrodes applying the voltage. The 0C60D is capable of applying 0 to 60,000 VAC between two electrodes that are spaced 2.5mm or 0.10 inches apart in a test cup that holds the test sample.

NOTE

During testing a safety cover is lowered to protect the test operator. The rate of applied voltage is determined by selecting the 3000 VPS (volts per second) setting on control panel energized by a facility power source of 115 VAC, 50/60 HZ. The breakdown voltage for SEBD is 300 volts per mil (minimum) and will require the test sample to be subjected to 30 kilovolts minimum to be considered sufficiently free of contaminating agents.

Specifications
Test Voltage: 0 to 60 kilo volts AC (50,000 VAC)
Power Rating: 115 VAC, 50/60 HZ, 15 amps

(1) Set-Up Procedures.

(a) Remove packing material, power cord, test cells, and any other components from the test cage.

(b) GROUND THE UNIT BEFORE CONNECTING INPUT POWER. The ground lug is located on the left side of the unit, below the plug receptacles.

(c) Insert the socket end of the power cord into the receptacle on the left side of the unit and connect it to a suitable power source. IF A TWO-PRONG ADAPTER IS USED, BE SURE TO GROUND THE PIGTAIL.

(2) Operating Procedures.

(a) ENSURE THAT THE UNIT IS PROPERLY GROUNDED BEFORE CONNECTING INPUT POWER. The ground lug is located on the left side of the unit, below the plug receptacle.

(b) Ensure that the power cord is properly plugged in as described in step c of the SET-UP PROCEDURE.

(c) Check and adjust the spacing of electrodes in the test cell using a 100 mil gage shim. Push electrodes tightly against gage shim. The distance between the two electrodes will be 100 mils (0.1 inches).

NOTE

Do not fill test receptacle inside test chamber.

(d) Fill the test cell with sufficient insulating liquid to completely cover the electrodes.

(e) Swirl the insulating liquid by rocking the test cell slowly. (Rapid agitation may create an excess of air bubbles in the liquid).

(f) Gently snap the filled test cell in place between the bushing(s) of the transformer and the test cage and close the safety glass cover.

(g) Before testing, allow the sample to stand for a minimum of three minutes to permit any accumulated air bubbles to escape. If a VDE test cell is used, plug the line cord into the receptacle on the left panel of the test cage.

(h) Turn the AC power switch ON.

(i) If the failure indicator lights, press the reset push-button until the voltmeter reading is zero.

(j) With the voltmeter reading zero, set the rate/rise rotary selector to 3000 VPS.

(k) Press the START push-button to activate the output voltage. Voltage is applied automatically at the specified rate until breakdown occurs, at which point the FAILURE indicator lights and the voltage is turned off.

NOTE

The voltage may be terminated before breakdown by releasing the test cage interlock switch (HV OFF ANYTIME). This is accomplished by opening the safety glass cover. Also, voltage may be maintained at any level prior to breakdown by setting the RATE/RISE selector to STOP (manual dwell).

(l) The voltmeter continues to display the breakdown voltage until the reset pushbutton is pressed. After reading and recording breakdown voltage, press the RESET push-button and allow the voltmeter to return to zero.

.

NOTE

Clean test cell between each test with methanol.

(m) Perform three (3) breakdown tests beginning with step k. If results are within ± 10% of the average of the sample taken, test is complete. If results are not within ± 10%, perform two additional tests. Discard the two- (2) high/low samples and average the remaining three (3) sample results. If results are within ± 10% of the average, the test is complete. Five breakdowns may be performed on one cup filling with one-minute interval between breakdowns.

NOTE

Minimum instrument reading shall be 30 kv which is equivalent to the dielectric strength of 300 volts/mil using the prescribed sample volume.

(3) Calculations. Dielectric strength = volts/mil (volts/100mil).

NOTE

"mil" refers to gap between electrodes.

7-9. Particulate Contamination.

a. Introduction. This procedure describes how to perform the counting of particles suspended in SEBD using the Hiac/Royco Model 800A Particle Counter.

b. Equipment and Materials.

Model 8000A Hiac/Royco, Particle Counter with Printer
Automatic Bottle Sampler unit (ABS)
Methonol or Isopropanol (filter the solution through a 0.45 micron filter)
Petroleum Ether (reagent grade)

c. Equipment Information. The referenced particle counting system is comprised of several individual components. A counter, an automatic bottle sampler, and a sensor. Descriptions of each of the components are given below:

(1) The counter is equipped with a keypad, a 40 column 16-line liquid crystal display (LCD), and an internal 40 character per line graphics printer. Although wide ranges of contamination standards are resident in the unit, the operator has the option of storing a different standard, which better describes the desired application. Any of the standards can then be selected with a single keyboard entry. The Model 8000A is capable of acquiring count data for eight particle size ranges. The calibration graph for the sensor being utilized shows the actual values that must be input to the counter to set the size range limits for the test. Whenever a different size range is desired or when a different sensor is utilized the corresponding graph must be entered into the counter. The manufacturer supplies the calibration graph and the counter is calibrated every 5 months. Before a test can be run, the operator must input the number of sample runs to be performed. The counter automatically gives results for each sample data run as well as the average of the selected number of runs. The operator must also input the limit for the counter's audible alarm. After the test has been performed, the results can be displayed in either tabular or histogram format, and a hard copy can be obtained from the printer.

(2) The automatic bottle sample is a Hiac/Royco model ABS sampler (P/N BS-13). The sampler is comprised of three components: A sample holder, a volume measuring tube, and a control box. The sample to be analyzed is placed in a container inside the sample holder. This sample holder has a pressure rating of 60 PSI and is equipped with a magnetic stirrer, which keeps the sample particles in a uniform suspension. Positive pressure is then used to transfer the sample, at a constant flow rate, from the sample holder through the sensor (which will be discussed later) to the volume measuring tube. The pressure required for this transfer can be provided by either a facility air supply or by a separate pump. The sampler is equipped with a locking regulator to regulate the supply pressure down to the desired 5 to 60 PSI. Once the sample has passed through the sensor, it goes into the volume measuring tube. This tube is equipped with two moveable light sensors, which generate the "start count" and "stop count" signals to the counter. The volume of sample to be analyzed is determined by the positioning of these two light blocks. Upon completion of a test, the volume measuring tube is drained by means of an automatic valve and drain line.

(3) A ac/Royco mode HRLD-400 sensor (P/N 040 x 300-1) is provided with the particle counting system. This sensor, which detects particles in the sample by means of the light obscuration method, has the following specifications:

(a) Measurement Range: 2 - 400 microns

(b) Recommended Concentration Limit: 8,000 particles/ml

(c) Flow Rate: 10 - 200 ml/Min

(d) Pressure Limit: 1000 psi

(e) Temperature Limit:: 150 degrees Fahrenheit

(f) Frequency Response: To 250 kHz

(g) Precision: Coefficient of variation less than 1% for mean mounts greater than 1000 particles per ml.

(h) Accuracy: Traceable to NIST Standard Reference Materials.

(4) As mentioned previously, a calibration curve is provided with the sensor so that the operator can key the desired size range limits into the Model 8000A Counter. This sensor will be calibrated with glass spheres in oil or water with latex spheres (use the values from the curve).

d. Test Procedures.

(1) Turn on the particle counter and the automatic bottle sampler.

(2) Press any key on the key pad to access the main function menu.

(3) Place a container of the sample to be analyzed into the sample holder. Put a clean stirring rod into the container and turn the sample holder's magnetic stirrer on.

NOTE

Be extremely careful that the stir bar is "just" moving to eliminate the counting of bubbles as particles.

If a vortex appears in the center of the liquid, it is being stirred too rapidly. Adjust stir speed until vortex is no longer visible.

(4) Position the volume measuring tube light blocks. The volume of sample that is analyzed is determined by the positioning of these two blocks. Volume should be set for a 100 ml sample size.

(5) Set the locking regulator on the sample holder to the desired pressure. Desire pressure will provide a flow rate of 20 ml in 20 seconds, ≈ 14-20 PSI.

(6) Press start key.

(7) Once the test is complete obtain results from the display and/or printer.

(8) First flush the system with a total of 60 ml of Petroleum Ether, followed by flush with 120 ml of menthanol.

(9) Turn off the particle counter and automatic bottle sampler.

NOTE

If initial set-up data is lost, reenter data using the following calibration procedures.

e. Calibration Procedures.

(1) Turn unit on and press any key.

(2) Press the more key on the main function menu.

(3) Press the user STD key.

(4) Press the alter STD key.

(5) Enter the following data:

(a) Standard Name: Latex

(b) Number of Classes: 16

(c) Coml/Diff: Cumulative

(d) Class Limit Units: Counts

(e) Sample Volume: 20.00 ml

(f) Classify: Runs only

(g) Number of Channels: 3

(h) Class 1 thru 16: N/A

(i) Channel 1: 10

(j) Channel 2: 200

(k) Channel 3: 400

(6) Press exit key.

(7) Save standard in storage slot #1.

(8) Using exit key return to main menu.

(9) From the main menu, press Set-up.

(10) Press the global set-up key and enter the following data:

(a) Operator ID: Operators Initials

(b) Number of Runs: 3

(c) Delete Time: 00H, 00M, 10S

(d) Delay Time: 00H, 00M, 00S

(e) Transducer Units: English

(f) Quick-Adjust-Rate: 02H, 30M

(11) Press the exit key to return to the parameter set-up function menu.

(12) Press the control set-up key and enter the following data:

(a) Sample ID: 000

(b) Background: OFF

(c) Dilution Factor: 1.00

(d) Standard: Latex in Water

(e) Mode: Volume

(f) Sample Volume: 20.00 ml

(13) Press the exit key and return to the parameter set-up function menu.

(14) Press the exit key to return to the main menu.

(15) From the main menu, press the cal key.

(16) Press the set cal key.

(17) Press the alter cal key and enter the following data:

(a) Sensor Model: HRLD-400

(b) Serial Number: 9306-003

(c) Calibration Date: dd/mm/yr

(d) Material: Latex in Water

(e) Flow Rate: 60 ml/Min

(f) Sensor Type: Extinction

(g) Algorithm: Interpolation

(h) Noise: 13.5 mV

(i) Extinction: 12

Diameter	MV
2.020	41
3.020	60
5.007	132
9.870	309
15.000	475
20.490	641
32.200	1020
40.100	1240
58.500	1720
112.000	3210
165.000	4300
301.000	7500

(18) Press the exit key to go to the calibration function menu.

(19) Press the bin size and enter the following data:

Number of Channels 3

Channel	Threshold (Micrometers)
1	10
2	200
3	400

(20) Press the exit key to return to the calibration function menu.

(21) Press the exit key and return to the main menu.

NOTE

The tester is now ready for use.

7-10. Volume Resistivity.

a. Introduction. This procedure describes the method for performing volume resistivity of silicate ester based coolant with the JPF-60 test set.

b. Equipment and Materials.

(1) QuadTech 1865

(2) Rosemond JPF-60 Test Cell

(3) Rosemond (PN JPF-60) Model TF-12 Test Fixture

(4) Glass Vials

(5) Petroleum Ether

c. Test Information.

(1) The referenced test set provides technicians and the capability to interface a liquid sample of SEBD with the resistivity test set (test fixture) and the megohmeter in order to perform a volume resistivity test. This test measures the dielectric properties of the fluid that may be degraded by particle contamination.

(2) The test set consists of a pronged end, a three terminal guarded electrode end, and a wire bale clasping section used to hold the glass vial, which contains the required sample.

(3) The pronged end is a three pole male connector that will mate with the resistivity test fixture. The test fixture is a rectangular box shaped fixture, which includes a hinged cover provided for safety concerns. When the user opens the cover during testing, the test voltage will be curtailed. The back of the test fixture contains a two input hard wire connection.

The back also contains a hard wire phone jack connection that mates with the ohmmeter rear phone jacks to establish a foot remote control feature. In addition, the back of the test fixture contains a single thin (ground) lead that will run to the ohmmeter's chassis ground terminal. Inside the test fixture cover, a cylindrical receptacle is installed that allows the resistivity test set to be mounted.

(4) A glass vial containing sample fluid will be clamped inside the test set, and at the same time the three terminal electrodes of the test set will become immersed in the vial fluid. The test set containing the sample fluid is put onto the test fixture part of the test set and the test fixture is connected to the megohmeter. When the resistivity test fixture, test cell, and glass vial containing the test sample of SEBD is connected to the megohmeter, a series resistance circuit is formed. The resistance of the sample is connected in series with a known value of resistance (in the megohmeter) selected for the test. These two resistance's (one unknown) form a voltage divider across the regulated power supply. The output of this voltage divider, which is inversely proportional to the value of the unknown resistance (test sample), is applied to an amplifier that drives the megohmeter meter (calibrated in megohms) to display the measured value.

d. Test Procedures.

(1) Preliminary adjustments - Model 1865 Megohmeter

(a) Turn unit on.

(b) Recall setup data. Recall function is found in the utility menu.

(c) Zero the megohmeter at 500 volts after connecting with the test fixture. Zero function is found in the utility menu.

(2) Megohmeter set-up:

(a) Set-Up Menu

1. Voltage: 500 volts

2. Change Time: 10 sec

3. Dwell Time: 1 sec

4. Measure Time: 60 sec

5. Discharge Time: 10 sec

6. Mode: Auto

7. Range: Auto

8. Limit: 1.52×10^8 ohms

9. Stop on Pass: 60

10. Average: 60

(b) I/O Menu

1. Display Type: Pass/Fail

2. Result Format: Engineering

NOTE

Remainder of I/O Menu is optional.

(c) Utilities Menu

1. Save Set-Up: Optional

2. Recall Set-Up: Optional

3. Zero: Refer to preliminary adjustment above.

4. Lock Out: Optional

NOTE

Remainder of menu is optional.

(3) Operation

(a) Fill a clean test cell vial to the reference mark with a sample. Insert the cell into the vial and latch the vial in place with the wire holder. Turn the vial (one or two quarter turns) to wet the electrode surfaces and clear any entrained air bubbles.

(b) Insert the test cell with sample into the test fixture receptacle. Close the test fixture lid. Press the green start key. The megohmeter will display a pass or fail message on the instrument screen.

(4) Calculations

$P = R/K$

(a) In the formula above P = volume resistivity, K = the test cell constant, and R = volume as indicated on the megohmeter. To determine the volume resistivity of the sample, divide the volume resistance (R) measured by the megohmeter by the test cell constant (K). A volume resistivity equal to or greater than 4×10^{10} ohm per centimeter is acceptable. The cell constant (K) for the JPF-60 test cell is .0038/cm.

(b) In the event the test cell changes, a new limit (volume resistance) will have to be calculated based on the new test cell constant (usually expressed as K) and entered in the megohmeter set-up screen. Using the JPF-60 test cell constant as a reference, calculate the new limit as follows:

$P = R/K$
$R = PK = (4 \times 10^{10})\ (.0038) = 152{,}000{,}000$ or
1.52 x 108 ohms

(5) Cleaning cell. For routine cell cleaning, rinse with petroleum ether and wipe with a clean cloth, particularly the area between the tip and the sleeve. Unscrew the outer cylindrical electrode from the cell body. Rinse with petroleum ether and wipe the insulator area with a clean cloth, particularly between the inner electrode and the guard ring.

7-11. Water Content.

a. Introduction. This procedure describes the method for measuring the water content of silicate ester based coolant with the Karl Fischer Coulometric Titrator (Aquatest 8). The Aquatest 8 uses both the dead stop electrode and the coulometric generation of iodine in a closed vessel system. The coulometric addition of iodine makes the Aquatest an absolute instrument. When a sample is added to the vessel reagent, the voltage rises across the sensing electrode to indicate the wet state. This triggers the coulometer and a constant current flow through the generator producing iodine in the vessel reagent. The iodine reacts with the water from the sample and the vessel solution. When all the water has reacted, the voltage at the sensing electrode drops. This signals the coulometer to stop. The electrical charge produced during the titration is measured coulometrically and is displayed as the total water content. Since the reagent in the vessel is returned to an initial state at the end of each sample addition, sequential analysis can be performed until the vessel reagent is exhausted.

b. Equipment and Materials.

(1) Titrator, Karl Fischer Coulometric (P/N 02-128-10) Solvent

(2) Generator Pyridine Free (50 ml) Solution

(3) Vessel Pyridine Free Isopropyl Alcohol TT-I-735

(4) Methanol O-M-232

(5) Sodium Hydroxide, 1 Normal Solution 0S598

c. Test Information.

(1) The referenced Karl Fischer Coulometric Titrator consists of an Aquatest 8 Titrator and a printer. The Aquatest 8 is a microprocessor-controlled, automated Karl Fischer Coulometric Titrator, which is manufactured by Photovolt, a division of Seradyn, Inc. (FSCM 47125). It is comprised of a base unit, which houses the microprocessor, a titration vessel assembly.

(2) the sample is inserted into the Titractor by means of a sample syringe. The sample will be taken from the sample container and injected into the Titrator's vent hole or its septum opening. At this point, test parameters and other data are input to the Aquatest 8 Titrator via a spill-resistant keypad on the base. The titration is then initiated, via the keypad, and the Aquatest 8 proceeds to automatically perform the titration.

Upon detection of the titration end-point, the results are displayed on the base's sixteen character alphanumeric display. This value can be given in terms of micrograms, percent water, or PPM (parts per million). The printer that is provided with the Aquatest 8 can then be used to obtain hard copies of the test results.

(3) The silicate in the SEBD will react with the reagent to produce water over an extended period of time. The addition of water to the solution will give inaccurate results. In order to remedy the situation, new solution and reagent will be used every 48 hours.

(4) Specifications for the Aquatest 8 are as follows:

(a)	Accuracy:	1 microgram or 0.05% whichever is greater.
(b)	Capacity:	Readouts to 999,999 micrograms of water.
(c)	Range:	1 PPM to 100% moisture.
(d)	Rate:	2540 micrograms of water per minute.
(e)	Electrical:	110 V, 50/60 Hz, 40 Watts

d. Test Procedures.

(1) Instrument Set-Up

(a) Place the Aquatest 8 instrument on the laboratory bench in an area away from direct sunlight and sources of heat such as ovens.

(b) Handle the generator assembly by the Teflon collar.

(c) Holding the vessel cover with the thumbscrews facing away from you, feed the generator plugs and wires through the larger threaded opening. While gently pulling the wires out of the way of the threads, insert the end of the generator that is opened into the cover. Carefully screw the generator into cover.

NOTE

Do not overtighten generator in the vessel cover.

(d) Lightly and evenly grease the ground glass rim of the Pyrex vessel jar with the Photovolt special sealant. Check to see that the three thumbscrew fasteners on the cover are fully unscrewed and extended.

(e) Place a clean and dry magnetic stir bar into the vessel jar.

(f) Carefully join the titration vessel jar and cover with the generator assembly. Twist the cover gently to spread the sealant. Finger tighten the thumbscrew grasps the lip of the vessel jar securely.

(g) Install a membrane septum.

(h) Lightly grease the ground glass collar area of the sensor electrode. Insert the electrode into the small opening of the vessel cover. Carefully and gently seal the collar into the cover. Assure the two circle platinum rings at the end of the electrode are parallel to each other and to the side area of the vessel jar closest to them.

(i) Enter the test parameters into the Aquatest 8 via the keypad.

(2) Pyridine Free Reagent Set-up

(a) In an exhaust hood or well ventilated area, remove the septum holder cap and membrane from the vessel cover, place the funnel supplied into the septum support, and add the entire contents of a bottle of vessel reagent. Remove the funnel and replace the septum and cap.

(b) Remove the generator cap and using a glass syringe, add approximately 3-4 ml of pyridine-free generator solution to the generator. Replace the generator cap.

(c) Place the vessel jar onto the Aquatest 8 inside the plastic retaining ring.

(d) Plug the two banana plugs from the generator into the two banana jacks on back of the Aquatest 8, black-to-black and red-to-red for proper polarity. Plug the sensing electrode plug into the smaller two jacks; the larger sensor plug goes into the small red jack.

(e) Plug the power cable of the Aquatest 8 into a 110-vac grounded receptacle.

NOTE

Assure the Aquatest 8 does not share its power line with devices capable of causing power line disturbances such as motor, compressors, refrigerators and ovens.

(f) Switch on power. The Aquatest 8 will perform internal diagnostics, then display select mode.

NOTE

Once the Aquatest 8 is first turned on, wait 30 minutes before performing a sample assay. This time allow the instrument and vessel assembly to stabilize in its new working environment. Photovolt pyridine-free reagent does not require the use of any neutralizing reagent.

(g) Dipswitch setting should be 1, 2, 4, 8, UP and 3, 5, 6, 7, DOWN.

(h) Turn on the Aquatest 8, and when select mode is displayed press monitor.

(i) Press the first key on the left of the upper 4 keys that correspond to sen.

(j) At this time you will see wet/dry status which will usually show the reagent being at set point or slightly wet; this will be displayed on the Aquatest 8 as follows:

WET….!..^…….DRY.

(k) When the vessel is at set point a caret (^) on the dotted line will appear. The instrument is ready to perform assays.

(3) PPM Moisture Assay.

(a) Press set-up.

(b) Press the fourth white function key under WT.

(c) Press the fourth white function key under NO to enter in a single sample weight.

(d) Press the fourth white function key under NO to allow manual entry of sample weight.

(e) Press clr to remove the weight value stored in memory.

(f) Key the 1800 mg as the weight of the sample and press enter. The Aquatest VIII will beep as it stores the value in memory.

NOTE

In order for the Aquatest 8 microproccessor to compute water content in ppm by weight, it must know the weight of the fluid sample. SEBD has a specific gravity of 0.9, weighing 0.9 grams per ml.

The sample size of 1 ml, therefore, represents a sample weight of 0.9 grams or 900 milligrams (mg). A sample size of 2 ml, therefore, represents a sample weight of 1800 mg.

(g) Again press set-up and this time press the first function key to choose unit.

(h) MCG PCT PPM will be displayed. Press the third function key to choose ppm.

CAUTION

If the test set has not been used for 12 hours or more, initial test results may tend to be inaccurate. Perform two or three analysis, using spare SEBD to allow the test set to stabilize.

NOTE

Since the weight analysis is to be based on the weight transferred, care must be taken to remove all air bubbles from both the syringe and the needle.

Careful wiping of the liquid clinging to the needle is required for precision. Do not draw the tissue all the way over the end of the needle. Wipe to just the edge of the needle tip and then stop. Blot the membrane septum between samples.

(i) Remove the cap from the sample bottle. Using a clean, dry 10 ml glass hypodermic syringe fitted with 4-1/2 inch needle, slowly draw approximately 1 ml of sample fluid from the sample bottle into the syringe. Withdraw the plunger past the 8 ml mark. Coat the interior walls of the syringe with the SEBD. Depress the plunger and expel the 1 ml of SEBD into a waste container. Wipe needle clean.

(j) Using the same 10 ml glass hypodermic syringe fitted with 4-1/2 inch needle, slowly draw approximately 7 ml of sample of fluid from sample bottle into the syringe.

(k) With the needle pointed up, allow the air bubbles to rise to the tip. Place the wiping material halfway over the needlepoint and slowly expel into wiping material any air trapped in the syringe and any fluid in excess of 6 ml. Syringe should now contain exactly 6 ml of sample fluid and no air. Clean the needle with wiping material.

(l) Press set-up. The third option is dly; press the white pad. Next menu will display mcg time. Press the second pad correlating to time. Press the clr key on the keypad and enter 0.3. This is 0.3 minutes or 18 seconds of a delay in the titration. Finally press enter. Now the instrument will delay the start of the titration by 18 seconds after the initial 7-second injection period has elapsed.

(m) Press start. Introduce sample immediately and add sample 7 sec is displayed as follows: Insert needle through membrane septum on sampling port in vessel cover until it is below the level of the vessel solution and discharge precisely 2 ml of fluid directly into the vessel solution. Remove the needle from sampling port. After 7 seconds, the display will show delay for 0.3 minutes and be automatically followed by titration.

(n) At the end of the titration, the weight that is in memory will be displayed as a confirmation test. If it is the correct weight, merely press enter and the results of the assay will be displayed in parts per million water.

NOTE

If the sample weight displayed after titration is incorrect, press clr and enter the correct weight followed by enter. If you are assaying a number of samples of the same weight, you will only need to enter this weight once. Results of water analysis should be reported as an average of at least three runs. Results are considered to have good repeatability if they are within 11 ppm of each other.

(o) Repeat step m above for next injection of the same sample. If a different sample is to be injected, repeat step l above.

(p) Thoroughly clean the syringe, attached needle and plunger with methanol and allow them to air dry. If an explosion-proof oven is available, place the syringe with plunger out of the barrel into the oven at 150-185 degrees F or 65-85 degrees C. After 5 minutes, remove the apparatus from the oven using protection for the hands and insert the plunger into the syringe barrel. Allow it to cool to room temperature (approximately 2 to 3 minutes).

e. Cleaning Generator for Silicate Diester.

(1) The bottom end of the generator assembly consists of a porous Pyrex glass frit. With use, the minute fluid passages in the frit will become clogged, retarding the transfer of generator solution to vessel solution during titration. This condition may be indicated by the error display gen overvoltage and can be corrected by cleaning the frit. (This display does not always occur).

WARNING

Do not get sodium hydroxide (NaOH) solution in eyes, on skin, or on clothing; it causes severe burns. Do not take it internally. Wear gloves and wear goggles (or face shield) when handling. Continuously stir solution while adding compound; add it slowly to surface of solution to avoid violent splattering. Limit the heat rise to 50◦F (10◦C) per minute. Do not allow temperature of solution to exceed 194◦F (90◦C) when mixing. Do not use on aluminum parts; reaction with aluminum forms large volumes of hydrogen gas. Flush area of spillage or leakage with water spray.

(2) The generator frit is cleaned by soaking it in a sodium hydroxide (caustic) solution (5, table 6-3) and applying a vacuum to the top of the generator assembly. The vacuum pulls the caustic solution through the frit, opening up the pore structure. To clean frit, proceed as follows:

(a) Remove power from the Aquatest 8 by switching the power off in back of the instrument.

(b) Disconnect the generator and sensing electrode cables from the jacks.

(c) Loosen the three thumbscrews on the vessel cover and swing pawls away from the titration vessel. Use gentle twisting motion to loosen grease seal and remove cover.

(d) Remove generator cap from generator assembly and pour used generator solution into an approved waste container.

(e) Pour used vessel solution into the same waste container used step 4.b.(4). Be careful not to pour out the magnetic stirring bar. Seal the waste container. Next transfer the magnetic stirrer bar from titration vessel onto a clean wiping cloth. Wipe and dry stirring bar.

CAUTION

Do not separate the sensor and generator assembly from the teflon cover.

(f) Grasp Teflon mounting collar on generator assembly and remove from vessel cover by carefully unscrewing threaded section. Remove sensing electrode and wipe it clean.

(g) Using the empty titration vessel, stand sensor and generator assembly to be cleaned in empty vessel. Pour technical grade one Normal (1N) sodium hydroxide (NaOH) solution into the empty vessel jar until a level of approximately 2 inches is reached.

(h) Pour additional solution into top opening of generator assembly, just enough to cover the frit.

(i) Allow generator assembly to soak 4 hours, or longer, in the sodium hydroxide solution. Periodically observe fluid level inside generator. An increase in level will indicate partial clearing of the frit; the open frit allows fluid to transfer from the vessel into the generator. Upon completion of soaking, discard used NaOH solution into an approved waste container, or dispose by approved methods.

(j) Expedite cleaning of porous frit after soaking procedure by the application of a vacuum (not to exceed 15 inches mercury (Hg)) to the generator assembly. Required vacuum can be obtained using the syringe and valve provided with contamination Analysis Kit, part No. 57L414. Locally fabricate required adapters to connect vacuum source to generator, using modified rubber or cork stopper to connect vacuum line to open end of generator.

(k) Place fresh sodium hydroxide solution in emptied titration vessel, enough to partially cover the generator assembly when it is placed in the titration vessel. Apply vacuum to generator assembly until caustic cleaning solution flows freely from the vessel jar to the inside of the generator. Carefully observe fluid level in generator and assure that fluid is not sucked into vacuum line. A filtering flask may be installed as a trap between the generator and the vacuum pump. If required, pour excess fluid from generator assembly to waste.

(l) When frit has been cleaned, remove sensor and generator assembly from vessel jar and discard caustic solution into an approve waste container, or dispose by approved methods. Rinse generator assembly and vessel jar using generous amounts of water, preferably hot.

(m) Return generator assembly to the vessel jar and partially fill vessel with water (tap or deionized). Using vacuum procedure specified in steps (j.) and (k.), flush frit with water to remove residual caustic solution.

(n) Remove generator assembly from vessel jar and discard water.

WARNING

Methanol is flammable - Do not use near open flames, near welding area, or on hot surfaces. Do not smoke when using it, and do not use it where others are smoking. Prolonged or repeated inhalation of vapor can cause eye irritation, drowsiness, and headache. Ingestion may be fatal or may cause eye damage. If vapor contacts eyes, immediately flush eyes with large amounts of water. Immediately remove solvent-saturated clothing. If vapor cause drowsiness, remove affected person from area and expose to fresh air. When handling or applying liquid at air-exhausted workbench, wear approved goggles and gloves. When handling or applying liquid at unexhausted workbench, wear approved respirator, goggles and gloves.

(o) Remove residual water from generator assembly by pulling Methanol through generator with vacuum, as described in steps (j) and (k), and then drying in oven (if available) at 150 to 185°F (65 to 85°C) for a period of 2 hours. If no oven is available, allow to air dry before use. Store generator in desiccator if available, until needed.

(p) In some cases, because of lack of equipment, it may not be possible to clean the frit in shipboard laboratories. In these cases the laboratory should change the generator assembly. The assemblies which need cleaning of the frits should be retained and subsequently taken to a shore based laboratory where cleaning can be accomplished.

f. Calibration.

NOTE

The Aquatest 8 does not require calibration. However, a user calibration procedure is provided so that the user can quickly confirm that the instrument is indeed titrating water accurately. User calibration is generally done every 6 months or as needed (whenever erroneous results are suspected).

(1) Set Aquatest 8 to mcg mode (see paragraph D (g) and (h)).

NOTE

In preparation for the following, fill beaker or other clean container with small amount of tap or deionized water. Set adapter on syringe to 1.0 microliter mark on syringe barrel. Pump syringe several times while needle is submerged in water to remove air. Remove membrane from sample port to enable needle (shorter length) to be below vessel solution.

(2) Press start. Introduce sample immediately after add sample 7 sec is displayed as follows: Insert needle of a gas tight 2 microliter syringe (15, table 3-1) with built in Chaney adapter directly through the septum on the sampling port in the vessel cover until it extends below the level of the vessel solution and discharge precisely 1.0 microliter of water into the vessel solution. After a brief moment, remove syringe and needle from sampling port and replace membrane. After 7 seconds, the display will show delay and be automatically followed by titration. Established that; you obtain 1000 $\pm$ 50 micrograms of water. Repeat additions until you have 5-10 replicates to determine precision (standard deviation less than or equal to 50 mcg is acceptable). Flush needle several times with water prior to storing to remove chemicals from Aquatest that will cause corrosion.

SECTION VIII

CONTAMINATION TESTING OF COOLANT IN OPERATING SYSTEMS, ETHYLENE GLYCOL/WATER (EGW)

8-1. Introduction. This section defines the procedures, requirements, equipment and material needed for sampling and testing Ethylene Glycol/Water (EGW) used in operating systems such as airborne systems, filtering and fluid supply carts, and other ground servicing equipment. The testing shall provide information on the degradation and contamination of EGW for controlling and monitoring their use.

8-2. General.

a. The equipment cooling system of the B-2 aircraft incorporates three liquid cooling subsystems and five circulated air subsystems. The liquid cooling subsystems consist of the Ethylene Glycol-Water Subsystem (EGW), DMS/LC Subsystem and the Liquid Cooling Subsystem (LCS).

b. The EGW subsystem is composed of two independent closed cooling loops which use Ethylene Glycol-Water (EGW) solution as a heat transfer fluid. Each loop circulates coolant from the heat sources and transports the heat to the sink heat exchanger for heat dissipation. The primary heat sources for the EGW loops are the aft bay rack mounted avionics, the forward left avionics, the forward right avionics, the forward left avionics, the forward right avionics, the DMS/LS and the LCS. The Ethylene-Glycol Water subsystem supplies coolant at a flow rate of 85 psig per minute to transport the sink heat from the heat sources to the heat exchangers. The coolant is supplied at a nominal temperature of 47 degrees F with a maximum system pressure of 175 psig.

c. The Ethylene Glycol-Water solution is a mixture of 62.8 ± 1.0 percent ethylene glycol by weight, distilled water and appropriate corrosion inhibitors. The EGW coolant appears as a clear, light straw colored liquid and has a characteristic odor. The EGW fluid is composed of the following:

MATERIALS SPECIFICATION

MATERIALS	OR SOURCE	PART BY WEIGHT
Ethylene Glycol, Technical	ASTM E 1119-92	62.80 ± 1.00
Triethanolamine-Phosphate (TEAP)	Commercial Grade	1.60 +/- 0.10
50 Percent (by weight) Sodium Mercaptobenzothia-Zole (NaMBT)	Commercial Grade	0.17 +/- 0.02
Benzotriazole	Commercial Grade	0.50 ± 0.5
Di Water	Commercial Grade	35.00 ± 1.00

TABLE 8-1. EGW COOLANT TEST REQUIRMENTS

Appearance	Clear and bright, with no evidence of turbidity, haze, cloudiness, gelation, sediment, visible particles or fibers, separation, precipitation, or contamination.
Foaming (Optional) - Increase in volume in 5 minutes. - Break Time.	 - 350 milliliters, maximum. - 30 seconds, maximum.
Particulate Contamination per 100 milliliters of Aircraft Fluid, microns: – 5 to 15 microns – 15 to 25 microns – 25 to 50 microns – 50 to 100 microns – over 100 microns - over 200 microns Particulate Contamination per 100 milliliters of GSE Fluid, microns: – 5 to 15 microns – 15 to 25 microns – 25 to 50 microns – 50 to 100 microns – over 100 microns – over 200 microns	 – 93,000 particles – 15,400 particles – 3,130 particles – 430 particles – 41 particles - 5 particles - 27,000 particles - 4,000 particles - 1,300 particles - 180 particles - 17 particles - 2 particles
pH at 60 F	7.80 to 8.50
Refractive Index at 60 F	1.3900 to 1.4030
Specific Gravity at 60 F	1.0850 to 1.0910
Accelerated Stability	No turbidity, cloudiness, precipitation, deposit formation, gelation or phase separation after the coolant is heated to 190 F for 24 hours.
Sodium Mercaptobenzothiazole (NaMBT) Content	0.13 to 0.20% by weight 50% NaMBT

8-3. Equipment.. Equipment identified to each specific test shall be maintained per manufacture's requirements. Records of maintenance and calibration of the equipment shall be maintained. Testing facilities shall be free of contaminates detrimental to test performance and shall be cleaned at intervals deemed necessary to maintain the cleanliness of the area.

8-4. Test Sequence. To minimize the quantity of fluid needed to perform the EGW tests and to minimize the effects of sample handling, testing should be conducted in the following sequence:

	Paragraph
Appearance	8-7
Dielectric Strength	8-8
Particulate Contamination	8-9
Refractive Index	8-10
Specific Gravity	8-11
Accelerated Stability	8-12
NaMBT Content	8-13

8-5. Laboratory Safety.

a. Standard lab safety procedures should be followed. All chemicals should be treated as potentially hazardous and handled with care. Petroleum ether and methanol, which will be used to clean the sample containers on the instruments are flammable and should not be exposed to a flame, spark or high heat.. Safety goggles and gloves impervious to organic solvents should be worn at all times. An eye wash station, fire blanket and fire extinguisher should be readily accessible at all times. Material Safety Data Sheets (MSDS) for all chemicals should be accessible to lab personnel while working in the lab. Never work in the lab alone-ensure there is someone else within easy calling distance.

b. Waste chemicals should be disposed of in approved marked waste containers. While the waste organic chemicals used in these procedures may be mixed in a single waste container, it may be more convenient to use one container for EGW waste chemicals and another for EGW wastes. Remove waste chemicals from the lab on a regular basis.

8-6. Testing.

8-7. Appearance.

a. Prior to the sample analysis, the unopened sample bottle shall be visually inspected for proper filling and sealing, as well as evidence of gross contamination. Properly filled bottles will be almost completely filled with fluid extending up to the bottom of the threaded neck section. The purpose of completely filling the bottle is to minimize the quantity of air present, which could contain large amounts of atmospheric moisture, and to assure that adequate fluid is available to perform all of the required tests. Activities submitting EGW fluid samples in improper or inadequately filled bottles shall be advised to resample the equipment.

b. Prior to sample analysis, fluid in the sample bottle shall be visually inspected for evidence of turbidity or visible particles. This inspection is somewhat limited by translucent plastic bottles but can be remedied by using a clean glass bottle or positioning the plastic bottle in front of a strong light source.

c. Gross particulate contamination, i.e., particles large enough to be seen with the unaided eye, will also be most visible when the fluid is allowed to stand motionless for a period of time. Particles will generally settle to the bottom of the bottle. Gross particulate contamination is usually indicative of improper sampling technique. If this is suspected, the submitting activity shall be advised and requested to resample the equipment.

d. Fluid turbidity results in the EGW fluid appearing cloudy as opposed to its normal clear, transparent appearance. Turbidity is most visible when the fluid is agitated and may be indicative of large amounts of air, free water or suspended foreign matter.Turbidity caused by suspended semi-solid matter is of particular concern as it may be indicative of chemical degradation of the EGW fluid. The contamination by-products of such degradation shall be cause for sample rejection.

8-8. Dielectric Strength.

a. Introduction. This procedure describes how to measure the pH content of EGW using the type M-245 pH test meter.

b. Equipment and Materials.

(1) Pyrex Beaker

(2) pH Meter, Corning 245

(3) Glass Electrode

(4) Calomel Electrode, commonly referred to as the reference electrode.

(5) Adapter (if required)

(6) Thermometer - Saybolt Viscosity 14C (Range 19C to 27C, reading to 0.01C)

(7) DI Water

(8) Buffer solution: Buffer solutions can be purchased pre-mixed and certified. (pH 4, pH 7).

c. Equipment Information and Test Procedures. The referenced pH test meter is an upright box design. On the face of the meter is a keypad operated control panel which programs the calibration, temperature, mode selection, and time interval adjustments.

The pH test meter has the following capabilities:

Range: -2 to 14 pH
Resolution: 0.01 pH
Relative Accuracy: +/- 0.01 pH
Modes: pH
Temperature Span: -5 C to 105 C
Power Requirements: 90 -127 or 198 -264 VAC, 50/60 HZ

NOTE

In use, the pH test meter is first set up with the calomel electrode and pH electrode attached to the electrode holder.

Before beginning the test, standardize instrument with pH and pH7 buffers for maximum accuracy,

Sample should be cooled in a water bath to 60°F or 15.6C before pH testing or calibration begins.

d. Calibration Procedures.

(1) Calibrate the pH meter, Corning Model 245, as follows:

(a) Remove protective caps from electrodes.

(b) Remove filler cap from reference electrode.

(c) Set the instrument to pH mode.

(d) Press cal button.

(e) Press right arrow key to select 2 point calibration.

NOTE

Lower display will read "cal 1" and upper display will read "7.00". If the upper display reads "0", press 7.00 on the keypad. Lower display will read "read".

(f) Place the electrodes in the pH 7 buffer solution and press the read button. Instrument will automatically adjust to pH 7 and a beep will be heard. Remove electrodes from buffer solution and clean.

(g) Lower display will read cal 2 and upper display will read 4.00. If the upper display reads 0 press 4.00 on the keypad. Lower display will read "read".

(h) Place electrodes in pH 4 buffer solution and press read button. Instrument will automatically adjust to pH 4 and a beep will be heard. Remove electrodes from the buffer solution and clean. Press exit button. Ensure unit is in pH mode.

(i) Verify calibration by measuring pH 4 and pH 7 buffer solutions as if they were a fluid sample.

e. Test Procedures.

(1) Before beginning the test, measure samples of both pH 4 and pH 7 buffers for maximum accuracy using preceding instructions. If samples do not measure correctly, calibrate instrument..

(a) Transfer sufficient volume of EGW fluid into a marked Pyrex beaker to allow the electrode tips to be fully immersed without touching the glass container.

(b) Remove electrodes from the storage solution and rinse with DI water. Gently blot the electrodes with clean, soft cloth.

(c) Using a twisting motion, remove the plastic caps from the electrodes.

(d) Pull black plug out of the electrode fill hole.

(e) Measure sample temperature with thermometer.

(f) Place pH electrodes in sample. The tips are fully immersed when 1/2 inch into a sample; they may be immersed further, but, never up to the fill holes.

(g) Ensure unit is in pH mode.

(h) Press read. Instrument will automatically display pH measurement and a beep will be heard.

f. Care of pH Meter. Remove electrodes from EGW fluid and rinse with DI water. Replace tip protectors and insert black plug into fill hole. The electrodes are stored immersed in pH 7 buffer solution, or distilled water, which is changed after every test setup or weekly at a minimum. Electrodes should be cleaned with DI water and blotted with a clean, soft cloth after each measurement.

CAUTION

Special care should be exercised in handling the electrodes, which are composed of a very fragile glass and may be easily broken.

8-9. Particulate Contamination.

a. Introduction. This procedure describes how to perform the counting of particles suspended in EGW using the Hiac/Royco Model 8000A Particle Counter.

b. Equipment and Materials.

(1) Model 8000A Hiac/Royco Particles Counter with printer

(2) Automatic Bottle Sampler Unit (ABS)

(3) Methanol or Isopropanol (filter the solution through a 0.45 micron filter)

(4) Petroleum Ether (Reagent grade)

c. Equipment Information.

(1) The referenced particle counting system is comprised of several individual components: A counter, an automatic bottle sampler, and a sensor. Descriptions of each of the components are given below.

(a) The counter is equipped with a keypad, a 40 column 16 line liquid crystal display (LCD), and an internal 40 character per line graphics printer. Although wide ranges of contamination standards are resident in the unit, the operator has the option of storing a different standard, which better describes his application. Any of the standards can then be selected with a single keyboard entry. The Model 8000A is capable of acquiring count data for eight particle size ranges. The calibration graph for the sensor being utilized shows the actual values that must be input to the counter to set the size range limits for the test. Whenever a different size range is desired or when a different sensor is utilized, the corresponding calibration graph must be entered into the counter. The calibration graph is supplied by the manufacturer, and the counter is recalibrated every 6 months. Before a test can be run, the operator must input the number of sample runs to be performed. The counter automatically gives results for each sample data run as well as the average of the selected number of runs. The operator must also input the limit for the counter's audible alarm. After the test has been performed, the results can be displayed in either tabular or histogram format, and a hardcopy can be obtained from the printer.

(b) The automatic bottle sampler is a Hiac/Royco model ABS sampler (P/N BS-313). The sampler is comprised of three components: A sampler holder, a volume measuring tube, and a control box. The sample to be analyzed is placed in a container inside the sampler holder.

This sample holder has a pressure rating of 60 PSI and is equipped with a magnetic stirrer, which keeps the sample particles in a uniform suspension. Positive pressure is then used to transfer the sample, at a constant flow rate, from the sample holder through the sensor (which will be discussed later) to the volume measuring tube. The pressure required for this transfer can be provided by either a facility air supply or by a separate pump. The sampler is equipped with a locking regulator to regulate the supply pressure down to the desired 5 to 60 psi. Once the sample has passed through the sensor, it goes into the volume measuring tube. This tube is equipped with two moveable light sensors, which generate the "start count" and "stop count" signals to the counter. The volume of sample to be analyzed is determined by the positioning of these two light blocks. Upon completion of a test, the volume measuring tube is drained by means of an automatic valve and drain line. A Hiac/Royco model HRLD-400 sensor (P/N 040 X 300-01) is provided with the particles in the sample by means of the light obscuration method, has the following specifications:

1. Measurement Range: 2 - 400 microns

2. Recommended Concentration Limit: 8,000 particles/ml

3. Flow Rate: 10 - 200 ml/Min

4. Pressure Limit: 1000 psi

5. Temperature Limit: 150 degrees Fahrenheit

6. Frequency Response: To 250 kHz

7. Precision: Coefficients of variation less than 1% for mean counts greater than 1000 particles per ml

8. Accuracy: Traceable to NIST Standard Reference Materials

d. Test Procedures.

(1) Turn on the particle counter and the automatic bottle sampler.

(2) Press any key on the keypad to access the main function menu.

(3) Place a container of the sample to be analyzed into the sample holder. Put a clean stirring rod into the container and turn the sample holder's magnetic stirrer on.

NOTE

Be extremely careful that the stir bar is "just" moving to eliminate the counting of bubbles as particles.If a vortex appears in the center of the liquid, it is being stirred rapidly. Adjust stir speed until vortex is no longer visible.

(4) Position the volume measuring tube light blocks. The volume of sample that is analyzed is determined by the positioning of these two blocks. Volume should be set for a 20 ml sample size.

(5) Set the locking regulator on the sample holder to the desired pressure. Desire pressure will provide a flow rate of 20 ml in 20 seconds, ≈ 14 -20 psi.

(6) Press start key.

(7) Once the test is complete obtain results from the display and/or printer.

(8) First flush the system with a total of 100 ml of Methanol or IPA, followed by a flush with 120 ml of Petroleum Ether.

(9) Turn off the particle counter and automatic bottle sampler.

NOTE

If initial set-up data is lost, reenter data using the following calibration procedures.

e. Calibration Procedures.

(1) Turn unit on and press any key.

(2) Press the more key on the main function menu.

(3) Press the user std key.

(4) Press the alter std key.

(5) Enter the following data:

(a) Standard Name: Latex

(b) Number of Classes: 16

(c) Coml/Diff: Cumulative

(d) Class Limit Units: Counts

(e) Sample Volume: 20.00 ml

(f) Classify: Runs only

(g) Number of Runs: 3

(h) Number of Channels: 3

(i) Class 1 thru 16: N/A

(j) Channel 1: 10

(k) Channel 2: 200

(l) Channel 3: 400

(6) Press exit key.

(7) Save standard in storage slot #1.

(8) Using exit key, return to main menu.

(9) From the main menu, press set-up.

(10) Press the global set-up key and enter the following data:

(a) Operator ID: Operator's Initials

(b) Number of Runs: 3

(c) Delete Time: 00H, 00M, 10S

(d) Delay Time: 00H, 00M, 00S

(e) Transducer Units: English

(f) Quick Adjust Rate: 02H, 30M

(11) Press the exit key to return to the parameter set-up function menu.

(12) Press the control set-up key and enter the following data:

(a) Sample ID: 000

(b) Background: OFF

(c) Dilution Factor: 1.00

(d) Standard: Latex in Water

(e) Mode: volume

(f) Sample Volume: 20.00 ml

(13) Press the exit key and return to the parameter set-up function menu.

(14) Press the exit key to return to the main menu.

(15) From the main menu press the cal key.

(16) Press the set cal key.

(17) Press the alter cal key and enter the following data:

(a) Sensor Model: HR-LD400

(b) Serial Number: 9306-003

(c) Calibration Date: dd/mm/yr

(d) Material: Latex in Water

(e) Flow Rate: 60 ml/Min

(f) Sensor Type: Extinction

(g) Algorithm: Interpolation

(h) Noise: 13.5 mV

(i) Extinction: 12

(j) Diameter mV

2.020	41
3.020	60
5.007	132
9.870	309
15.000	475
20.490	641
32.200	1020
40.100	1240
58.500	1720
112.000	3210
165.000	4300
301.000	7500

(18) Press the exit key to go to the calibration function menu.

(19) Press the bin size and enter the following data:

Number of Channels 3

Channel	Threshold (micrometers)
1	10
2	200
3	400

(20) Press the exit key to return to the calibration function menu.

(21) Press the exit key and return to the main menu.

NOTE

The tester is now ready for use.

8-10. Refractive Index

a. Introduction. This procedure describes the method for measuring the refractive index of EGW coolant fluid using a refractometer and water bath.

b. Equipment and Materials.

(1) Refractometer

(2) Thermometer - Saybolt Viscosity 17C (range 19C to 27C, reading to 0.01C)

(3) Water Bath, Model F3K

(4) Distilled Water

(5) Glass Standard

(6) Lens Tissue Paper

(7) Methanol

(8) Monobromonaphthalene ***Usually supplied with refractometer for calibration. Calibration procedures are found in the manufacturers manual.

c. Equipment Information.

(1) The refractometer is a precision optical instrument, with a focusable eyepiece and dispersion corrective prism, equipped for connection to a water bath for uncompensated measurements. It also has an adjustable built-in illumination system.

(2) The refractometer has the following specifications:

(a) Display: Direct reading LED

(b) Range, Dissolved solids: 0 to 85 degrees Brix, and % solids.
Refractive index 1.3210 to 1.7001 ND.

(c) Accuracy: +/-0.1 Birx, +/-0.0001 ND, +/-0.1% Solids

(d) Temperature Compensation Accuracy: +/- 0.2 degrees Centigrade

(e) Sample Types: Transparent or translucent liquids or solids.

(f) Sample Temperature Control: Refractive index and uncompensated Brix or % solids.

(3) The circulating heated electric water bath, part number F3-K, NSN 4920-01-096-6405, is used in conjunction with the refractometer. The circulating water bath is necessary to maintain prism temperature so sample is at the desired temperature (60°F).

Calibrate the refract meter with standards such as monobromonaphthalene and a glass standard.

(4) The water bath has the following specifications:

(a) Mounting type: stand

(b) Inside dimensions of the reservoir: 295 x 190 x 150 mm

(c) Operating temperature range: 10 to 150 degrees Fahrenheit (-23 to 65 C)

(d) Heating element current type: single

(e) Heating element wattage in watts: 1000

d. Test Procedures.

(1) Instructions for performing Refractive Index (RI) are as follows:

(a) Turn on circulating water bath and adjust controls to allow refractometer prism to reach 60°F +/-0.5°F or 15.6°C +/- 0.2°C.

(b) Place sample container in water bath and allow to come to 60°F +/- 0.5°F or 15.6°C +/- 0.2°C.

(c) Turn the mode selector to measurement mode N.

NOTE

Prism face is easily scratched which will cause inaccurate measurements. Use only lens tissue designed for instrument cleaning on prism surface.

(d) Verify prism temperature is 60 degrees F by pressing temp button.

(e) Open prism assembly and remove lens tissue from prism face (used to protect prism when instrument is not in use). When adding sample be careful not to touch the eyedropper to the prism face. Never "wipe" sample onto prism. Sample should be added dropwise and when prism is closed it will spread.

(f) Place sample on prism using an eyedropper (the entire surface of the lower prism should be covered). Do not touch prism face with eyedropper.

(g) Position the illuminator arm and lens for maximum contrast.

NOTE

While viewing through eyepiece, turn the adjustment control knob (located on right hand side of instrument) until the shadow line appears in the reticle field. The adjustment should be counterclockwise when the field appears dark and clockwise when bright.

(h) Press temperature button on front panel for readout of sample temperature. Sample should be tested at 15.2 - 15.6C.

(i) When sample reaches correct temperature range, focus on the shadow line. Turn the knob to precisely intersect the shadow line with the cross hair.

(j) Depress the read button for measurement. Unit will count then display the measurement.

NOTE

If test fails, check accuracy of tester using distilled water. If tester is proven to be accurate, the EGW sample is out of the specification requirement. If test failed, recalibrate the instrument using the calibration procedures.

e. Calibration Procedures.

(1) Calibrate refractometer as follows:

(a) Turn mode selector to refractive index.

(b) Open the prism assembly and insure that the surfaces are clean.

(c) Apply a minute drop of 1-bromonaphthalene to the illuminator end of the refracting prism surface.

(d) Place the test glass standard on the contact liquid with the polished side down (refractive index alue face up), polished end toward the illuminator end of the refracting prism. Do not use an excessive amount of 1-bromonaphthalene, and avoid build-up along the polished front end of the standard.

(e) Gently press down on the test glass to insure there are no bubbles between the test glass and the refracting prism.

(f) Align the illuminator arm and lens so that the front edge face of the test glass is fully illuminated.

NOTE

To achieve the best possible contrast of the liquid field for this measurement, place a sheet of white tissue between the lamp and prism assembly. Diffused lighting will eliminate the black-white fringes (horizontal lines).

(g) Follow the steps in the general operating instructions for focusing the eyepiece, aligning the shadow line with the cross hair and obtaining a measurement.

NOTE

The alignment of the lamp and color compensation must be accurate. Lamp mispositioning can create a secondary shadow line. The recognition of the proper contrast line can be easily achieved. Move the illuminator slightly up and down; the primary shadow line will not move. The accuracy of the instrument depends on how well the shadow line is set on the cross half.

(h) Depress the read button; 1.3330 will be instantaneously displayed, followed by counting. When the counting stops, the ND value of the test glass is displayed. Note the value shown. The accuracy of calibration should be within 0.0001 ND of the value stamped on the test glass.

(i) If calibration is necessary, rotate the adjustment control knob and depress the read button, Repeat until the correct value, as indicated on the test glass, is obtained. Insert the allen wrench provided through the access hole in the dispersion control. Turn the adjusting screw carefully to move the reticle up and down until the shadow line is aligned with the center of the crosshair. Remove the test glass; clean and close the prism assembly.

CAUTION

Care should be taken to avoid any contact between the edges or sharp corners of the solid sample and the prism. If the flat surface of the sample is smaller than the refracting prism, place the sample on the far half of the prism surface, toward the illuminator. This will improve the contrast line visibility.

f. Care of Refractometer. - Prism should be cleaned after each sample is removed with a soft cloth or cotton swab dampened with DI water. The prism may be wiped with lens cleaning tissues but it should NOT be wiped with a hard, dry cloth.

8-11. Specific Gravity.

a. Introduction. This procedure describes the method of measuring the specific gravity of EGW using the hydrometer.

b. Equipment and Materials.

(1) Glass Stirrer or Glass Rod (to use with cylinder)

(2) Thermometer - Gravity 12 C, (range -20 to +120 C) or 12 F (range -5 to +215 F)

(3) Water Bath

(4) Hydrometers, Numbers 111H to 117H, specific gravity range 1.000 to 1.350, precision 0.050 each hydrometer.

(5) Hydrometer Cylinder

c. Test Procedures.

NOTE

Assure that the sample temperature is 60 F ± 0.5 F, by immersing a thermometer into sample.

(1) Carefully pour the sample into the hydrometer cylinder without splashing. Remove the bubbles formed after they have collected on the surface of the sample by touching with a clean, dry glass rod. Fill cylinder about 2/3 - 3/4 full.

(2) Place sample in water bath and allow sample to reach 15C (60F).

(3) Lower the hydrometer gently into the sample. Avoid wetting the stem above the level to which it will be immersed. Stir the sample with glass rod, and record the temperature when a steady temperature has been reached. Remove the thermometer after recording temperature.

(4) Depress the hydrometer about two scale divisions into the sample and then release it, imparting a slight spin.

(5) When the hydrometer has come to rest away from the cylinder walls and with no air bubbles present, read the density/specific gravity, by placing the eye slightly below the level of the liquid and slowly raising it until the surface of the sample becomes a straight line cutting the hydrometer scale.

(6) Again determine the sample temperature. If this differs from the initial value, repeat the hydrometer test and then thermometer observations until no more than 1 F difference is obtained.

(7) Report the specific gravity/relative density to the nearest 0.001, and temperature measurement to the nearest 1 F.

8-12. Accelerated Stability.

a. Fill a 100-ml centrifuge tube to the 100 +0, –2 ml mark with coolant or add coolant to an acceptable level in a 100 ml to 500 ml three-neck flask so that a thermometer will have its bulb in the fluid. Cap with a properly sized one-hole rubber or cork stopper.

NOTE

Cork stopper particles will float. Rubber particles will not.

b. Insert a 12-inch long glass condenser tube through the stopper. Insert a dry Nichrome or stainless wire into the condenser past the bottom of the condenser but not into the coolant as shown in ASTM D5828 Figure 1. The purpose of the wire is to provide a means of directing condensate back to the centrifuge tube. It is also permissible to have the fluid in a 100 ml to 500 ml three-neck flask and to utilize a 600 mm Vigreux distillation column in the center neck with an appropriate thermometer in one of the side necks and a solid rubber, cork, ground glass or Teflon stopper in the other side neck.

c. Expose the fluid to a target temperature of 200 F for 24 to 30 hours. It is permissible for the fluid temperature to fluctuate between 185 F and 210 F during the test. At the end of the test period, remove the fluid from the heat source and allow to cool to room temperature for at least one hour.

d. Remove the air condenser and stopper and replace with a solid rubber or cork stopper. Balance the centrifuge tube, stopper and fluid sample against another centrifuge tube (with stopper) containing another coolant sample that was not heated 190 F. If a three-neck flask was used, decant 100 ml +0, –2 ml of cooled fluid into a 100 ml centrifuge tube, then balance with another centrifuge tube filled with coolant to 100 ml +0, –2 ml.

8-13. NaMBT Content.

a. Adjust reagent grade deionized water (resistivity ≥ 3,000,000 ohm-cm) to a pH of 5.2 using a pH meter, a small Pasteur pipette and glacial acetic acid that is diluted to 1% acetic acid by volume.

Stir the water constantly with a magnetic stirrer while adding the diluted acetic acid. Use a Ross combination electrode or other suitable sensing electrode. Adjust at least 500 ml of deionized water that has been freshly boiled and allowed to cool to room temperature while covered.

NOTE

UV-visible measurement of NaMBT in EGW is not feasible because the 310-nm peak for this compound is strongly interfered by other ingredients that absorb at a lower but close frequency. If NaMBT is converted to MBT by adjusting the pH to near 5.2, the analytical peak changes to 322nm where the interference is slight.

b. Adjust a 100 ml sample of the coolant to a pH of 5.2 using reagent grade or better glacial acetic acid, a small Pasteur pipette, a magnetic stirrer, and a pH meter with Ross or other suitable electrode. Stir the sample constantly while adding the acid drop wise.

c. If available, use reagent grade ethylene glycol, benzotriazole, deionized water, triethanolamine, and phosphoric acid to formulate EGW fluid in accordance with MS-139, omitting the 50% NaMBT. Standards cannot be made using water alone, since the NaMBT is converted to the MBT form at pH 5.2, and is insoluble in water. Adjust the pH of the fluid to 5.2 as per step 2, then add known amounts of 50% NaMBT (R.T. Vanderbilt "NACAP") to the fluid (weighing to the nearest 0.1 mg) to provide the desired standard (suggested approximate values of weight % of 50% NaMBT added to the fluid are 0.05, 0.10, 0.15, 0.20, and 0.25). Store the standards in a dark place in carefully sealed bottles (amber glass preferred).

d. Use pH 5.2 water or pH 5.2 EGW with no NaMBT to fill both cells and perform a baseline analysis. Perform a zero analysis as well, operating the instrument in accordance with the manufacturer's instructions. After completion of the baseline analysis, remove the cell from the sample beam, and leave the cell in the reference beam.

e. Dilute a 1 ml aliquot of each standard with pH 5.2 water to 1% standard by volume for a 1 cm cell or 10% standard by volume for a 1 mm cell. Use a Class A glass pipette or a Gilmont Micrometer Buret to obtain the 1 ml sample for the Cary 400 spectrophotometer. Other spectrophotometers may require different dilutions. Rinse the cell down with the diluted sample, then fill, and place in the sample beam. Scan the sample from 500 nm to 200 nm or other desired wavelengths, as long as there is sufficient distance on either side of the 322 nm peak. Multiple scans may be performed if the instrument does not demonstrate sufficient repeatability (the Cary 400 typically will not vary more than 0.001 absorbance unit from run to run, and does not normally required more than one analysis). Print the results, making note of the absorbance at 322 nm, and determine the absorbance of the valley just to the left of the 322 nm peak, and of the baseline to the right. Add the two absorbances on either side of the 322 nm peak, divide by two, and subtract from the 322 nm absorbance. Repeat for all of the standards, so as to have a reference range for all analyses. Use only Class A glass volumetric flasks for all dilutions.

f. Use a Class A glass pipette or a Gilmont micrometer buret to obtain a 1 ml aliquot of the sample, and dilute as specified in step 5. Perform the analysis per step 5, and determine the 50% NaMBT content by computing the ratio of the net absorbance of the sample (calculated as in step 5) to the standard closest in net absorbance to the sample, and multiplying by the amount of NaMBT in the standard. Alternatively, the absorption coefficient may be determined using Beer's law (A = axbxc; b= pathlength of the cell, c is the concentration in whatever desired units, and a is the absorption coefficient) and at least two of the known concentration standards. The method of known additions may be used when NACAP and only used MS-139 are available. Add a known amount of NACAP to the EGW fluid after analysis, dilute as in step 5, and analyze.Use the 2 net absorbances to determine your absorption coefficient via subtraction and division into the remaining net absorption. The weight % of 50% NaMBT = net absorbance divided by response factor.

NOTES

Do not calculate concentration based on just the maximum peak values of the samples and the standard or use nonscanning UV-visible spectrometers that measure fixed wavelengths. Do not determine concentration based on the area of the 322 nm peak rather than the peak height. Samples with lower concentrations of NaMBT give slightly higher values when analyzed by UV-visible spectroscopy because the interference is relatively greater for these samples.

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SECTION IX

CONTAMINATION OF TURBOJET ENGINES WITH AUTOMOTIVE OIL

9-1 Introduction. This section provides information concerning contamination of turbojet engine oil systems with automotive oil. The information is general in nature, as there are many types of engines enrolled in the JOAP.

9-2 General.

a. Detection. If you suspect that automotive engine oil was inadvertently added to an aircraft engine, there are some indicators of this condition. If the oil from an oil servicing cart or the turbojet engine is tested on a spectrometer by the JOAP laboratory and molybdenum (Mo) and zinc (Zn) are far above normal expected levels, this is the best indication that contamination with automotive oil may have occurred. Mo and Zn are common additives in automotive oil.

b. Oil Servicing Carts. The oil-contaminated oil servicing cart(s) must be thoroughly cleaned, re-serviced and tested until the Mo and Zn levels are at acceptable levels: normally below 3 parts per million (PPM)

c. Aircraft Engines. Even a small amount of automotive oil can have a severe impact on the health of a turbojet engine oil system. The engine oil filters may become ineffective due to a chemical reaction between the two types of oil. The reaction causes a precipitate that will clog the filter. If contamination is confirmed, the filters must be changed first. Then, the oil system must be drained and flushed, possibly several times, until the Mo and Zn levels return to less than 3 PPM. The engine must be operated to circulate the oil prior to additional testing on a spectrometer. This procedure may require 15 minutes. Follow local procedures for required engine operation time to ensure that the oil is circulated enough for the specific engine. Operating the engine in this manner will ensure that the sample is representative of the entire oil system. When the results are satisfactory, the affected engine must be monitored for at least 10 operating hours to ensure that no elements, especially Mo and Zn, exceed the recommended limits.

d. Prevention. Contamination with incorrect oils must be prevented from recurring. Put a plan in place that will prevent this circumstance in the future. Additional training, segregating oil supplies, etc., are good first steps. The consequences of this type of contamination can be severe. Procedures must be in place that will prevent contamination.

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APPENDIX A

NON-AUTOMATED LABORATORY DATA SUBMISSION

The following instructions apply to non-automated Air Force laboratories, but may be directed for use by other Service Program Managers for their non-automated laboratories or for automated laboratories experiencing ADP equipment malfunctions, to transmit manually accumulated data into the JOAP Data Base.

Laboratories shall use DD Form 2026 as a source document for completing 80 column detail records. The resulting data will be forwarded to the JOAP-TSC via e-mail on or about the 15th and last day of each month. Data will be transmitted in accordance with instructions provided by the JOAP-TSC. The JOAP Data System will require submission of six different types of inputs which are described in detail in this section. These inputs were established to provide for independent sample and feedback records and to permit data deletion/correction actions as required. See Appendix E for data index codes.

A-1. Control Data. Data in record columns 1 through 24 and 80, as applicable, are designated as control data fields. These columns must be completed on all source documents and all 80 column record cards.

a. JOAP Laboratory Codes. Record columns 1-3.

(1) Designation: JOAP Laboratory Code.

(2) Entry: Alpha/Numeric.

(3) Instructions: JOAP laboratory codes consist of three digit alpha/numeric codes listed in the JOAP Directory.

b. Major Command Codes. Record column 4.

(1) Designation: Major Command.

(2) Entry: Alpha/Numeric.

(3) Instructions: Major Command codes consist of two digit alpha/numeric codes to identify the major command, foreign government, contractor, etc., which owns the unit from which the sample was taken. Non-automated laboratories will use only the last digit of the command code. These codes are listed in Appendix

c. Operating Activity Codes. Record columns 5-10.

(1) Designation: Operating Activity.

(2) Entry: Alpha - Left justified.

(3) Instructions: Enter base location codes in record columns 5-8 (Air Force). Base location codes (also known as geographical location codes or GEOLOC's) consist of four digit alphanumeric codes as reflected on the following Scott AFB hosted website: https://tmds03.scott.af.mil/ap_info.shtml Enter the base location in the "AP NAME" block, click on "Find AP Name Data", and the GEOLOC will be displayed.

d. Equipment/End Item Model Codes. Record columns 11-14.

(1) Designation: Equipment/End Item Model Codes.

(2) Entry: Alpha/Numeric.

(3) Instructions: Equipment model field will reflect codes established in Appendix B to identify the engine type, model and series and the end item mission, design and series for engine samples. Samples from accessory equipment such as CSD, main transmission, etc., will be reported by entering the first three digits of appropriate end item code and entering the appropriate accessory equipment code as the last digit.

e. Equipment Serial Number. Record columns 15-20.

(1) Designation: Equipment Serial Number.

(2) Entry: Alpha/Numeric - Left justified.

(3) Instructions: Enter last six digits of the equipment serial number from which the oil sample was taken, e.g., engine, transmission, CSD, etc. Dashes and slashes will be excluded.

f. Date. Record columns 21-24.

(1) Designation: Julian Date Sample Taken.

(2) Entry: Numerics.

(3) Instructions: Enter Julian date sample was taken, e.g., YDDD. Y will be the last position of the year and DDD will be the Julian Day.

A-2. Analytical Sample Record. Analytical sample record is required to report all sample identification data and analytical results. Analytical sample record will contain control data (record columns 1-24 and 80 as applicable) and the following data (see table A-1).

TABLE A-1. ANALYTICAL SAMPLE RECORD

Record Columns	Data Elements
1*	L Instrument
	A
	B
	O
	R
2 *	A Command
	T
	O
	R
3 *	Y Laboratory
4 *	Major Command
5-10 *	Operating Activity
11-14*	Equipment/End Item Model
15-20*	Equipment Serial Number
21-24*	Julian Date (YDDD)
25-29	Hours/Miles Since Overhaul
30-33	Hours/Miles Since Oil Change
34	Reason for Sample
35-36	Oil Added Since Last Sample
37-38	Type Oil
39-40	Sample Response Time
41-76	Sample Analytical Results

41-43	44-46	47-49	50-52	53-55	56-58
Fe	Ag	Al	Cr	Cu	Mg
59-61	62-64	65-67	68-70	71-73	74-76
Ni	Pb	Si	Sn	TI	Mo

77-78	Laboratory Recommendation
79	File Maintenance Action Code
80*	Data Sequence

*Control Data

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a. Hours/Miles Since Overhaul. Record columns 25-29.

(1) Designation: Hours/Miles Since Overhaul.

(2) Entry: Numerics.

(3) Instructions: Total hours/miles since overhaul will be reported as five digit numerics reflecting nearest whole hours/miles. Total hours/miles which do not complete the field (5 digits) will be preceded with zeros, e.g., 21 = 00021.

b. Hours/Miles Since Oil Change. Record columns 30-33.

(1) Designation: Hours/Miles Since Oil Change.

(2) Entry: Numerics.

(3) Instructions: Total hours/miles since oil change will be reported as four digit numerics reflecting nearest whole hours/miles. Total hours/miles which do not complete the field (4 digits) will be preceded with zeros, e.g., 245 = 0245.

c. Reason for Sample. Record column 34.

(1) Designation: Reason for Sample Code.

(2) Entry: Alpha.

(3) Instructions: Reason for sample code is established to identify specific reason for sample submission. Reason for sample codes are listed in Appendix F.

d. Oil Added Since Last Sample. Record columns 35-36.

(1) Designation: Quantity Oil Added Since Last Sample.

(2) Entry: Alpha/Numeric.

(3) Instructions: This data field will be left blank unless use is directed by applicable weapon system technical order or Major Command. If data requirement is imposed, first digit must be alpha "0", “C”, "P", "Q", "G", or numeric, second digit will be numeric. 0, P, Q, G code indicates measurement in ounces, cups, pints, quarts or gallons, respectively, e.g., 5 pints = P5. Quantities greater than 9 gallons will be entered as pure numeric indicating gallons, e.g., 20 gallons = 20.

e. Type Oil Code. Leave blank.

f. Sample Response Time. Record columns 39-40.

(1) Designation: Sample Response Time in Hours.

(2) Entry: Alpha/Numeric - right justified.

(3) Instructions: Compute and enter the sample response time to nearest whole hour. Interval will be the elapsed hours between time sample is taken to time laboratory issues recommendation or determines that a recommendation is not required. If the interval is less than 10, precede entry with (0) zero. If the interval is greater than 96 hours (4 days), time will be reported as whole days by entering 5D, 6D, 7D, 8D and 9D, which indicates 5 days, 6 days, 7 days, 8 days and 9 days, respectively. Time greater than 9 days will be reported as 9 days or 9D.

g. Sample Analytical Results. Record columns 41-76.

(1) Designation: Sample Analytical Wear-metal Results in parts per million (PPM).

(2) Entry: Numerics.

(3) Instructions: Oil analysis results will be reflected as 12 segregated fields containing three digits each for specified wear-metal elements. Each element will be reflected in whole numerics. Readings, which do not complete the field, will be preceded by zeros. Entire field will be skipped for elements which are not analyzed. Results from instruments which read-out In tenths will be converted to the nearest whole number as follows: Results with five tenths or greater will be converted to the next higher whole number. Tenths results of four tenths or less will be dropped. Examples: Fe=129, Ag=0.4, AI=49.7, Cr=3.5, Cu=13.2, Mg=97.8, Ni=0.2, Pb=6.6, Si=236.9, Sn=1.3, Ti=9.8, Mo=1.7.

Record Columns	41-43	44-46	47-49	50-52	53-55	56-58
	Fe	Ag	Al	Cr	Cu	Mg
OAP Results (PPM)	129	000	050	004	013	098

Record Columns	59-61	62-64	65-67	68-70	71-73	74-76
	NI	Pb	Si	Sn	Ti	Mo
OAP Results (PPM)	000	007	237	001	010	002

h. Laboratory Recommendation Code. Record columns 77-78.

(1) Designation: Laboratory Recommendation.

(2) Entry: Alpha - Right justified.

(3) Instructions: Laboratory recommendation codes consist of one digit alpha codes to identify specific action recommended by OAP laboratory based on wear-metal trends. Applicable code will be entered in card column 78. Card column 77 will be blank and is reserved for future use. Laboratory Recommendation codes are listed in Appendix G.

i. File Maintenance Action Codes. Record column 79.

(1) Designation: File Maintenance Action.

(2) Entry: None.

(3) Instructions: Skip this field when inputting analytical sample record.

j. Data Sequence. Record column 80.

(1) Designation: Data Sequence.

(2) Entry: Numeric.

(3) Instructions: Data sequence field is established to reflect sequence of samples taken on the same day from the same equipment. Blank field will signify initial sample of the day and subsequent samples will be sequentially numbered 2 through 9, e.g., initial sample of the day from same equipment, leave field blank; second sample of the day from same equipment, enter numeric 2, etc.

A-3. Analytical Sample Record Deletion. (See table A-2.)

TABLE A-2. ANALYTICAL SAMPLE RECORD DELETION

Record Columns	Data Elements
1*	L Instrument
	A
	B
	O
2*	R
	A
	T
	O
3 *	R Laboratory
	Y
4 *	Major Command
5-10 *	Operating Activity
11-14*	Equipment/End Item Model
15-20*	Equipment Serial Number
21-24*	Julian Date (YDDD)
25-78	Blank
79	File Maintenance Action Code "N"
8 0	Data Sequence

*Control Data

a. Errors in the Control Data fields (Columns 1-24 and 80) on a previously submitted Analytical Sample Record which is in the computer data bank, can only be corrected by deletion of entire record and resubmittal of corrected record. To effect an Analytical Sample Record Deletion, the deletion record must contain identical control data (record columns 1-24 and 80) as the erroneous sample record requiring deletion, coupled with File Maintenance Action Code.

NOTE

Errors listed on the OAP DATA EXCEPTIONS Report have been rejected by computer and are not in computer data base. Such errors will be corrected by resubmission of correct data and will not require Change or Delete action.

b. Analytical Sample Record Deletion requires submittal of a deletion record as described above with an alpha "N" entry in Record Column 79. Record Columns 25-78 will be left blank on deletion record. This input will automatically delete the erroneous record and a corrected record must be resubmitted.

c. Record Columns 1-24 and 80.

(1) Designation: Analytical Sample Record Deletion.

(2) Entry: As detailed in paragraphs A-1,a. through f and A-2,j.

d. Record Column 79. (File Maintenance Action Code.)

(1) Designation: File Maintenance Action (Deletion).

(2) Entry: Alpha Code "N".

A-4. Analytical Sample Record Change. (See table A-3.)

a. Errors in Record Columns 25-78 on a previously submitted JOAP Analytical Sample Record which is in the computer data base, may be corrected by changing erroneous data. To effect an Analytical Sample Record Change, the change record must contain identical control data (Record Columns 1-24 and 80) as the erroneous sample record requiring change, coupled with appropriate File Maintenance Action Code.

b. Analytical Sample Record Change requires submittal of a change record as described above with an alpha R entry in Record Column 79. Data in change fields (Record Columns 25-78) will only be entered for data which requires change. A change field with all asterisks will automatically blank that field, e.g., if laboratory does not have nickel (Ni) analysis capability, and Ni results are inadvertently reported, this erroneous entry may be deleted by submitting change record with asterisks in Ni field. A change field with data will automatically update that field with new data, e.g., if laboratory erroneously reports 800 in iron (Fe) field and it should have read 080, this erroneous entry may be changed to 080 by submitting change record with correct data in Fe field.

c. Record Columns 1-24 and 80.

(1) Designation: Analytical Sample Record Change.

(2) Entry: As detailed in paragraphs A-1,a. through f and A-2j.

d Record Column 79. (File Maintenance Action Code.)

(1) Designation: File Maintenance Action (Change).

(2) Entry: Alpha Code "R".

A-5. Maintenance Feedback Record. Maintenance Feedback Record is required to report all maintenance actions to oil wetted components. Maintenance Feedback Record will contain control data (Record Columns 1-24 and 80) and the following data. (See table A-4.)

a. Hours/Miles Since Overhaul. Record columns 25-29.

(1) Designation: Hours/Miles Since Overhaul.

(2) Entry: Numeric.

(3) Instructions: Total hours/miles since overhaul will be reported as five digit numerics reflecting nearest whole hours/miles. Total hours/miles which do not complete the field (5 digits) will be preceded with zeros, e.g., 148 =, 00148.

b. Action Taken Code. Record column 30.

(1) Designation: Maintenance Action Taken.

(2) Entry: Alpha.

TABLE A-3. ANALYTICAL SAMPLE RECORD CHANGE

Record Columns	Data Elements
1 *	L Instrument
	A
	B
	O
2 *	R Command
	A
	T
	O
	R
3 *	Y Laboratory
4 *	Major Command
5-10 *	Operating Activity
11-14*	Equipment/End Item Model
15-20*	Equipment Serial Number
21-24*	Julian Date (YDDD)
25-29	Hours/Miles Since Overhaul
30-33	Hours/Miles Since Oil Change
34	Reason for Sample
35-36	Oil Added Since Last Sample
37-38	Type Oil
39-40	Sample Response Time
41-76	Sample Analytical Results

41-43	44-46	47-49	50-52	53-55	56-58
Fe	Ag	Al	Cr	Cu	Mg
59-61	62-64	65-67	68-70	71-73	74-76
Ni	Pb	Si	Sn	Ti	Mo

77-78	Laboratory Recommendation
79	File Maintenance Action Code "R"
80*	Data Sequence

*Control Data

(3) Instructions: Action Taken Codes are established to identify the corrective maintenance accomplished to remedy a suspected discrepancy. Codes are listed in Appendix H.

c. Discrepant Item Codes. Record columns 31-32.

(1) Designation: Discrepant Item.

(2) Entry: Alpha.

TABLE A-4. MAINTENANCE FEEDBACK RECORD

Record Columns	Data Elements
1 *	L Instrument
	A
	B
	O
2 *	R Command
	A
	T
	O
	R
3 *	Y Laboratory
4 *	Major Command
5-10 *	Operating Activity
11-14*	Equipment/End Item Model
15-20*	Equipment Serial Number
21-24*	Julian Date (YDDD)
25-29	Hours/Miles Since Overhaul
30	Action Taken .
31-32	Discrepant Item
33	How Malfunctioned
34	How Found
35-78	Blank
79	File Maintenance Action Code "F"
80*	Data Sequence

*Control Data

(3) Instructions: Discrepant Item Codes are established to identify the item which has malfunctioned or which was examined for discrepancy. If a discrepant item is not coded, use the coded Item which is most directly related to the failed part. Discrepant Item Codes are listed in Appendix I.

d. How Malfunctioned Codes. Record column 33.

(1) Designation: How Malfunctioned.

(2) Entry: Alpha/Numeric.

(3) Instructions: How Malfunctioned Codes are established to identify the nature of the defect that existed on the item identified in Discrepant Item block. How malfunctioned codes are being kept to a minimum to simplify reporting. Therefore, established codes do not specifically describe all possible conditions, which may be encountered. A code, which best describes or most nearly describes the defect, will be used. How Malfunctioned Codes are listed In Appendix J.

e. How Found Codes. Record column 34.

(1) Designation: How Found.

(2) Entry: Alpha.

(3) Instructions: How Found Codes are established to indicate how the necessity for maintenance action was determined. How Found Codes are listed in Appendix K.

f. File Maintenance for Reporting Maintenance Feedback Data. Record column 79.

(1) Designation: File Maintenance Action (Feedback).

(2) Entry: Alpha.

(3) Instructions: Enter an alpha "F" to indicate that this record is a Maintenance Feedback Record.

g. Data Sequence. Record column 80.

(1) Designation: Data Sequence.

(2) Entry: Numeric.

(3) Instructions: Data sequence field is established to reflect sequence of JOAP maintenance feedback data submitted on same day from the same equipment. Blank field will signify Initial feedback data submittal. Subsequent data on same day will be sequentially numbered 2 through 9.

A-6. Maintenance Feedback Record Deletion. (See table A-5.)

a. Errors in the Control Data Fields (Columns 1-24 and 80) on a previously submitted JOAP Maintenance Feedback Record, which is in the computer database, can only be corrected by deletion of entire record and resubmittal of corrected record. To affect a Maintenance Feedback Record Deletion, the deletion record must contain identical control data (Columns 1-24 and 80) as the erroneous feedback record requiring deletion, coupled with File Maintenance Action Code.

b. Maintenance Feedback Record deletion requires submittal of a deletion record as described in paragraphs c and d below with an alpha "J" entry in Record Column 79. Record Columns 25-78 will be left blank on deletion record. This input will automatically delete the erroneous record and a corrected record must be submitted.

c. Record Columns 1-24 and 80.

(1) Designation: Maintenance Feedback Record Deletion.

(2) Entry: As detailed in paragraphs A-1,a. through f. and A-2,,j.

d. Record Column 79. (Maintenance Record Feedback Deletion Code.)

(1) Designation: File Maintenance Action (Feedback Deletion).

(2) Entry: Alpha Code "J".

TABLE A-5. MAINTENANCE FEEDBACK DELETION

Record Columns	Data Elements
1 *	L Instrument
	A
	B
	O
	R
2 *	A Command
	T
	O
	R
3 *	Y Laboratory
4 *	Major Command
5-10 *	Operating Activity
11-14*	Equipment/End Item Model
15-20*	Equipment Serial Number
21-24*	Julian Date (YDDD)
25-78	Blank
79	File Maintenance Action Code "J"
80*	Data Sequence

*Control Data

A-7. Maintenance Feedback Record Change. (See table A-6.)

a. Errors in Record Columns 25-34 on a previously submitted JOAP Maintenance Feedback Record, which is in the computer data bank, may be corrected by changing erroneous data. To affect a Maintenance Feedback Record Change, the change record must contain identical control data (Record columns 1-24 and 80) as the erroneous feedback record requiring change, coupled with appropriate File Maintenance Action Code.

b. Maintenance Feedback Record Change requires submittal of a change record as described in paragraphs c and d below with an alpha "T" entry in Record Column 79. Data in change fields (Record Columns 25-34) will only be entered for data, which requires change. A change field with data will automatically update that field with new data, e.g., if laboratory erroneously reports wrong How Malfunctioned Code, the erroneous entry may be changed by submitting a change record with correct How Malfunctioned Code in How Malfunctioned field.

c. Record Columns 1-24 and 80.

(1) Designation: Maintenance Feedback Record Change.

(2) Entry is as detailed in paragraph A-1,a. through f. and A-2,j.

d. Record Column 79. (Maintenance Feedback Record Change Code.)

(1) Designation: File Maintenance Action (Feedback Change).

(2) Entry: Alpha Code "T".

TABLE A-6. MAINTENANCE FEEDBACK RECORD CHANGE

Record Columns	Data Elements
1 *	L Instrument
	A
	B
	O
	R
2 *	A Command
	T
	O
	R
3 *	Y Laboratory
4 *	Major Command
5-10 *	Operating Activity
11-14*	Equipment/End Item Model
15-20 *	Equipment Serial Number
21-24 *	Julian Date (YDDD)
25-29	Hours/Miles Since Overhaul
30	Action Taken
31-32	Discrepant Item
33	How Malfunctioned
34	How Found
35-78	Blank
79	File Maintenance Action Code "T"
80*	Data Sequence

*Control Data

APPENDIX B

TYPE EQUIPMENT CODES

CONTENTS

Page No.

AERONAUTICAL

CRITERIA RESTRICTION B-2

CR = CRITERIA RESTRICTION

CR	EXPLANATION
AO	ARMY ONLY
CE	ARMY CORP OF ENGINEERS
FA	AIR FORCE AND ARMY
FN	AIR FORCE AND NAVY
FO	AIR FORCE ONLY
NC	NAVY AND COAST GUARD
NO	NAVY ONLY
SO	NASA ONLY

NONAERONAUTICAL

MARINE CORPS COMPONENTS B-8

ARMY COMPONENTS B-10

ARMY CORPS OF ENGINEERS B-22

U.S. AIR FORCE B-24

FLIGHT SIMULATORS B-24

NAVY SHIPS..... B-25

AERONAUTICAL TYPE EQUIPMENT CODES

CRITERIA RESTRICTION

END ITEM	COMPONENT	TEC	CR
A/M32A-95	GTCP 85-180	DJBC	
A-10	GTCP36-50	DCBA	
A-10	TF34-GE-100	KDAA	FO
A-37	J85-GE-17	ERFA	
A-4	CSD	DSAA	NO
A-4	J52-P-408	EECA	NO
A-4	J52-P-6C	EEDA	
A-4	J52-P-8B	EEBA	NO
A-6	CSD	DSBA	NO
A-6	J52-P-408 Gbx	EECB	
A-6	J52-P-408 TANK	EECC	
A-6	J52-P-8B	EEBB	NO
AH-1G	42/Int Gbx	GAIG	FA
AH-1G	90/Tail Gbx	GATC	FA
AH-1G	HYD SYS 1	HA1G	FA
AH-1G	HYD SYS 2	HA2G	FA
AH-1G	HYD SYS 3	HA31	
AH-1G	Main Xmsn	GAMG	FA
AH-1G	T53-L-13B	SBEA	AO
AH-64A	#1 Nose Gbx	GM1A	
AH-64A	#2 Nose Gbx	GM2A	
AH-64A	APU	DQAA	
AH-64A	HYD SYS 1	HM11	
AH-64A	HYD SYS 2	HM21	
AH-64A	Main Xmsn	GMMA	
AH-64A	PTO Clutch	GMPA	
AH-64D	HYD SYS	HMAD	
AH-64D	HYD SYS 2	HM22	
AH-64D	PTO Clutch	GMPD	
AH-64D	T700-GE-701	SHCA	
AH-6C	90/Tail Gbx	GHTC	
AH-6C	HYD SYS	HHA1	
AH-6C	Main Xmsn	GHMC	
AH-6C	T63-A720	SFCB	AO
AH-6J	90/Tail Gbx	GHTJ	AO
AH-6J	HYD SYS	HHA2	
AH-6J	Main Xmsn	GHMJ	AO
AH-6N	90/Tail Gbx	GHTN	AO
AH-6N	HYD SYS	HHA3	
AH-6N	Main Xmsn	GHMN	AO
AIRCRAFT	HYDRAULICOIL	HHYD	AO
AIRCRAFT	SYNTHETICOIL	ASYN	AO
AV-8	F402-RR-402	FMAA	
AV-8	F402-RR-404	FMCA	
AV-8	ING DR GEN	DPAA	NO
AV-8B	F402-RR-406	FMEA	
AV-8B	F402-RR-408	FMFA	
B-1	F101-GE-102	FBAA	
B-111	TF30-P-107	KAEA	
B-111	TF30-P-7	KABA	
B-1B	GTCP165-9	DLBA	
B-2	F118-GE-100	FKAA	FO
B-52	J57-P-19	EFGA	
B-52	J57-P-43	KFCA	
B-52	TF33-P-103	KCGA	
B-52	TF33-P-3	KCAA	
BE-65	IO-720-A1B	RHBA	
BIO-RAD	FT-IR	AIRA	
C-10	FI 03-G E- 101	FDBA	
C-12	PT5A-41	SPHA	
C-12	PT6A-27	SPCC	
C-12	PT6A-34	SPFA	
C-12	PT6A-38	SPGA	
C-12	PT6A-42	SPJA	
C-12C	PT6A-41	SPHB	
C-12D	PT6A-41	SPHC	
C-12J	PT6A-65B	SPPA	
C-130	GTC85-71	DGEA	

END ITEM	COMPONENT	TEC	CR
C-130	GTCP85-180	DJBA	
C-130	Nose Gear	GTNK	
C-130	T56-A-15	SDFA	FN
C-130	T56-A-15 Gbx	GTMF	
C-130	T56-A7	SDAA	FN
C-130	T56-A-9	SDCA	FN
C-130	T56-A-9 Gbx	GTMC	
C-135	F108-CF-100	FFAA	
C-135	GTC70-15	DFAA	
C-135	J57-P-43	EFCB	
C-135	J57-P-59	EFDA	
C-135	T41 M-9	DAAA	
C-135	TF33-P-5	KCBA	
C-135	TF33-P-9	KCDA	
C-135	TF33-PW-102	KCFA	
C-135	TF33-PW-102/JT3D–3B	KCFC	
C-137	GTCP 85-97	DJDA	
C-137	GTCP85-98	DJEA	
C-137	JT-3D-3	KJAA	
C-137	TF33-PW-102/JT3D-3B	KGBA	
C-140	J60-P-5	EHCA	FO
C-141	GTCP85-106	DJAA	
C-141	TF33-P-7	KCCA	
C-17	F117-PW-100	FLAA	
C-18	TF33-PW-102	KCFB	
C-2	GTCP36-201C	DCAA	NO
C-20	F113-RR-100	FJAA	
C-20	GTCP36-100	DCCA	
C-21	TFE731-2	KMAA	
C-22	JT-8D-7	KKAA	FO
C-23	PT6A-45	SPKA	
C-27	CTCP36-16A	DCGA	
C-27	T64-P4D	SPLA	
C-5	GTCP165-1	DLAA	
C-5	TF39-GE-1	KGAA	
C-6	PT6A-20	SPAA	
C-9	JT-8D-9	KKBA	FO
C-9	JT-8D-9	KKBB	NO
CH-47A	HDY SYS 3	HE3A	
CH-47A	HYD SYS 1	HE1A	
CH-47A	HYD SYS 2	HE2A	
CH-47B	HDY SYS 3	HE3B	
CH-47B	HYD SYS 1	HE1B	
CH-47B	HYD SYS 2	HE2B	
CH-47C	HYD SYS 1	HE1C	
CH-47C	HYD SYS 2	HE2C	
CH-47C	HYD SYS 3	HE3C	
CH-47D	1 EngMecXmsn	GEGD	
CH-47D	2 EngMecXmsn	GEHD	
CH-47D	Aft Xmsn	GEAD	
CH-47D	ENGCOMBXMSN	GEED	
CH-47D	FWDXMSN	GEFD	
CH-47D	HYD SYS 1	HE1D	
CH-47D	HYD SYS 2	HE2D	
CH-47D	HYD SYS 3	HE3D	
CH-47D	T55-GA-714A	SCFA	
CH-47D	T55-L-712	SCDB	
CH-47D	T55-L-714	SCED	
CH-47F	1 ENG MEC XMSN	GEGF	
CH-47F	2 ENG MEC XMSN	GEHF	
CH-47F	ENG COMB XMSN	GEEF	
CH-47F	HYD SYS 1	HE1F	
CH-47F	HYD SYS 2	HE2F	
CH-47F	HYD SYS 3	HE3F	
CH-47F	T55-L-712	SCDD	
CH-47F	T55-L-714	SCEE	
CH-47FS	HYD PUMP	HEAD	
CH-54	T73-P-1	SSAA	
CH-54A	HYD SYS 1	HG1A	
CH-54A	HYD SYS 2	HG2A	
CH-54A	HYD SYS 3	HG3A	
CH-54B	HYD SYS 1	HG1B	
CH-54B	HYD SYS 2	HG2B	
CH-54B	HYD SYS 3	HG3B	
CV-22	Emer Lube Res	DVAC	
CV-22	Mid-Wing Gbx	GVBC	
CV-22	Prop Rotor Gbx	GVDC	
CV-22	T406-AD-400	SWAA	
CV-22	Tilt Axis Gbx	GVJC	
E-3	GTCP165-1	DLAB	
E-3	TF33-PW-100	KCEA	
E-4	CSD	DSFA	
E-4	JT-9D-7	KNAA	
E-4B	GTCP660-4	DMAA	
E-6A	CFM56-2A-2	FFAB	
E-6A	GTCP165-1	DLAC	
E-8	TF33-PW-102/JT3D-3B	KCFD	
EA-6B	CSD	DSBB	NO
EA-6B	CSD	DSBB	NO
EH-60A	42/INT GBX	GLID	
EH-60A	90/Tail Gbx	GLTD	
EH-60A	MAIN XMSN	GLMM	
EH-60A	Main Xmsn (3u)	GLMC	
EH-60A	T62T-40-1	DBEB	
EH-60L	APU	DQAB	
EH-60L	Main Xmsn	GLML	

END ITEM	COMPONENT	TEC	CR
EH-60L	Int Gbx	GLIJ	
EH-60L	Tgb	GLTJ	
EMU-30	T62T-32	DBDA	
EMU-36	T62T-32	DBDB	
EO-5B	PT6A-50	SPNB	AO
F-111	CSD	DSGA	
F-111	TF30-P-100	KAJA	
F-111	TF30-P-103	KADA	
F-111	TF30-P-109	KAFA	
F-111	TF30-P-3	KAAA	
F-111	TF30-P-9	KACA	
F-14	CSD	DSEA	NO
F-14	F110-GE-400	FHBA	
F-14A	TF30-P-414A	KAHA	
F-15	F100-PW-100	FAAA	
F-15	F100-PW-220	FACA	
F-15	F100-PW-229	FADA	
F-16	F100-B	FAEA	
F-16	F100-PW-200	FABA	
F-16	F100-PW-220	FACB	
F-16	F100-PW-229	FADB	
F-16	F110-GE-100	FHAA	
F-16	F110-GE-100B	FHDA	
F-16	F110-GE-129	FHCA	FO
F-16	T62T40-8	DBFA	
F-16N	F110-GE-100	FHAB	
F-18	F404-GE-400	PPAA	NO
F-18	GTCP36-200	DCDA	NO
F-21	J79-JIE	EPFA	
F-22	F119-PW-100A	FRAA	
F-4	J79-GE-10	EPCA	
F-4	J79-GE-15	EPDA	
F-4	J79-GE-17	EPEA	
F-4	J79-GE-8	EPAA	
F-5	J85-GE-13	EREA	
F-5	J85-GE-21	ERGA	
G-159	MK-529-8X	SQAA	SO
GSE	GTC 85-16	DGBA	NO
GSE	GTC 85-116	DGJA	NO
GSE	GTC 85-180L	DGHA	NO
GSE	GTC 85-56	DGCA	NO
GSE	GTC 85-72	DGFA	NO
GSE	GTC 85-76	DGGA	NO
H-1	42/Int Gbx	GAIA	NO
H-1	90/Tail Gbx	GATA	NO
H-1	Main Xmsn	GAMA	NO
H-1	T400-CP-400	SRAA	NO
H-1	T400-WV-402	SRCA	NO

END ITEM	COMPONENT	TEC	CR
H-1	T53-L-11-D	SBCD	NO
H-1	T53-L-13	SBDA	FO
H-1	T58-GE-3	SEAA	
H-2	42/Int Gbx	GBIA	NO
H-2	90/Tail Gbx	GBTA	NO
H-2	Main Xmsn	GBMA	NO
H-2	T58-GE-8F	SEDA	NC
H-3	42/Int Gbx	GCIA	NO
H-3	90/Tail Gbx	GCTA	NO
H-3	Main Xmsn	GCMA	NO
H-3	T58-GE-10	SEEA	NC
H-3	T58-GE-402	SEJA	NC
H-3	T58-GE-5	SEBA	
H-3	T58-GE-8F	SEDB	NC
H-3	T62T-16	DBBB	
H-46	Aft Xmsn	GDAA	NO
H-46	Fwd Xmsn	GDFA	NO
H-46	T58-GE-10	SEEB	NC
H-46	T58-GE-16	SEFA	NC
H-46	T62T-l 1	DBAA	NO
H-52	42/Int Gbx	GRIA	NC
H-52	90/Tail Gbx	GRTA	NC
H-52	Main Xmsn	GRMA	NC
H-52	T58-GE-8	SECA	NC
H-53	#1 Nose Gbx	GF1A	NO
H-53	#2 Nose Gbx	GF2A	NO
H-53	42/Int Gbx	GFIA	NO
H-53	90/Tail Gbx	GFTA	NO
H-53	Acesory Gbx	GFCA	NO
H-53	Main Xmsn	GFMA	NO
H-53	T62T-27	DBCA	
H-53	T64-GE-100	SGGA	
H-53	T64-GE-413	SGFA	
H-53	T64-GE-6B	SGBA	
H-53	T64-GE-7	SGCA	
H-53D	T64-GE-415	SGDA	
H-60	T400-GE-401	SRBB	
H-60	T700-GE-700	SHBA	
HH-1H	42/Int Gbx	GAID	FA
HH-1H	90/Tail Gbx	GATID	FA
HH-1H	MAIN Xmsn	GAMD	FA
HH-60L	GRCP36-15BH	DCHB	
HH-60L	HYD SYS 1	HL1D	
HH-60L	HYD SYS 2	HL2D	
HH-60L	INT GBX	GLII	
HH-60L	MAIN XMSN	GLMI	
HH-60L	T62T-40-1	DBEG	
HH-60L	TAIL GBX	GLTI	

END ITEM	COMPONENT	TEC	CR
HH-60J	INT GBX	GLIK	
HH-60J	TAIL GBX	GLTK	
HH-65	90/Tail Gbx	GPTA	
HH-65	LTS-101-750	STAA	
HH-65	Main Xrnsn	GPMA	
HM-60L	MAIN XMSN	GLMJ	
HU-25	CSD	DSJA	
HU-25	HYD SYS 1	HT1A	
HU-25	HYD SYS 2	HT2A	
KC-135	T62T-40LC	DBGA	
M32A-60	GTCP 85-180	DJBB	
M32A-60	GTCP 85-397	DJCA	
MA-1	GTC 85-70	DGDA	
MH-47D	1ENG MEC XMSN	GEGG	
MH-47D	2ENG MEC XMSN	GEHG	
MH-47D	AFT SP	GESG	
MH-47D	ENG COMB XMSN	GEEG	
MH-47D	FWDSP	GERG	
MH-47D	HYD SYS 1	HE1G	
MH-47D	HYD SYS 2	HE2G	
MH-47D	HYD SYS 3	HE3G	
MH-47D	T55-L-712	SCDE	
MH-47D	T55-L-714	SCEG	
MH-47E	1EngMecXmsn	GEGE	
MH-47E	2EngMecXmsn	GEHE3	
MH-47E	Aft Xmsn	GEAF	
MH-47E	Eng CombXmsn	GEEE	
MH-47E	Fwd Xmsn	GEFE	
MH-47E	HYD SYS 1	HE1E	
MH-47E	HYD SYS 2	HE2E	
MH-47E	HYD SYS 3	HE3E	
MH-47E	T55-GA-714A	SCFB	
MH-47E	T55-L-714	SCDC	
MH-53E	T64-GE-419	SGHA	
MH-60L	GTCP36-150H	DCHA	
MH-60L	HYD SYS 1	HL1B	
MH-60L	HYD SYS 2	HL2B	
MH-60L	HYD SYS 3	HL3B	
MH-60L	INT GBX	GLIG	
MH-60L	Main Xmsn	GLMG	
MH-60L	T62T-40-1	DBED	
MH-60L	Tail Gbx	GLTG	
MH-60R	Int Gbx	GLIF	
MH-60R	Main Xmsn	GLMF	
MH-60R	Tail Gbx	GLTF	
MH-60S	Int Gbx	GLIE	
MH-60S	Main Xmsn	GLME	
MH-60S	Tail Gbx	GLTE	

END ITEM	COMPONENT	TEC	CR
MH-6C	90/Tail Gbx	GHTD	
MH-6C	HYD SYS	HHAD	
MH-6C	Main Xmsn	GHMD	
MH-6C	T63-A-720	SFCH	
MH-6H	90/Tail Gbx	GHTH	AO
MH-6H	HYD SYS	HHA4	
MH-6H	Main Xmsn	GHMH	
MH-6J	90/TailGbx	GHTK	AO
MH-6J	HYD SYS	HHA5	
MH-6J	Main Xmsn	GHMK	AO
MH-6N	90/TailGbx	GHTP	AO
MH-6N	HYD SYS	HHA6	
MH-6N	Main Xmsn	GHMP	AO
MV-22	Emer Lube Res	DVAM	
MV-22	Mid-Wing Gbx	GVBM	
MV-22	Prop Rotor Gbx	GVDM	
MV-22	Tilt Axis Gbx	GVJM	
O-2	IO-360	RBAA	
O-5A	PT6A-50	SPNA	AO
OH-58A	90/Tail Gbx	GKTA	
OH-58A	HYD SYS	HKAA	
OH-58A	Main Xrnsn	GKMA	
OH-58A	T63-A 700	SFBA	AO
OH-58A	T63-A-720	SFCG	
OH-58C	Main Xmsn	GKMC	
OH-6A	HYD SYS	HHA7	
OIL CART	PON-6	DRAA	
OIL-LUBE	MIL-H-5606	A007	
OIL-LUBE	MIL-H-83282	A006	
OIL-LUBE	MIL-L-23699	A001	
OIL-LUBE	MIL-L-7808	A003	
OIL-LUBE	MIL-L-85734	A005	
OIL-LUBE	MIL-PRF23699	A002	
OIL-LUBE	MIL-PRF85734	A004	
OV-10	T76-G-10	SMAA	
OV-10	T76-G-12	SMBA	
OV-10	T76-G-418	SMCA	
OV-10	T76-G-419	SMDA	
OV-10	T76-G-420	SMEA	
OV-10	T76-G-421	SMFA	
P-3	GTCP 95-2	DKAA	NO
QF-86F	J47-GE-27	ECAA	
RC-12D	PT6A-41	SPHD	
RC-12G	PT6A-41	SPHE	
RC-12K	PT6A-67	SPMA	
RC-12P	PT6A-41	SPHG	
RC-12Q	PT6A-41	SPHH	
RQ-5A	Main Gbx	GNMA	

END ITEM	COMPONENT	TEC	CR
RQ-5A	V-75	RNAA	
RU-9D	O-480-B1A6	RDEA	
S-3	GTCP36-201A	DCAB	NO
S-3	TF34-GE-400B	KDBA	NO
SH-2G	#1 Nose Gbx	GB1G	NO
SH-2G	#2 Nose Gbx	GB2G	NO
SH-2G	42/Int Gbx	GBIG	NO
SH-2G	90/Tail Gbx	GBTG	NO
SH-2G	Acesory Gbx	GBCG	NO
SH-2G	Main Xmsn	GBMG	NO
SH-60B	42/Int Gbx	GLIB	
SH-60B	90/Tail Gbx	GLTB	
SH-60B	Main Xmsn	GLMB	
T-34B	O-470	RCAA	NO
T-34C	BRAKE SYS	HNBC	
T-34C	PT6A-25	SPBA	NO
T-37	J69-T-25	EKAA	
T-38	J85-GE-5	ERDA	
T-39	J60-P-3	EHAA	FO
T-39	J60-P-3A	EHBA	NO
T-39	JT-12A-8	KLAA	NO
T-41	IO-360	RBAB	
T-41	O-300D	RLAA	
T-41B	IO-360-D	RBCA	
T-41C	IO-360-C	RBBA	
T-41C	IO-360-D	RBCB	
T-41D	IO-360-D	RBCC	
T-43	JT-8D-9	KKBC	FO
T-44A	PT6A-34B	SPFB	NO
T-45A	F405-RR-400	FQAA	
T-46	F109-GA-100	FGAA	
Test Cell	GTCP 95-3	DKBA	NO
Test Cell	T56-A-10	SDDX	FN
Test Cell	T56-A-14	SDEX	FN
Test Cell	T56-A-16	SDGX	FN
Test Cell	T56-A-425	SDHX	FN
Test Cell	T56-A-426	SDJX	FN
Test Cell	T56-A-7B	SDBX	FN
Test Cell	T62T-16	DBBA	
Test Cell	T700-GE-401	SHAX	
TG-7	O-235	RAAA	
TH-1G	HYD SYS 3	HA32	
TH-57B	90/Tail Gbx	GSTB	NO
TH-57B	Main Xmsn	GSMB	NO
TH-57B	T63-A-720	SFCA	NO
TH-67	250-C-30	SVAA	
TH-67	90/TAIL GBX	GUTA	
TH-67	HYD SYS	HUAA	

END ITEM	COMPONENT	TEC	CR
TH-67	MAIN XMSN	GUMA	
U-10	GO-480-G1D6	RDHA	
U-2	J57-P-31	EFBA	
U-2	J75-P-17	EMAB	
U-21F	PT6A-28	SPDA	
U-21G	T74-CP-700	SUAF	
U-2S	F118-GE-101	EMAC	
UH-1B	42/Int Gbx	GAIB	FA
UH-1B	90/Tail Gbx	GATB	FA
UH-1B	HYD SYS	HAAB	FA
UH-1B	Main Xmsn	GAMB	FA
UH-1B	T53-L-11	SBCA	AO
UH-1C	42/Int Gbx	GAIC	FA
UH-1C	90/Tail Gbx	GATC	FA
UH-1C	HYD SYS	HAAC	FA
UH-1C	Main Xmsn	GAMC	FA
UH-1C	T53-L-11	SBCB	AO
UH-1FS	HYD PUMP	HAA1	
UH-1H	42/Int Gbx	GAIH	FA
UH-1H	90/Tail Gbx	GATH	FA
UH-1H	HYD SYS	HAAH	FA
UH-1H	Main Xmsn	GAMH	FA
UH-1H	T53-L-13B	SBEE	AO
UH-1M	42/Int Gbx	GAIM	FA
UH-1M	90/Tail Gbx	GATM	FA
UH-1M	HYD SYS 1	HA1M	FA
UH-1M	HYD SYS 2	HA2M	FA
UH-1M	Main Xmsn	GAMM	FA
UH-1M	T53-L-13B	SBEF	AO
UH-1N	42/Int Gbx	GAIN	FA
UH-1N	90/Tail Gbx	GATN	FA
UH-1N	ENG COMB GBX	GAEN	FN
UH-1N	HYD SYS	HAA4	
UH-1N	Main Xmsn	GAMN	FA
UH-1N	T400-CP-400	SRAB	
UH-1V	42/Int Gbx	GAIV	FA
UH-1V	90/Tail Gbx	GATN	FA
UH-1V	HYD SYS	HAAV	FA
UH-1V	Main Xmsn	GAMV	FA
UH-1V	T53-L-11	SBCC	AO
UH-1V	T53-L-13B	SBEG	AO
UH-1X	42/Int Gbx	GAIX	FA
UH-1X	90/Tail Gbx	GATX	FA
UH-1X	HYD SYS	HAAX	FA
UH-1X	Main Xmsn	GAMX	FA
UH-60	HYD-PUMP	HLPA	
UH-60A	90/Tail Gbx	GLTI	
UH-60A	Main Xmsn	GLMK	

END ITEM	COMPONENT	TEC	CR
UH-60A	Main Xmsn (3u)	GLMA	
UH-60FS	HYD PUMP	HLAA	
UH-60L	42/Int Gbx	GLIC	
UH-60L	HYD SYS 1	HL12	
UH-60L	T62T-40-1	DBEC	
UH-60L	T700-GE-701C	SHDA	
UH-60Q	HYD SYS 1	HL1C	
UH-60Q	HYD SYS 2	HL2C	
UH-60Q	HYD SYS 3	HL3C	
UH-60Q	Main Xmsn (3u)	GLMH	
UH-60Q	TAIL GBX	GLTH	
UV-18	PT6A-27	SPCA	
UV-18A	PT6A-27	SPCB	
VC-140	GTCP 30-92	DNAA	
VH-3D	42/Int Gbx	GCID	NO
VH-3D	90/Tail Gbx	GCTD	NO
VH-3D	HYD SYS	HCA1	
VH-3D	Main Xmsn	GCMD	NO
VH-3D	T58-GE-400	SEGA	NC
VH-3D	T58-GE-400B	SEHA	NC
X-32	F119-PW-614C	FRCA	
X-35	F119-PW-611C	FRBA	

NONAERONAUTICAL
TYPE EQUIPMENT CODES
U.S. MARINE CORPS COMPONENT

EIMOD	COMPMOD	TEC
1150-MC	A38714	MEDH
1150-MC	DD453	MEGC
1150-MC	HYD SYS	MEDN
4000K-MC	18314-2	MJBG
4000K-MC	4BT3.9	MJBA
4000-MC	DD353	MEBC
4000-MC	HYD SYS	MEBN
4000-MC	TTB2221-1	MEBJ
420-C-MC	DD353	MECB
420-C-MC	HMD2315CB	MECH
48MC-MC	DD453	MEBB
48MC-MC	HR18325	MEBH
580-MC	A38714	MEFH
580-MC	CASE-G188D	MEFB
6000K-MC	6359T	MKZA
6000K-MC	FUNK-1724	MKZG
6000RTL-MC	A3331-1	MDBJ
6000RLT-MC	A38714	MDAG
6000RLT-MC	DD453	MDBB
6000RLT-MC	HYD SYS	MDBN
6000RLT-MC	MHR18325	MDAH
UH-60L	HYD SYS 3	HL32
600GPM-MC	DD353	MEDC
621B-MC	3406	MECA
621B-MC	7G2780	MECG
621B-MC	HYD SYS	MECN
72-31-MC	CRT 3333-1	MEEH
72-31-MC	DD471	MEEC
72-31-MC	HYD SYS	MEEN
AAVC7A1-MC	HS400-3A1	MWAG
AAVC7A1-MC	VT-400	MWAA
AAVP7A1-MC	HS400-3A1	MWBG
AAVP7A1-MC	VT-400	MWBA
AAVR7A1-MC	HS400-3A1	MWCG
AAVR7A1-MC	HYD SYS	NWCN
AAVR7A1-MC	VT-400	MWCA
AIRCOMP-MC	DEUTZ-F4L912	META
AVLB-MC	1790-2DA	MAGB
AVLB-MC	CD850-6A	MAGH
AVLB-MC	HYD SYS	MAJN
BRIDGE-MC	SABRE 212	MXJA
CAT-130G-MC	5R6172	MEMH
CAT-130G-MC	CAT-3304	MEMC
CAT-130G-MC	HYD SYS	MEMN
CAT-D7G-MC	9R5382	MENG
CAT-D7G-MC	CAT-3306	MENA
CAT-D7G-MC	HYD SYS	MENN
CAUSEWAY-MC	CMD-2A-221	MWFN
CAUSEWAY-MC	DD8V71T	MWDC
CAUSEWAY-MC	F301HY1PCNTB	MWQN
CAUSEWAY-MC	MH30L	MWDH
CAUSEWAY-MC	PAVC38RA	MWEN
CAUSEWAY-MC	RSA 04K	MWDN
COMPACTO-MC	DD4534	MVPA
COMPACTO-MC	HMD2315CB	MVPG
CONMIXER-MC	TRI-02	MEMB
CRANE-MC	4133.9	MEKA
CRANE-MC	CAT-3208T	MXBA
CRANE-MC	CLARK-28000	MXBG
CRANE-MC	FUNK-17243E	MEKG
DECONAPP-MC	4A084-3	MBQA
DRCH2500-MC	DD6V53	MEAB
DRCH2500-MC	R28621-12	MEAH
EXCAVATO-MC	5043-7000	MEJA
EXCAVATO-MC	FUNK-17243E	MEJG
GRADER-MC	CAT-3304	MEGA
GRADER-MC	POWESHIFT	MEGG
HOSEREEL-MC	AT5CC	MDCN
HOSEREEL-MC	DD371	MDCB
LAV-25-MC	DD6V53T	MWGA
LAV-25-MC	MT653	MWGG
LAV-AT-MC	DD6V53T	MWHA
LAV-AT-MC	MT653DR	MWHG
LAV-C2-MC	DD6V53T	MWJA
LAV-C2-MC	MT653DR	MWJG
LAV-L-MC	DD6V53T	MWKA
LAV-L-MC	MT653DR	MWKG
LAV-M-MC	DD6V53T	MWLA
LAV-M-MC	MT653DR	MWLG
LAV-R-MC	DD6V53T	MWMA
LAV-R-MC	MT653DR	MWMG
M109A3-MC	DD8V71T	MAAA
M109A3-MC	XTG-411-2A	MAAG
M110A2-MC	DD8V71T	MABA
M110A2-MC	XTG-411-2A	MABG
M123A1C-MC	V8-300	MBCC
M123E2-MC	V8-300	MBDC
M1A1-MC	AGT-1500	MACA
M1A1-MC	HYD SYS	MAVN
M1A1-MC	X1100-3B	MACG
M35A2C-MC	LD-465-1	MBAC
M45A2-MC	LD-465-1	MBFC

EIMOD	COMPMOD	TEC
M49A2C-MC	LD-465-1	MBEC
M50A2-MC	LD-465-1	MBGC
M543A2-MC	LD-465-1	MBLC
M578-MC	DD8V71T	MADA
M578-MC	XTG-411-2A	MADG
M60A1-MC	1790-2CA	MAEA
M60A1-MC	CD850-6A	MAEG
M813A1-MC	NHC-250	MBAA
M814-MC	NHC-250	MBBA
M816-MC	HYD SYS	MBCN
M816-MC	NHC-250	MBCA
M817-MC	HYD SYS	MBDN
M817-MC	NHC-250	MBDA
M818-MC	NHC-250	MBEA
M88A1-MC	1790-2DR	MAFA
M88A1-MC	XT-1410-4	MAFG
M893-MC	LD-465-1	MBDB
M923A1-MC	NHC-250	MCFA
M923-MC	NHC-250	MBFA
M925A1-MC	HYD SYS	MCGN
M925A1-MC	NHC-250	MCGA
M925-MC	HYD SYS	MBGN
M925-MC	NHC-250	MBGA
M927A1-MC	NHC-250	MCHA
M927-MC	NHC-250	MBHA
M928A1-MC	HYD SYS	MCJN
M928A1-MC	NHC-250	MCJA
M928-MC	HYD SYS	MBJN
M928-MC	NHC-250	MBJA
M929A1-MC	HYD SYS	MCKN
M929A1-MC	NHC-250	MCKA
M929-MC	HYD SYS	MBKN
M929-MC	NHC-250	MBKA
M930A1-MC	NHC-250	MCLA
M930-MC	NHC-250	MBLA
M931A1-MC	NHC-250	MCMA
M931-MC	NHC-250	MBMA
M934	HYD SYS	BTBM
M934A1-MC	NHC-250	MCMB
M935	HYD SYS	BTCM
M936A1-MC	HYD SYS	MCMN
M936A1-MC	NHC-250	MCNA
M936-MC	HYD SYS	MBMN
M936-MC	NHC-250	MBNA
M970-MC	ONAN	MBNC
M9-MC	CLARK-1345	MHPH
M9-MC	CUMMINSV903C	MHPB
MEP-003-MC	ONAN/DJC	MVCB
MEP-005A-MC	D298ERX37	MVMC
MEP-006A-MC	AC3500	MVDC
MEP-007A-MC	CAT-D333CT	MVEC
MEP-021A-MC	42032	MVBA
MEP-112A-MC	ONAN/DJC	MVDB
MEP-113A-MC	D198ERX51	MVLC
MEP-114A-MC	D298ERX37	MVMC
MEP-115A-MC	AC3500	MVHC
MEP-16A-MC	42032	MVAB
MEP-208A-MC	KTA-2300G	MVNC
MEP-208A-MC	ONAN	MVPC
MK-23	ENGINE	MBPB
MK-23	XMSN	MBPH
MK-23	HYD SYST	MBPP
MK-25	ENGINE	MBPC
MK-25	XMSN	MBPJ
MK-25	HYD SYST	MBPQ
MK-27	ENGINE	PBCA
MK-27	XMSN	PBCG
MK-27	HYD SYST	PBCN
MK-28	ENGINE	PBDA
MK-28	XMSN	PBDG
MK-28	HYD SYST	PBDN
MK48 4X4-MC	DD8V92TA	MBPA
MK48 4X4-MC	HT740D	MBPG
MK48 4X4-MC	HYD SYS	MBPN
P19A-MC	ALLIS750DRD	MBRH
P19A-MC	NHC-250	MBRB
P250WDN-MC	F2L511	MEMA
RTCH-MC	3P9094	MDAW
RTCH-MC	CAT-3408T	MDAC
RTCH-MC	CAT-5R3855	MDAJ
RTCH-MC	HYD SYS	MDAN
SCRAPER-MC	3406	MEHA
SCRAPER-MC	POWERSHIFT	MEHG
SLWT-4-MC	70823300	MAEB
SLWT-4-MC	CMD-2A-221	MAGN
SLWT-4-MC	DD8V71T	MAEC
SLWT-4-MC	F301HY1PCNTB	MAHN
SLWT-4-MC	MH30L	MAEH
SLWT-4-MC	PAVC38RA	MAFN
SLWT-4-MC	RSA 04K	MAEN
SWEEPER-MC	4239D	MSEA
SWEEPER-MC	ALLISON-540	MSEG
TRACTOR-MC	4WG-200	MJCG
TRACTOR-MC	6076ADW02	MJCA
TRACTOR-MC	BENZ-320	MEDA
TRACTOR-MC	BENZ-MECH	MEDG
TRACTOR-MC	CASE-6T590	MHPA
TRACTOR-MC	CASE-G107561	MHPG
TRK FIRE-MC	NTC-400	MTCA
WINCH-MC	1489	MDDN
WINCH-MC	50438301	MDDB
WINCH-MC	DD453	MDDC
WLDTLMTD-MC	PERKINS4236	MEFC

NONAERONAUTICAL TYPE EQUIPMENT CODES
ARMY COMPONENTS

EIMOD	COMPMOD	TEC	EIMOD	COMPMOD	TEC
10000M	6BT5.9	DJFA	515	S710	NC2G
10000M	FUNK-1723M	DJFG	515	HYD SYS	NC2M
10000M	HYD SYS	DJFN	530B	LDS-465-1	TEDA
1200	CSG649	NC4A	530BAM	LDS-465-1	TEEA
1200	C-6	NC4G	544E	HYD SYS	TDBN
1500M	DD6V53	TVAA	544E	JD6059TDW04	TDBA
140H	CAT-3306	EHAB	544E	WG-120	TDBG
140H	CAT-1442234	EHAG	609-C	F6L912B	ZTCA
140H	HYD SYS	EHAM	6000M	6BT5.9	TDHA
175B	CLK4000	EFBG	6000M	FUNK-1723	TDHG
175B	DD8V71N	EFBF	6000M	HYD SYS	TDHN
175B	HYD SYS	EFBN	600TV75	T-1010 S-39	TVFA
175B	NT-855-C	EFBB	613BSNS	8S3543	EHZG
1854	9.0L180F	NB2A	613BSNS	CAT-3208	EHZA
1854	CM-5552D	NB2G	613BSNS	HYD SYS	EHZN
1854	HYD SYS	NB2N	613BSNSI	8S3543	EJLG
2500L	DD6V92	TCWA	613BSNSI	CAT-3208	EJLA
2500L	HT750DRD	TCWG	613BSNSI	HYD SYS	EJLN
250DCMS1	JD403	DWSA	613BSS	8S3543	EH2G
250RPV	DD453	DWLA	613BSS	CAT-3208	EH2A
270-9	DD353	EU5A	613BSS	HYD SYS	EH2N
3000 KW-N	CB LSV16T	PVDA	613BSSI	8S3543	EJKG
3000M	2067761	DJ8G	613BSSI	CAT-3208	EJKA
3000M	C-180	DJ8A	613BSSI	HYD SYS	EJKN
35KVA	GPT 30-150E	TVYA	613BWDNS	8S3543	EVGG
4200	3TNE78A	NB5A	613BWDNS	CAT-3208	EVGA
4200	4200HST	NB5G	613BWDNS	HYD SYS	EVGN
4200	HYD SYS	NB5M	613BWDS	8S3543	EVFG
444C	6329	NA5A	613BWDS	CAT-3208	EVFA
444C	NOII	NA5G	613BWDS	HYD SYS	EVFN
444C	HYD SYS	NA5M	621B	3406	EH3A
450D	4219	NA7A	621B	7G2780	EH3G
450D	NOII	NA7G	621B	HYD SYS	EH3N
450D	HYD SYS	NA7M	645M	AC3500	EFLA
450E	TO4276	NC3A	645M	HYD SYS	EFLN
450E	JD4SPD	NC3G	645M	TT2420-1	EFLG
450E	HYD SYS	NC3M	6M125	D2000X16	TVGA
4700	T444E	NA4A	750PQ	DD6V71N	TVJA
4700	AT545	NA4G	75TPH EAGLE	N855-P235	TFAA
4700	HYD SYS	NA4M	780T	T4.236	E47A
4800	DT466	NB9A	950BNS	7G4851	EFWG
4800	MT643	NB9G	950BNS	CAT-3304	EGEA
4800	HYD SYS	NB9M	950BNS	HYD SYS	EFWN
5060	DD23010052	EMKG	950BNSCE	7G4851	EGEG
5060	DD471T	EMKA	950BNSCE	CAT-3304	EGEA
515	D-359N	NC2A	950BMSCE	HYD SYS	EGEN

950BS	7G4851	EFVG	BP	4002	WAHA
950BS	CAT-3304	EFVA	BP	4003	WAFA
950BS	HYD SYS	EFVN	BRIDGE-MA	DD8V71	TWDA
950BSCE	7G4851	EGFG	BRIDGE-MA	HT70	TWDG
950BSCE	CAT-3304	EGFA	BSF-400	DD353	EXEA
950BSCE	HYD SYS	EGFN	BSF-400	HYD SYS	EXEN
AMTC	HYD SYS	TMTN	C350B	DD353	TEHA
AN/MJQ-10A	D298ERX37	VCOA	C350B	HYD SYS	TEHN
AN/MJQ-11A	CAT-D343TA	VENA	C350B-D	DD353	TEWA
AN/MJQ-12A	AC3500	VELA	C3508-D	HYD SYS	TEWN
AN/MJQ-15	D198ERX51	VLOA	C530A	393303	EURG
AN/MJQ-18	D198ERX51	VLAA	C530A	DD353	EURA
AN/MJQ-18	100-1345	VLAB	CAT-12	CAT-D333	EHKA
AN/MJQ-21	T62T32A	VIHA	CAT-120ROPS	3R9859	EHKG
AN/MJQ-24	A04043B02	VICA	CAT-130G	5R6192	EHFG
AN/MJQ-35	DN2M	VICD	CAT-130G	CAT-330DIT	EHFA
AN/MJQ-35A	DN2M	VICE	CAT-130G	HYD SYS	EHFN
AN/MJQ-36	DN2M	VICF	CAT-130GNS	CAT-3304	EHNA
AN/MJQ-37	DN4M-1	VIDA	CAT-130GNS	5R6192	EHNG
AN/MJQ-38	DN4M-1	VIDB	CAT-130GNS	HYD SYS	EHNN
AN/MJQ-39	ISUZU-C240	VICJ	CAT-130GNSC	5R6192	EJJG
AN/MJQ-40	JD4039T	VICB	CAT-130GNSC	CAT-3304DIT	EJJA
AN/MJQ-41	JD6059T	VICC	CAT-130GNSC	HYD SYS	EJJN
AP308	4B3.96	DXLA	CAT-130GNSE	5R6192	TAAG
AP308	FORD C-6	DXLG	CAT-130GNSE	CAT-3304	TAAA
APP-1	GTCP85-127	VAFC	CAT-130GNSE	HYD SYS	TAAN
ARTFT6	ALS 3331-1	DJCG	CAT-130GS	5R6192	EHPG
ARTFT6	DD453N	DJCF	CAT-130GS	CAT-3304	EHPA
ARTFT6	HYD SYS	DJCN	CAT-130GS	HYD SYS	EHPN
AT422T	13.9LFHR	ELTG	CAT-130GSCE	5R6192	TABG
AT422T	6BTA5.9	ELTA	CAT-130GSCE	CAT-3304	TABA
AT422T	HYD SYS	ELTM	CAT-130GSCE	HYD SYS	TABN
B413	RTG3600C-S1	TVPB	CAT-814F	1223774	E5DG
B8	4-53T	NA9A	CAT-814F	CAT-3306B	E5DA
B8	13.3HR28420	NA9G	CAT-814F	HYD SYS	E5DM
B8	HYD SYS	NA9M	CAT-815F	1223774	E5EG
BBBUESCSBMK1	10-18-002	XJGG	CAT-815F	CAT-3306B	E5EA
BBBUESCSBMK1	SABRE 212	XJGA	CAT-815F	HYD SYS	E5EM
BBBUESCSBMK2	10-18-002	TWVG	CAT-816F	1223774	E5FG
BBBUESCSBMK2	SAVE 212	TWVA	CAT-816F	CAT-3306B	E5FA
BD 264B	CO-5EN668	WACE	CAT-816F	HYD SYS	E5FM
BD 264B	CO-6EN68	WACB	CAT-D5	3S7094	EAPG
BD 264B	CO-DSM-6	WACC	CAT-D5	CAT-3306	E5FA
BD 264B	CO-GAB4	WACA	CAT-D5	HYD SYS	E5FM
BD 264B	FM-316A6	WACD	CAT-D5A	3S7094	EAPG
BD-6802	NTA-855-63	WB1A	CAT-D5A	CAT-3306	EAPA
BD-6802	KTA38-G2	WB1B	CAT-D5A	HYD SYS	EANN
BD-6802	HYD SYS	WB1M	CAT-D5B	3S7094	TEKG
BD-6802	HYD SYS ANC1	WB1N	CAT-D5B	9P4905	TEKH
BD-6802	HYD SYS ANC2	WB2N	CAT-D5B	CAT-2WA1/UP	TEKI
BD-6802	HYD SYS ANC3	WB3N	CAT-D5B	CAT-3306	TEKA
BIO-RAD	FT-IR	GRDA	CAT-D5B	D5/3T3394	TEKJ

CAT-D5B	HYD SYS	TEKN	FLU419	BENZ-OM352	TEYA
CAT-D7E	CAT-D333	EA3G	FLU419	HYD SYS 1	TEYN
CAT-D7F	5R82	EA2G	FLU419	HYD SYS 2	TEYM
CAT-D7F	CAT-3306	EA2A	FT750	LDT-465-1	ZMAA
CAT-D7F	CAT-6CYL638C	EA2B	GTGE709-2	GPT 70-52	VLVA
CAT-D7F	HYD SYS	EA2N	H100C	HYD SYS	EFRN
CAT-D7G	9P5382	TELG	H100C	IHDT817C	EFRA
CAT-D7G	CAT-3306	TELA	H100C	P-2004	EFRG
CAT-D7G	HYD SYS	TELN	H100C GPB	HYD SYS	EFSN
CAT-D7H	9P5382	TELH	H100C GPB	IHDT817C	EFSA
CAT-D7H	CAT-3306	TELB	H100C GPB	P-2004	EFSG
CAT-D7H	HYD SYS	TELM	H40XL-MIL	360311	TDEG
CAT-D7R	CAT-3306	TEMA	H40XL-MIL	HYD SYS	TDEN
CAT-D7R	CAT-9TXI-UP	TEMG	H40XL-MIL	ISUZU-C240	TDEA
CAT-D7R	HYD SYS	TEMN	H446	DD353	EKTA
CAT-D8K	3N1869	EADG	H60XL-MIL	360311	TDFG
CAT-D8K	CAT-D342	EADA	H60XL-MIL	HYD SYS	TDFN
CAT-D8K	HYD SYS	EADN	H60XL-MIL	ISUZU-C240	TDFA
CB-534B	CAT-3054	E5BA	HC-238A	DD671N	DSFA
CB-534B	HYD SYS	E5BN	HC-283A	DD6V92TC	DSFB
CS433C	HYD SYS	E5HM	HC-238A	HYD SYS	EFJN
CS433C	CAT-3054	E5KA	HMMH	BENZ-OM352	TEXA
CS563D	CAT-3114	E5JA	HMMH	HYD SYS 1	TEXN
CS563D	CAT-3116	E5JB	HMMH	HYD SYS 2	TEXM
CS563D	CAT-3126	E5JC	HSPB	400MERLIN	WCRA
CS563D	HYD SYS	E5JM	JD230LC-RD	JD6068	AKXA
D424A	A0403B02	TVPA	JD230LC-RD	JD4045	AKXB
D5	HYD SYS	EAPM	JD230LC-RD	HYD SYS	AKXM
D5 ENG TS	HYD SYS	TB3N	JD230LCR	JD6068	AKXC
D5BNS	CAT-2WA1/UP	EBAH	JD230LCR	HYD SYS	AKXN
D5BNS	CAT-3306	EBAA	JD330LCR	JD6081	AKYD
D5BNS	D5/3T3394	EBAG	JD330LCR	HYD SYS	AKYM
D5BS	CAT-2WA1/UP	EBBH	JD410	4-2-19DT-03	EDHA
D5BS	CAT-3306	EBBA	JD410	DP23981	EDHG
D5BS	D5/3T3394	EBBG	JD410	HYD SYS	EDHN
D5BS	HYD SYS	EBBN	JD550	4276TT01	TEQA
D5BS1	CAT-2WA1/UP	TFBA	JD550	AT49678	TEQG
D5BS1	CAT-3306	TFBA	JD550	HYD SYS	TEQN
D5BS1	D5/3394	TFBH	JD644G	6081HDW04	TERG
D5BS1	HYD SYS	TFBN	JD644G	609T	TERA
D6	HYD SYS	TCMM	JD644G	HYD SYS	TERM
DV43	CAT-2408T	DJNA	JD770C	6081HDW03	TEQB
DV43	CAT-3408	DJNB	JD770C	DF1888E00WA	TEQH
DV43	CAT-3P9094	DJNH	JD770C	HYD SYS	TEQM
DV43	CAT-5R3855	DJNG	JD862B	6101AT012	TERB
DV43	HYD SYS	DJNN	JD862B	AT59822	TERH
DV-100	HYD SYS	EBCM	JD862B	HYD SYS	TERN
DV-100	POWER SHIFT	JCCG	JEEP77	JAM4.0T5ND1	NA2A
DV-100	CAT-3126	JCCA	JEEP77	AX5	NA2G
EMD12567	16-567-C	TVQA	JHTWX1096	GTCP85-127	TVUA
EPPIII	BF8L513	VCAA	K300	CAT-3208	EXBA
F5070	HT750CRD	EZYH	K300	CLK28000	EXBG
F5070	HYD SYS	EZYN	K300	HYD SYS	EXBN
F5070	NTC-290	EZYA	KTA50GS	KTA50GS	NB7A

LARC-LX	6080RA	WANB	LT	3408DITAJW	WGEB
LARC-LX	6081RC	WANA	LT	CAT-3304NA	WGEC
LARC-XV	300	WARA	LT	CAT-3306TA	WGED
LCM8	671LB63A	WASA	LT	EMD12645F7B	WGEA
LCM8	671LD63A	WAEA	LT	HS400-3	WAMG
LCM8	671RB63A	WAZA	LT	LS6DRT	WAMA
LCM8	671RD63A	WAYA	LT9500	CAT-C10	NB3A
LCM8	DD12V71T	WAEB	LT9500	RM0131454	NB3G
LCM8MOD1	DD12V71T	WASB	LT9500	HYD SYS	NB3M
LCM8MOD1SL	DD12V71T	WASC	LT9513	CAT-C10	NC6A
LCM8-SLEP	7000	WGDA	LT9513	RTLO12713A	NC6G
LCMB-SLEP	7122	WGCA	LT9513	HYD SYS	NC6M
LCM8-SLEP	7000	WGDA	LVTC-7	DD8V53T	TWNA
LCM8-SLEP	7122	WGCA	LVTC-7	HS400-3	TWNG
LCU1646	1033-7005	WAAD	LVTC-7A1	HS400-3	TWPG
LCU1646	GM1043-7000	WAAB	LVTC-7A1	VT-400	TWPA
LCU1646	GM7122-7000	WAAC	LVTP-7	DD8V53T	TWRA
LCU1646	MG514	WAAG	LVTP-7	HS-400-3	TWRG
LCU2000	4B3.9	WBSC	LVTP-7A1	HS400-3	TWSG
LCU2000	KTA-50M	WBSA	LVTP-7A1	VT-400	TWSA
LCU2000	NT-855-M	WBSD	LVTR-7	DD8V53T	TWTA
LCU2000	NTA-855	WBSB	LVTR-7	HS400-3	TWTG
LCU2000	WAV850PT	WBSG	LVTR-7A1	HS400-3	TWUG
LCU2000	WAV850SB	WBSH	LVTR-7A1	V903	TWUB
LOCO100T	AMER 539	XCUA	LVTR-7A1	VT-400	TWUA
LOCO100T	EMD8-567B	XCIA	M1	AGT-1500	AAAA
LOCO10T	DD3080	TXAA	M1	HYD SYS	AAAN
LOCO115T	AMER 539S	XCAA	M1	X1100-3B	AACG
LOCO120T	38D-81/8	TXDA	M1 IP	AGT-1500	AACA
LOCO120T	AMER 244F	XCPA	M1 IP	HYD SYS	AACN
LOCO120T	BALDWING 606A	TXBA	M1 IP	X1100-3B	AAAG
LOCO120T	EMD16-567B	XCKA	M1000	HYD SYS	CXUN
LOCO120T	EMD16-645E	XCQA	M1025	6.2 L DIESEL	BBFA
LOCO120T	FM-H12-44	XCCA	M1025	6.5 L DIESEL	BBFC
LOCO25T	HBI-600	XCWA	M1025	THM-3L80	BBFG
LOCO44T	CAT-D17000	XCLB	M1025A1	6.2 L DIESEL	BBFD
LOCO45T	HBI-600	XDFA	M1025A1	6.5 L DIESEL	BBFB
LOCO60T	CAT-3508	XCTA	M1025A1	THM-3L80	BBFH
LOCO60T	CAT-D397	XCSA	M1025A2	6.5 L DIESEL	BCLB
LOCO80T	LI-600	XCVA	M1025A2	THM-4L80E	BCFG
LOCO80T	NTA-855L4	XC3A	M1026	6.2 L DIESEL	BBGA
LOCO80T-470	NHBIS-600	XCMA	M1026	6.5 L DIESEL	BBGC
LOCO80T-550	NHBIS-600	XCNA	M1026	THM-3L80	BBGG
LPU-71	GTCP85-127	VAFB	M1026A1	6.2 L DIESEL	BBGB
LPU-71W	GTCP85-127	VAAA	M1026A1	6.5 L DIESEL	BBGD
LRT-110	17243E	EKZG	M1026A1	THM-3L80	BBGH
LRT-110	4B3.9	EKZA	M1035	6.2 L DIESEL	BBLA
LRT-110	HYD SYS	EKZN	M1035	6.5 L DIESEL	BBLC
LSV	3304-B	WAXC	M1035	THM-3L80	BBLG
LSV	3306-B	WAXD	M1035A2	6.5 L DIESEL	BCLB
LSV	3406-B	WAXB	M1035A2	THM-4L80E	BCLG
LSV	EMD16-645E6	WAXA	M1036	6.2 L DIESEL	BBHA
LSV	MG509	WAXG	M1036	6.5 L DIESEL	BBHC
LSV	WAV630-2240	WAXH	M1036	THM-3L80	BBHG

M1037	6.2 L DIESEL	BBKA	M1075	CLT-755	B4HG
M1037	6.5 L DIESEL	BBKC	M1075	DD8V92TA	B4HA
M1037	THM-3L80	BBKG	M1075	HYD SYS	B4HM
M1038	6.2 L DIESEL	BBEA	M1078	CAT-3116-225	BHDA
M1038	6.5 L DIESEL	BBEC	M1078	HYD SYS	BHHM
M1038	THM-3L80	BBEG	M1078	MD3070PT	BHDG
M1038A1	6.2 L DIESEL	BBEB	M1078A1	CAT-3126	BHRA
M1038A1	6.5 L DIESEL	BBED	M1078A1	MD3070PT	BHRG
M1038A1	THM-3L80	BBEH	M1078A1	HYD SYS	BHRM
M1042	6.2 L DIESEL	TCTA	M1079	CAT-3116-225	BHEA
M1042	6.5 L DIESEL	TCTC	M1079	MD3070PT	BHEG
M1042	THM-3L80	TCTG	M1079A1	CAT-3126	BHSA
M1043	6.2 L DIESEL	BBJA	M1079A1	MD3070PT	BHSG
M1043	6.5 L DIESEL	BBJC	M1079A1	HYD SYS	BHSM
M1043	THM-3L80	BBJG	M1080	CAT-3116-290	BHCA
M1043A2	6.5 L DIESEL	BCJB	M1080	MD3070PT	BHCG
M1043A2	THM-4L80E	BCJG	M1081	CAT-3116-225	BHFA
M1044	6.2 L DIESEL	BBNA	M1081	MD3070PT	BHFG
M1044	6.5 L DIESEL	BBNC	M1080A1	CAT-3126	BHTB
M1044	THM-3L80	BBNG	M1080A1	MD3070PT	BHTH
M1046	6.2 L DIESEL	TCSA	M1081A1	CAT-3126	BHUA
M1046	6.5 L DIESEL	TCSC	M1081A1	MD3070PT	BHUG
M1046	THM-3L80	TCSG	M1081A1	HYD SYS	BHUM
M1059	DD6V53	AESA	M1083	CAT-3116-290	BR2A
M1059	TX-100-1	AESG	M1083	MD3070PT	BR2G
M1059A3	DD6V53T	AFAA	M1083A1	CAT-3126	BT9A
M1059A3	X200-4	AFAG	M1083A1	MD3070PT	BT9G
M1064	DD6V53	AE4A	M1083A1	HYD SYS	BT9M
M1064	TX-100-1	AE4G	M1084	CAT-3116-290	BR3A
M1064A3	DD6V53T	AE8A	M1084	HYD SYS	BR3N
M1064A3	X200-4	AE8G	M1084	MD3070PT	BR3G
M1065	OM603.950	TCPA	M1084A1	CAT-3126	BUBA
M1065	W4A040	TCPG	M1084A1	MD3070PT	BUBG
M1066	OM603.950	TCPA	M1084A1	HYD SYS	BUBM
M1066	W4A040	TCQG	M1085	CAT-3116-290	BR7A
M1067	OM603.950	TCRA	M1085	MD3070PT	BR7G
M1067	W4A040	TCRG	M1085A1	CAT-3126	BUGA
M1068	DD6V53	AE5A	M1085A1	MD3070PT	BUGG
M1068	TX-100	AE5G	M1085A1	HYD SYS	BUGM
M1068A3	DD6V53T	AFCA	M1086	CAT-3116-290	BR8A
M1068A3	X200-4	AFCG	M1086	HYD SYS	BR8N
M1069	6.2 L DIESEL	AKZA	M1086	MD3070PT	BR8G
M1069	6.5 L DIESEL	AKZB	M1086A1	CAT-3126	BUHA
M1069	THM-3L80	AKZG	M1086A1	MD3070PT	BUHG
M106A1	DD6V53	AEFA	M1086A1	HYD SYS	BUHM
M106A1	TX-100-1	AEFG	M1087	CAT-3116-290	BT3A
M106A2	DD6V53	AERA	M1087	MD3070PT	BT3G
M106A2	TX-100-1	AERG	M1087A1	CAT-3126	BUTA
M1070	CLT-754	B5CG	M1087A1	MD3070PT	BUTG
M1070	DD8V92TA	B5CA	M1088	CAT-3116-290	BTJA
M1070	HYD SYS	B5CM	M1088	MD3070PT	BTJG
M1074	CLT-755	B4GG	M1088A1	CAT-3126	BUCA
M1074	DD8V92TA	B4GA	M1088A1	MD3070PT	BUCG
M1074	HYD SYS	B4GM	M1088A1	HYD SYS	BUCM

M1089	CAT-3116-290	BR4A	M1123	6.5 L DIESEL	B6GA
M1089	HYD SYS	BR4N	M1123	THM-4L80E	B6GG
M1089	MD3070PT	BR4G	M113A2	DD6V53	AENA
M1089A1	CAT-3126	BUDA	M113A2	TX-100-1	AENG
M1089A1	MD3070PT	BUDG	M113A3	DD6V53	AEYB
M1089A1	HYD SYS	BUDM	M113A3	DD6V53T	AEYA
M1090	CAT-3116-290	BR5A	M113A3	TX-100-1	AEYH
M1090	HYD SYS	BR5N	M113A3	X200-4	AEYG
M1090	MD3070PT	BR5G	M113A3BMP-2	DD6V53T	AEZA
M1090A1	CAT-3126	BUEA	M113A3BMP-2	X200-4	AEZG
M1090A1	MD3070PT	BUEG	M150 CSWP	4BT3.9C	TBCF
M1090A1	HYD SYS	BUEM	M150 CSWP	6CT8.3G	TBCB
M1091	CAT-3116-290	BT2A	M150 CSWP	6CTA8.3-C#1	TBCD
M1091	MD3070PT	BT2G	M150 CSWP	6CTA8.3-C#2	TBCE
M1091A1	CAT-3126	BUSA	M150 CSWP	M11-C	TBCC
M1091A1	MD3070PT	BUSG	M1977	DD8V92TA	DV4A
M1092	CAT-3116-290	BRZA	M1977	HT740D	DV4G
M1092	MD3070PT	BRZG	M1977	HYD SYS	DV4M
M1092A1	CAT-3126	BT8A	M1A1	AGT-1500	AABA
M1092A1	MD3070PT	BT8G	M1A1	HYD SYS	AABN
M1093	CAT-3116-290	BR9A	M1A1	X1100-3B	AABG
M1093	MD3070PT	BR9G	M1A2	AGT-1500	TAUA
M1093A1	CAT-3126	BUAA	M1A2	HYD SYS	TAUM
M1093A1	MD3070PT	BUAG	M1A2	X1100-3B	TAUG
M1093A1	HYD SYS	BUAM	M2A3	VTA-903T	APGA
M1094	CAT-3116-290	BTKA	M2A3	HMPT-500	APGH
M1094	HYD SYS	BTKN	M2	HMPT-500	APAG
M1094	MD3070PT	BTKG	M2	HMPT-500-3	APAH
M1094A1	CAT-3126	BUFA	M2	HMPT-500-3E	APAJ
M1094A1	MD3070PT	BUFG	M2	HMPT-500-B	APAK
M1094A1	HYD SYS	BUFM	M2	VTA903T	APAA
M1096	CAT-3116-290	BR6A	M270	HMPT-500-3EC	QBDG
M1096	HYD SYS	BR6N	M270	HYD SYS	QBDM
M1096	MD3070PT	BR6G	M270	VTA-903T	QBDA
M1097	6.2 L DIESEL	BBMA	M291A1	ENDT-673	BRPA
M1097	THM-3L80	BBMG	M291A1	LD-465-1C	BRPD
M1097	6.5 L DIESEL	BBMC	M291A1	LDS-427-2	BRPC
M1097A1	6.2 L DIESEL	BBUA	M291A1	LDS-465-1	BRPB
M1097A1	THM-3L80	BBUG	M291A1	LDT-465-1C	BRPF
M1097A2	6.5 L DIESEL	BCMB	M291A1	LDT-465-1D	BRPE
M1097A2	THM-4L80E	BCMG	M291A2	LDS-465-1	TBCA
M109A3	LDT-465-1C	BMJC	M292A1	LD-465-1C	BGMB
M10A	HYD SYS	DJUN	M292A1	LDS-427-2	BGMA
M10A	IHCDT-466B	DJUA	M292A1	LDT-465-1C	BGMD
M10A	IHCS-700	DJUG	M292A1	LDT-465-1D	BGMC
M1109	6.2 L DIESEL	B6AA	M292A2	LD-465-1	BGLA
M1109	THM-3L80	B6AG	M292A2	LD-465-1C	BGLB
M1109	6.5 L DIESEL	B6AC	M292A2	LDS-427-2	BGLE
M1113	6.5 L DIESEL	B6BA	M292A2	LDT-465-1C	BGLD
M1113	THM-4L80E	B6BG	M292A2	LDT-465-1D	BGLC
M1114	6.5 L DIESEL	B6CA	M292A4	LD-465-1C	TBDB
M1114	THM-4L80E	B6CG	M292A4	LDS-427-2	TBDA

M292A4	LDT-465-1C	TBDD	M3A2	HMPT-500	TASG
M292A4	LDT-465-1D	TBDC	M3A2	HMPT-500-3	TASH
M292A5	LD-465-1	BGNA	M3A2	HMPT-500-3E	TASJ
M292A5	LD-465-1C	BGNB	M3A2	HMPT-500-3TE	TASK
M292A5	LDS-427-2	BGNE	M3A2	VTA-903T	TASA
M292A5	LDT-465-1C	BGND	M3A3	VTA-903T	APHA
M292A5	LDT-465-1D	BGNC	M3A3	HMPT-500	APHG
M2A1	HMPT-500	ALEG	M4	6BT5.9	APCA
M2A1	HMPT-500-3	ALEH	M4	VTA-903T	APCB
M2A1	HMPT-500-3E	ALEJ	M4	HMPT-500-3E	APCG
M2A1	HMPT-500-B	ALEK	M44A1	LDT-465-1C	TCFB
M2A1	VTA-903T	ALEA	M487	A413	DXJG
M2A2	HMPT-500	TARG	M487	TMD27	DXJA
M2A2	HMPT-500-3	TARH	M48A5	1790-2A	ABCB
M2A2	HMPT-500-3E	TARJ	M48A5	1790-2DA	ABCD
M2A2	HMPT-500-3TE	TARK	M48A5	HYD SYS	ABCM
M2A2	VTA-903T	TARA	M48A5AVLB	1790-2DA	AREA
M3	HMPT-500	APBG	M48A5AVLB	CD850-6A	AREG
M3	HMPT-500-3	APBH	M48A5AVLB	CD850-6A1	AREH
M3	HMPT-500-3E	APBJ	M48A5AVLB	HYD SYS	AREN
M3	HMPT-500-B	APBK	M49A1C	LD-465-1C	BMXB
M3	VTA-903T	APBA	M49A1C	LDS-427-2	BMXA
M34A2	LD-465-1	TBEA	M49A1C	LDT-465-1C	BMXD
M34A2	LD-465-1C	TBEB	M49A1C	LDT-465-1D	BMXC
M34A2	LDS-427-2	TBEE	M49A2C	LD-465-1	BMEA
M34A2	LDT-465-1C	TBED	M49A2C	LD-465-1C	BMEB
M34A2	LDT-465-1D	TBEC	M49A2C	LDS-427-2	BMEE
M35A2	LD-465-1	BMAA	M49A2C	LDT-465-1C	BMED
M35A2	LD-465-1C	BMAB	M49A2C	LDT-465-1D	BMEC
M35A2	LDS-427-2	BMAE	M4K	CASE-207D	DJVA
M35A2	LDT-465-1C	BMAD	M4K	CLK18340	DJVG
M35A2	LDT-465-1D	BMAC	M4K	HYD SYS	DJVN
M35A2C	LD-465-1	BMRA	M51A2	HYD SYS	BQEN
M35A2C	LD-465-1C	BMRB	M5142	LDS-465-1	BQEA
M35A2	LDS-427-2	BMRE	M548	DD6V53	AEGA
M35A2	LDT-465-1C	BMRD	M548	TX-100-1	AEGG
M35A2	LDT-465-1D	BMRC	M548A1	DD6V53	AEUA
M35A2C	LD-465-1	BMRA	M548A1	TX-100-1	AEUG
M35A3	3116ATAAC	BM6A	M548A3	DD6V53T	AEUB
M35A3	AT1545	BM6G	M548A3	X200-4	AEUH
M35A3C	AT1545	BHQG	M551A1	DD6V53	ALBB
M35A3C	CAT-3116	BHQA	M551A1	DD6V53T	ALBA
M36A2	LD-465-1	BMCA	M551A1	G250-1A	ALBG
M36A2	LD-465-1C	BMCB	M551OPFOR	DD6V453T	ALDA
M36A2	LDS-427-2	BMCE	M551OPFOR	G250-1A	ALDG
M36A2	LDT-465-1C	BMCD	M577A2	DD6V53	AEQA
M36A2	LDT-465-1D	BMCC	M577A2	TX-100-1	AEQG
M36A3	AT1545	BHNG	M577A3	DD6V53T	AEQB
M36A3	CAT-3116	BHNA	M577A3	X200-4	AEQH
M3A1	HMPT-500	ALFG	M58	DD6V53T	AE8B
M3A1	HMPT-500-3	ALFH	M58	X200-4A	AE8H
M3A1	HMPT-500-3E	ALFJ	M6	VTA-903T600	AP6A
M3A1	HMPT-500-B	ALFK	M6	HMPT-500-3EC	AP6G
M3A1	VTA-903T	ALFA	M60A1	CD850-6A1	ABHG

M60A1AVLB	1790-2DA	ARCA	M901	DD6V53	AEMA
M60A1AVLB	CD850-6A	ARCG	M901A1	DD6V53	AEVA
M60A1AVLB	CD850-6A1	ARCH	M901A1	TX-100-1	AEVG
M60A1AVLB	HYD SYS	ARCN	M911	CLBT750	B5BG
M60A3	1790-2C	ABBA	M911	DD8V92T	B5BA
M60A3	CD850-6A	ABBG	M911	DD8V92TA	B5BB
M60A3	CD850-6A1	ABBH	M911	HYD SYS	B5BN
M60A3	HYD SYS	ABBN	M915	CAT-D7155	B4AG
M7	VTA-903T	AP7A	M915	NTC-400	B4AA
M7	HMPT-500-3EC	AP7G	M915A1	HT754CRD	B4BG
M764	LD-465-1	BMVA	M915A1	NTC-400	B4BA
M792	DD353	BFAA	M915A2	DD12.7L	B4EA
M809	NHC-250	TBNA	M915A2	DDHT740	B4EG
M809A1	NHC-250	TBPA	M915A3	DDEC IV	B4LA
M810	NHC-250	TBQA	M915A3	HD4560P	B4LG
M811	NHC-250	BRNA	M915A4	BIG CAM I	B4MA
M811A1	NHC-250	TBRA	M915A4	HD4560P	B4MG
M811A2	NHC-250	TBSA	M916	CAT-D7155	B4CG
M812	NHC-250	TBTA	M916	HYD SYS	B4CN
M812A1	NHC-250	TBUA	M916	NTC400	B4CA
M813	NHC-250	BSBA	M916A1	DD12.7L	B4FA
M813A1	NHC-250	BSDA	M916A1	DDHT740	B4FG
M814	NHC-250	BSKA	M916A1	HYD SYS	B4FN
M815	NHC-250	BSEA	M916A2	DDEC III	B4JA
M816	HYD SYS	BSQN	M916A2	HT740	B4JG
M816	NHC-250	BSQA	M916A2	HYD SYS	B4JN
M817	HYD SYS	BSRN	M917	CAT-D7155	EZZG
M817	NHC-250	BSRA	M917	HYD SYS	EZZN
M818	NHC-250	BSHA	M917	NTC-400	EZZA
M819	HYD SYS	BSLN	M917A1	DDC III	E5CA
M819	NHC-250	BSLA	M917A1	HT740	E5CG
M820	NHC-250	BSMA	M917A1	HYD SYS	E5CN
M820A1	NHC-250	TBVA	M917A1MCS	DDEC III	E5CB
M820A2	NHC-250	BSNA	M917A1MCS	HD456P	E5CH
M821	NHC-250	BSPA	M918	CAT-D7155	EXCG
M876	HYD SYS	BHAN	M918	HYD SYS	EXCN
M876	IHD190	BHAA	M918	NTC-400	EXCA
M876	MT650	BHAG	M919	CAT-D7155	EXDG
M877	CAT-11614457	B3GH	M919	HYD SYS	B4DN
M877	CAT-D333	B3GB	M919	NTC-400	EXDA
M878	DD6V53	BTAA	M920	CAT-D7155	B4DG
M877	PS4R219	B3GG	M920	HYD SYS	B4DN
M878	MT653	BTAG	M920	NTC-400	B4DA
M878A1	DD6V53T	BTLA	M923	MT654	BRYG
M878A1	MT653	BTLG	M923	NHC-250	BRYA
M88A1	1790-2DR	AQAA	M923A1	MT654	BSSG
M88A1	HYD SYS	AQAN	M923A1	NHC-250	BSSA
M88A2	1790-8CR	AQAB	M923A2	6CTA0-8.3	BS7A
M88A2	HYD SYS	AQAM	M923A2	MT654	BS7G
M88A2	XT-1410-5A	AQAH	M924	MT654	BRXG
M9	HYD SYS	ASAN	M924	NHC-250	BRXA
M9	13.5HR3610-2	ASAG	M924A1	MT654	BSUG
M9	V903	ASAA	M924A1	NHC-250	BSUA

M925	HYD SYS	BRTN	M931A1	MT654	BS2G
M925	MT654	BRTG	M931A1	NHC-250	BS2A
M925	NHC-250	BRTA	M931A2	6CTA-8.3	BTPA
M925A1	HYD SYS	BSTN	M931A2	MT654	BTPG
M925A1	MT654	BSTG	M932	HYD SYS	BTDN
M925A1	NHC-250	BSTA	M932	MT654	BTPG
M925A2	6CTA-8.3	BS8A	M932	NHC-250	BTDG
M925A2	MT654	BS8G	M932A1	HYD SYS	BS3N
M926	HYD SYS	BRWN	M932A1	MT654	BS3G
M926	MT654	BRWG	M932A1	NHC-250	BS3A
M926	NHC-250	BRWA	M932A2	6CTA-8.3	BTQA
M926A1	HYD SYS	BSVN	M932A2	HYD SYS	BTQN
M926A1	MT654	BSVG	M932A2	MT654	BTQG
M926A1	NHC-250	BSVA	M934	MT654	BTBG
M927	MT654	BRVG	M934	NHC-250	BTBA
M927	NHC-250	BRVA	M934A1	MT654	BS4G
M927A1	MT654	BSWG	M934A1	NHC-250	BS4A
M927A1	NHC-250	BSWA	M931A2	6CTA-8.3	BTRA
M927A2	6CTA-8.3	BS9A	M931A2	MT654	BTRG
M927A2	MT654	BS9G	M935	MT654	BTCG
M928	HYD SYS	BRUN	M935	NHC-250	BTCA
M928	MT654	BRUG	M935A1	HYD SYS	BS5M
M928	NHC-250	BSUA	M935A1	MT654	BS5G
M928A1	HYD SYS	TCHN	M935A1	NHC-250	BS5A
M928A1	MT654	TCHG	M935A2	6CTA-8.3	BTSA
M928A1	NHC-250	TCHA	M935A2	MT654	BTSG
M928A2	6CTA-8.3	BTMA	M936	HYD SYS	BTFN
M928A2	HYD SYS	BTMN	M936	MT654	BTFG
M928A2	MT654	BTMG	M936	NHC-250	BTFA
M929	HYD SYS	BTHN	M936A1	HYD SYS	BS6N
M929	MT654	BTHG	M936A1	MT654	BS6G
M929	NHC-250	BTHA	M936A1	NHC-250	BS6A
M929A1	HYD SYS	BSYN	M936A2	6CTA-8.3	BTTA
M929A1	MT654	BSYG	M936A2	HYD SYS	BTTN
M929A1	NHC-250	BSYA	M936A2	MT654	BTTG
M926A1	HYD SYS	BSVN	M939	MT654	BRSG
M929A2	6CTA-8.3	BTNA	M939	NHC-250	BRSA
M929A2	HYD SYS	BTGN	M939A2	6CTA8.3	BRSB
M929A2	MT654	BTNG	M939A2	MT654	BRSH
M930	HYD SYS	BTGN	M940	MT654	TBXG
M930	MT654	BTGG	M940	NHC-250	TBXA
M930	NHC-250	BTGA	M941	MT654	TBYG
M930A1	HYD SYS	BSZN	M941	NHC-250	TBYA
M930A1	MT6654	BSZG	M942	MT654	TBZG
M930A1	NHC-250	BSZA	M942	NHC-250	TBZA
M93A1FOX	OM402A	559B	M943	MT654	TCAG
M93A1FOX	HP500 TYPE 6	559H	M943	NHC-250	TCAA
M93A1FOX	HYD SYS	559M	M944	MT654	TCBG
M930A2	6CTA-8.3	BTOA	M944	NHC-250	TCBA
M930A2	HYD SYS	BTON	M945	MT654	TCCG
M930A2	MT654	BTOG	M945	NHC-250	TCCA
M931	MT654	BTEG	M966	6.2 L DIESEL	BBCA
M931	NHC-250	BTEA	M966	THM-3L80	BBCG

M966	6.5 L DIESEL	BBCC	M997A1	6.5 L DIESEL	BBAD
M966A1	6.2 L DIESEL	BBCB	M997A2	6.5 L DIESEL	BCAC
M966A1	THM-3L80	BBCH	M997A2	THM-4L80E	BCAG
M966A1	6.5 L DIESEL	BBCD	M998	6.2 L DIESEL	BBDA
M973	OM617952	BXAA	M998	THM-3L80	BBDG
M973	W4A018	BXAG	M998	6.5 L DIESEL	BBDD
M973A1	OM603.950	BXBA	M998A1	6.2 L DIESEL	BBDB
M973A1	W4A040	BXBG	M998A1	THM-3L80	BBDH
M977	DD8V92TA	B2GA	M998A1	6.5 L DIESEL	BBDE
M977	DDA-HT740D	B2GG	M998A2	6.5 L DIESEL	BCDC
M977	HYD SYS	B2GN	M998A2	THM-4L80E	BCDG
M978	DD8V92TA	B2HA	MCD	4.236	NA6A
M978	DDA-HT740D	B2HG	MCD	542-L1	NA6G
M978	HYD SYS	B2HN	MCD	HYD SYS	NA6M
M981	DD6V53	AETA	MEMP, TN	COE	LVEA
M981	TX-100-1	AETG	MEMP, TN	COE	LVFA
M981A1	DD6V53T	TAQA	MEMP, TN	COE	LVGA
M981A1	TX-100-1	TAQG	MEP-003A	D198ERX51	VCDB
M981A3	DD6V53T	TAQB	MEP-003A	100-1345	VCDD
M981A3	X200-4	TAQH	MEP-003	100-345	VCDC
M983	DD8V92TA	B2AA	MEP-004A	D198ERX51	VCDA
M983	DDA-HT740D	B2AG	MEP-005A	D298ERX37	VCCA
M983	HYD SYS	B2AN	MEP-006A	AC3500	VECA
M984	DD8V92TA	B2BA	MEP-007A	CAT-D333CT	VCGA
M984	DDA-HT740D	B2BG	MEP-007B	CAT-76-4106	VDSA
M984	HYD SYS	B2BN	MEP-009A	CAT-D343TA	VEGA
M984A1	DD8V92TA	TCDA	MEP-009B	CAT-D3434TA	TVCA
M984A1	DDA-HT740D	TCDG	MEP-012A	KTA-2300G	VEPB
M984A1	HYD SYS	TCDN	MEP-029A	VTA-1710G	VFJA
M985	DD8V92TA	B2JA	MEP-029A	VTA-28G1	VFJB
M985	DDA-HT740D	B2JG	MEP-103A	D198ERX51	VCEA
M985	HYD SYS	B2JN	MEP-104A	D298ERX37	VCFA
M985E1	DD8V92TA	TCJA	MEP-105A	AC3500	VEDA
M985E1	DDA-HT740D	TCJG	MEP-106A	CAT-D333CT	VCHA
M985E1	HYD SYS	TCJN	MEP-108A	CAT-D343TA	VEVA
M992A2	DD8V71TLHR	TAWB	MEP-113A	D198ERX51	VLFA
M992A2	HYD SYS	TAWN	MEP-114A	D298ERX37	VLGA
M992A2	XTG-411-4	TAWH	MEP-115A	AC3500	VLHA
M993	HMPT-500	TANG	MEP-116A	CAT-D333CT	TVBA
M993	HMPT-500-3	TANH	MEP-208A	KTA-2300G	VEPA
M993	HMPT-500-3E	TANJ	MEP-360A	GTCP36-50(H)	UAGA
M993	HMPT-500-B	TANK	MEP-360A	HYD SYS	UAGN
M993	VTA-903T	TANA	MEP-362A	TT10-1	VKEA
M996	6.2 L DIESEL	BBBA	MEP-36A	16-567-E4	TUSA
M996	THM-3L80	BBBG	MEP-36A50	16-567-E4	VEIA
M996	6.5 L DIESEL	BBBC	MEP-36A60	CAT-D398A	VEHA
M996A1	6.2 L DIESEL	BBBB	MEP-404B	T62T32A	VIBA
M996A1	THM-3L80	BBBH	MEP-802A	DN2M-1	VG2A
M996A1	6.5 L DIESEL	BBBD	MEP-803A	DN4M	VG3A
M997	6.2 L DIESEL	BBAA	MEP-804A	C-240PW-28	VG4A
M997	THM-3L80	BBAG	MEP-805A	JD4039T	VG5A
M997	6.5 L DIESEL	BBAC	MEP-806A	JD6059T	VG7A
M997A1	6.2 L DIESEL	BBAB	MEP-812A	DN2M-1	VG2B
M997A1	THM-3L80	BBAH	MEP-813A	DN4M	VG3B

MEP-814A	C-240PW-28	VN4B	PU802	C-240PW-28	VLLC
MEP-815A	JD4039T	VN5A	PU803	JD4039T	VLNB
MEP-816A	JD6059T	VN6A	PU804	JD4039T	VLNC
MEP-903A	D722TB-11	VCJA	PU805	JD6059T	VLND
MEP-903B	D722TB-11	VCJB	PU806	JD6059T	VLNE
MEP-903C	D722TB-11	VCJC	R60SL-DC	F4L912W	TDCA
MHE-269	A38714	DJ4A	R60SL-DC	HYD SYS	TDCN
MHE-269	MHR18325	DJ4G	R60SL-DC	PR-2	TDCG
MHE-270	1102T1236210	DJ6G	RAIL C 25T	D13,000	XDGA
MHE-270	4B3.9	DJ6A	RAIL C 40T	DD671	TXCA
MHE-270	HYD SYS	DJ6N	RMS-250	DD6V53N	TVRA
MHE-271	1102T1236210	DJ5G	RS28	DD453	EVPA
MHE-271	4B3.9	DJ5A	RS28	HYD SYS	EVPN
MHE-271	HYD SYS	DJ5N	RT41AA	126HR183278	ELLG
MLT6	ALS 3331-1	DJJG	RT41AA	D3400X289	ELLA
MLT6	DD453N	DJJA	RT41AA	HYD SYS	ELLM
MLT6	HYD SYS	DJJN	RT875CC	6CTA-8.3	DKDA
MLT6-2	DD453N	DJBF	RT875CC	CLARK-C273.5	DKDG
MLT6-2	HYD SYS	DJBN	RT875CC	HYD SYS	DKDN
MLT6-2	R28422-1	DJBG	RTFL	6BT5.9	DJWA
MLT6CH	ALS 3331-1	DJLG	RTFL	FUNK-1723	DJWH
MLT6CH	DD453N	DJLA	RTFL	HYD SYS	DJWN
MLT6CH	HYD SYS	DJLN	RTL10	CRT 3531-1	DJHG
MT250	DD6V53N	ELAA	RTL10	DD6V53	DJHA
MT250	HYD SYS	ELAN	RTL10	HYD SYS	DJHN
MW24C	CASE-504BD	EFQA	RTL10-1	CRT 3531-1	DJDG
MW24C	CASE-A504BDT	EFQB	RTL10-1	DD6V53	DJDF
MW24C	HYD SYS	EFQN	RTL10-1	HYD SYS	DJDN
MW24C	TT2421-1	EFQG	SM50068003	D398A 3AC	VEJA
OH-58D	HYD SYS	HKAD	SM50068004	CAT-D398A	VEKA
P250WDMH268	DEUTZ	DWTA	SM54A	DEUTZ-F2L51	TETA
PACAR9999	NHC-250	XMAA	SP848	DD353	EUUA
PPU85-4	GTCP85-127	VAAB	SP848	HYD SYS	EUUN
PPU85-5	GTCP85-127	VAFA	ST	320	WAKB
PU405A/M	D198ERX51	VCNA	ST-TUG-200	6DCMR 1879	WAKA
PU406B/M	D298ERX37	VCMA	ST-TUG-600	3004	WALA
PU495A/G	CAT-D333CT	VCLA	SU252G	CSG64916001H	NA8A
PU495B/G	CAT-76-4106	VDTA	SU252G	C-6	NA8G
PU650B/G	AC3500	VEMA	T449	180DAC	TWWB
PU699A/M	AC3500	VFBA	T449	CAT-D375	TWWA
PU700A/M	AC3500	VFCA	TC6DO42	350LIDV85.7L	NB4A
PU707A/M	AC3500	VLMA	TC6DO42	AT545	NB4G
PU732M	100-1345	VLLA	TC6DO42	3043LE	NA3G
PU753M	100-1345	VLNF	TC6DO42	HYD SYS	NB4M
PU760M	D298ERX37	VLNA	TMS-300-5	DD671	ELHA
PU797	DN2M	VLPA	TMS-300-5	HYD SYS	ELHN
PU797A	DN2M	VLPB	TO730HKEG	6BT5.9	E45A
PU798	DN4M-1	VLPC	TO730HKEG	HYD SYS	E45N
PU798A	DN4M-1	VLPD	TUG-900	6B5.9-G1	WA2A
PU799	DN4M-1	VLPE	TUG-900	KTA19-M3	WA2B
PU799A	DN4M-1	VLPF	UNKNOWN	HYDRAULIC	XXHN
PU800	C-240PW-28	VLLD	UNKNOWN	MINERAL	XXMX
PU801	C-240PW-28	VLLB	UNKNOWN	SYNTHETIC	XXSX
PU801A	C-240PW-28	VLLE	US612ACD1	DEUTZ-91213	ZD8A

US90CCD1	DD353	ZHCA
W150Y	28265	DJ7A
W150Y	AUTO79410	DJ7G
W150Y	HYD SYS	DJ7M
W15A	ENDT-673	TEVA
WC17	TMD	NB6A
WC17	W410TT	NB6G
WF1700/1000	DD8V92T	ZM3A
WF1700/1000	TD61-1168	ZM3G
WPS6006	JD4039T	VG6A
XJJL72	RCR4.078GAEA	NA3A
XJJL72	3043LE	NA3G
XJJL72	TCR4.01BGFEK	NB3B
XM104	AGT-1500	ARDA
XM104	X1100-3B	ARDG
XM104	HYD SYS	ARDM

NONAERONAUTICAL TYPE EQUIPMENT CODES

ARMY CORPS OF ENGINEERS

EIMOD	COMPMOD	TEC	EIMOD	COMPMOD	TEC
10235100	DD2A102916	852A	CAT-D5	CAT-3306	8B3A
10245102	DD2A0105034	854A	CAT-D5	3S7094	8B3G
10245102	DD2A0105612	853A	CAT-D5	HYD SYS	8B3N
10245102	DD2A0106018	656A	CAT-D7E	CAT-3R2211	8B2G
10245102	DD2A0106038	855A	CAT-D7E	HYD SYS	8B2N
10245102	DD2A0106177	857A	CHALMETTE	8.0MDKD3CR	897B
175DG1803	NT-855	858A	CHALMETTE	DD8V71	897A
22BM	JN61	831A	CHALMETTE	M20L	897G
250D33	CAT-D353	85DA	D6	CAT-D333	8B4A
4031C	DD4A171904	819A	D7H	CAT-3306B	8B6A
500FD63D47A	MT865PG270	85AA	DAVID BOYD	DD8V92	89EA
599C	DD471	81BA	DULUTH	AI45M5X8	8D8A
67110431	LCN8	822A	DULUTH	GM271G3	8D8B
71637305	DD16VA019218	85CA	F800	C8.3	8C5A
71637305	DD16VA019219	85BA	FAIRCHILD	DD671	8D6A
76SX9E	CAT-3304PC	85GA	FORNEY	DD371	8DAA
80623400	DD6VF079684	8F1A	FREDERICK	DD271	8DBA
80827400	DD6VF079688	8F2A	G-1	DD353	851A
80827402	DD80827402	EF3A	GRANADA	271	896B
ALEXANDER	271	893B	GRANADA	DD12V71T	896A
ALEXANDER	DD12V71	893A	GRANADA	MG514	896G
ALEXANDER	MG512	893G	H60XL-MIL	360311	841G
B-40FT	DD453	811A	H60XL-MIL	HYD SYS	841N
B-40FT	HYD SYS	811N	H60XL-MIL	ISUZU-C240	841A
BAYFIELD	DD671	8D7A	HAMMOND BAY	DD671	8D4A
BIENBILLE	371	8A2B	HARVEY	DD371	814A
BIENBILLE	DD12V71	8A2A	HODGE	DD8V92	89CA
BIENBILLE	MG514	8A2G	HURON	DD453	817A
BRAY	DD692	81CA	JD550	HYD SYS	8B5N
BRETON	15MOL3J1A	899B	JD550	JD4276TT01	8B5A
BRETON	DD8V71	899A	JD550	JDAT49678	8B5G
BRETON	MH20L	899G	JOHN BOPP	8.0614D	895B
BURRWOOD	271	898B	JOHN BOPP	DD8V92	895A
BURRWOOD	DD12V71T	898A	JOHN BOPP	MH20L	895G
BURRWOOD	MG514	898G	KENT	16V1499	8A3A
C-1303-24	AI45MSX8	8D3A	KENT	DD671	8A1A
CAT-130G	5R6192	861G	KENT	DD671	8A3B
CAT-130G	5R6192	862G	KENT	MG540	8A3G
CAT-130G	CAT-3304	85HA	L9000	CAT-3406C	8C4A
CAT-130G	CAT-3304DI	862A	LABORDE	11.0KWD	89BA
CAT-130G	CAT-3304DIT	861A	LABORDE	DD8V71	894A
CAT-130G	HYD SYS	861N	LABORDE	MH20L	894G
CAT-130G	HYD SYS	862N	LB-1	DD453	8E2A
CAT-D4	CAT-3306	8B1A	LB-1	HYD SYS	8E2N
CAT-D4	CAT-7R559	8B7G	LT-18	GM3906	8D1A
CAT-D4	HYD SYS	8B1N	LUDINGTON	GM371R641	8DCA

EIMOD	COMPMOD	TEC
M109A5	DD8V71T	3E7A
M109A5	HYD SYS	3E7N
M109A5	XTG-411-2A	3E7G
M109A6	DD8V71T	3FCA
M109A6	HYD SYS	3FCN
M109A6	XTG-411-4	3FCG
M4K	CASE-207D	8C1A
M4K	CLK18340	8C1G
M4K	HYD SYS	8C1N
M50A1	DD671	8C2A
M578	DD8V71T	3LAA
M578	HYD SYS	3LAN
M578	XTG-411-2A	3LAG
MANITOWAC	DD353	812A
MT250	HYD SYS	831N
MW24C	CASE-504BD	871A
MW24C	HYD SYS	871N
MW24C	TT24211	871G
N CENTRAL	DD8V71	89FA
NI9752	DD671	83CA
NICOLET	DD471	818A
P38	DD853	891A
PAJ	DD8V92	89DA
PB-1	GMC871	881A
PU406A/M	D298ERX37	85FA
RACINE	DD353	8D2A
RG4031C	DD4A171903	81AA
RT855B	CAT-3116	832A
RT855B	HYD SYS	832M
RT855B	R32620-4	832G
RTCH-MC	3P9094	MDAW
RTCH-MC	CAT-3408T	MDAC
RTCH-MC	CAT-5R3855	MDAJ
RTCH-MC	HYD SYS	MDAN
S2200	NTC-240	8C3B
S2200	NTC-300	8C3C
S2200	NTC-855	8C3A
SCOW #31	DD6068	815A
SCOW #32	DD671	816A
SHOALHUNTER	CAT-3406B	824A
SPD-1	DD371	8E4B
SPD-1	DD6V71	8E4B
SR-4	CAT-3304	85EA
TAWAS BAY	DDD671	8D9A
TBCL4	DD16V149	8A4A
TBCL4	DD671	8A4B
TBCL4	MG540	8A4G
TD-15C	IHDT-466B	8B8A
UPS-8	DD671	81DA
USCCBMK1	363CI	821A
VELER	DD371	813A
W-38	DDC671	892A
W-38	MG509	892G
W-46	8.0MKDB/1	89AB
W-46	M20L	89AG
W-48	DD8V71	89AA
WHITEFISH	DD12V71	8D5A
XM93FOX	HP500 TYPE 6	559G
XM93FOX	HYD SYS	559N
XM93FOX	OM402A	559A
YF-865	DD371	8E6A
YF-865	DD6V149	8E6B
YSD-22	DD12V71	8E3A
YSD-22	DD471	8E3B
YSD-59	DD12V71	8E5A
YSD-59	DD471	8E5B
YSD-67	DD671	823B
YSD-67	NTA855M	823A
YSD-78	DD353	8E7A
YSD-78	DD371	8E7B
YSD-78	DD671	8E7C
YSD-78	DD6V53	8E7D

NONAERONAUTICAL TYPE EQUPMENT CODES

US AIR FORCE

EIMOD	COMPMOD	TEC	EIMOD	COMPMOD	TEC
100KW-AF	NTC-380-1	LVAA	PWR GEN-AF	DSK38	VJAA
1750KW-AF	DSR38	LVBA	PWR GEN-AF	S-12NPTA	VJBA
87H-AF	AIR-COMP	LVCA	SF256128-AF	AIR COMP	LVHA
FS136SC-AF	NORDBERG	LVDA			

NONAERONAUTICAL TYPE EQUIPEMENT CODES

FLIGHT SIMULATORS

END ITEM	COMPONENT	TEC	END ITEM	COMPONENT	TEC
UH-60FS	Hydraulic Pump	HLAA	UH-1FS	Hydraulic Pump	HAA1
CH-47FS	Hydraulic Pump	HEAD			
PON-6	OILCART	DRAA			

NONAERONAUTICAL
TYPE EQUIPMENT CODES
US NAVY SHIPS EQUIPMENT

End Item	Component	TEC
	ANCHORS	
ALL	ANCHOR HYDRAULIC	1A01
ALL	ANCHOR 80-90	1A02
	CRANES	
ALL	CRANE 80-90	2A01
ALL	CRANE HYDRAULIC	2A02
ALL	CRANE 9250	2A03
	Hydraulic Equipment	
ALL	HYDRAULIC POWER UNIT	3A01
	AIR CONDITIONING AND REFRIGERATION	
ALL	AIR CONDITIONING/REFRIGERATION SW 68	4001
ALL	AIR CONDITIONING/REFRIGERATION RC02	4002
ALL	AIR CONDITIONING/REFRIGERATION RC04	4003
ALL	AIR CONDITIONING/REFRIGERATION POE 48	4004
	MISCELLANEOUS EQUIPMENT	
ALL	MISCELLANEOUS EQUIPMENT 2190	5A01
ALL	MISCELLANEOUS EQUIPMENT 9250	5A02
ALL	MISCELLANEOUS EQUIPMENT 23699	5A03
ALL	MISCELLANEOUS EQUIPMENT HYDRAULIC	5A04
ALL	MISCELLANEOUS EQUIPMENT 80-90	5A05
	BLOWERS	
ALL	BLOWER 2190	6A0Y
	TURBO CHARGERS	
ALL	TURBO CHARGERS 9250	7001
	MISC GENERATORS	
ALL	MISC GENERATORS 9250	8001
ALL	MISC GENERATORS 2190	8002
	AIR COMPRESSORS	
ALL	AIR COMPRESSORS 2190	AA01
ALL	AIR COMPRESSORS 9250	AA02
ALL	AIR COMPRESSORS 23699	AA03
ALL	AIR COMPRESSORS HYDRAULIC	AA04

End Item	Component	TEC
	BEARINGS	
ALL	BEARINGS 2190	B001
	CONTROLLABLE PITCH PROPELLERS	
AOE 6 Class	ROLLS ROYCE NAVY MARINES 245-6361975	C41M
ARS 50 Class	ROLLS ROYCE NAVY MARINES 7309	C50M
CG 47 Class	ROLLS ROYCE NAVY MARINES 115652102	C80M
CG 66 Class	ROLLS ROYCE NAVY MARINES 115652103	C8AM
DD 963 Class	ROLLS ROYCE NAVY MARINES 7309	CF0M
DDG 51 Class	ROLLS ROYCE NAVY MARINES 7309	CF1M
DDG 993 Class	ROLLS ROYCE NAVY MARINES 115657001	CF2M
FFG 7 Class	ROLLS ROYCE NAVY MARINES 7309	CG0M
LCAC Class	DOWDY CO. LTD.	CH0N
LHD 1 Class	ROLLS ROYCE NAVY MARINES 80-3S-CP	CI1M
LSD 41 Class	ROLLS ROYCE NAVY MARINES 112152001	CN0M
LSD 49 Class	ROLLS ROYCE NAVY MARINES 112157071	CP0M
LST 1179 Class	ROLLS ROYCE NAVY MARINES DWG110251003PORT	CQ0M
MCM 1 Class	ROLLS ROYCE NAVY MARINES 7309	CR0M
MISC Class	MISC CPP	CH5M
WAGB 10 Class	ROLLS ROYCE NAVY MARINES	CU0M
WHEC 715 Class	ROLLS ROYCE NAVY MARINES	CV0M
WLB 200 Class	ROLLS ROYCE NAVY MARINES	CW0M
WMEC 620 Class	ROLLS ROYCE NAVY MARINES DWG620WPC4301-51	CX0M
	GUIDED MISSLE SYSTEMS	
ALL	GUIDED MISSILE HYDRAULIC	D001
	EMERGENCY DIESEL GENERATORS	
AE 26 Class	DETROIT DIESEL CORP. 7124-320212V71LC	E101
AE 26 Class	DETROIT DIESEL CORP. 7124-320212V71RC	E1A1
AGF 11 Class	COLTEC INDUSTRIES INC. 38F5 1/4	E213
AGF 3 Class	CATERPILLER INC. D334TA	E202
AGSS Class	EDG 555	E221
AO 177 Class	COLTEC INDUSTRIES INC. 6-38D8 1/8	E303
AO 177 Class	COLTEC INDUSTRIES INC. 6-38ND8 1/8	E3A3
AOE 1 Class	COLTEC INDUSTRIES INC. 38ND8 D3051/8	E403
AOE 1 Class	GENERAL MOTORS CORP. 16-567C	E408
AOE 1 Class	COLTEC INDUSTRIES INC. 38ND8-1/8	E4A3
AOE 6 Class	CATERPILLER INC. 3608	E412
ARDM 5 Class	ARDM 5 EDG	E510
AS 33 Class	COLTEC INDUSTRIES INC. 8-38D8 1/8	E603
AS 33 Class	GENERAL MOTORS CORP. 12-645E2	E608
AS 39 Class	COLTEC INDUSTRIES INC.38 D8 1/8AR3	E703
AS 39 Class	COLTEC INDUSTRIES INC. 38ND8 1/8	E7A3
CGN 36 Class	COLTEC INDUSTRIES INC. 38D8 1/8	E003
CGN 38 Class	COLTEC INDUSTRIES INC. 38D8 1/8	E9A3
CV 59 Class	COLTEC INDUSTRIES INC. 38ND8 1/8	EA03
CV 63 Class	COLTEC INDUSTRIES INC. 12-38D8 1/8	EB03
CV 63 Class	GENERAL MOTORS CORP. 16-567C	EB08

End Item	Component	TEC
CV 63 Class	COOPER CAMERON CORP. FVAM8T	EB0L
CV 63 Class	COLTEC INDUSTRIES INC. 38ND8 1/8	EBA3
CVN 65 Class	GENERAL MOTORS CORP. 16-567C	ED08
CVN 68 Class	GENERAL MOTORS CORP. LL16-645E5	EE08
CVN 68 Class	GENERAL MOTORS CORP. LL16-645E5N	EEA8
LCC 19 Class	COLTEC INDUSTRIES INC. 6-38D8 1/8	EH13
LHA 1 Class	COLTEC INDUSRIES INC. 251C	EI03
LHD 1 Class	COLTEC INDUSTRIES INC. 251C	EI13
LPD 1 Class	COLTEC INDUSTRIES INC. 38F5 1/4	EJ03
LPD 14 Class	DETROIT DIESEL CORP. 7123-730012V71RC	EL01
LPD 7 Class	COLTEC INDUSTRIES INC. 38F5 1/4	EK03
LSD 36 Class	DETROIT DIESEL CORP. 7123-730012V71RC	EM01
MCM Class	MCM EDG	ER00
MCS 12 Class	COLTEC INDUSTRIES INC. 12-38D8 1/8	ER13
ALL	MISC EDG	EH50
SSBN 726 Class	COLTEC INDUSTRIES INC. 38ND8 1/8	ET03
SSN 21 Class	COLTEC INDUSTRIES INC. 38ND8 1/8	ET13
SSN 637 Class	COLTEC INDUSTRIES INC. 38F5 1/4	ET23
SSN 640 Class	COLTEC INDUSTRIES INC. 38F5 1/4	ET33
SSN 671 Class	COLTEC INDUSTRIES INC. 38F5 1/4	ET43
SSN 688 Class	COLTEC INDUSTRIES INC. 38ND8 1/8	ET53
WAGB 10 Class	DETROIT DIESEL CORP. 16V149	EU01
WLB 200 Class	CATERPILLER INC. 3406TA	EW02
WLB 277 Class	DETROIT DIESEL CORP. 8V-71	EW11
WLB 277 Class	CATERPILLER INC. 3306DI	EW12
WLIC 298 Class	DETROIT DIESEL CORP. #6-71	EW51
WLIC 75301 Class	DETROIT DIESEL CORP. #4-71	EW61
WLIC 75301 Class	DETROIT DIESEL CORP. #6-71	EWB1
WLM 540 Class	CATERPILLER INC. 406T	EW82
WLR 311 Class	DETROIT DIESEL CORP. #3-53	EW91
WLR 75401 Class	DETROIT DIESEL CORP. #4-71	EWY1
WMEC Class	CATERPILLER INC. 3306	EX02
WMEC Class	CATERPILLER INC. D348TA	EXA2
	FIN STABLIZIERS	
ALL	FIN STABILIZER HYDRAULIC	F001
	GAS TURBINE ENGINES	
AOE 6 Class	GENERAL ELECTRIC CO LM2500	G41O
CG 47 Class	STEWART & STEVENSON SERVICES INC 139A200	G80J
CG 47 Class	GENERAL ELECTRIC CO LM2500	G80O
DD 963 Class	ROLLS ROYCE NAVY MARINES 501-K17	GF0M
DD 963 Class	GENERAL ELECTRIC CO LM2500	GF0O
DDG 51 Class	ROLLS ROYCE NAVY MARINES 501-K34	GF1M
DDG 51 Class	ALLIED SIGNAL GTCP 100-82	GF1P
DDG 993 Class	GENERAL ELECTRIC CO LM2500	GF2O
FFG 7 Class	GENERAL ELECTRIC CO LM2500	GG0O
LCAC Class	AVCO-LYCOMING TF40B	GH0Q
LCAC Class	SUNDSTRAND T-62T-40-7	GH0R
MCM 1 Class	SOLAR T-1000S-28AA	GR0B

End Item	Component	TEC
MCM 1 Class	SOLAR T-1302S-28AA	GRAB
WHEC Class	WHEC GTE	GV0M
	GAS TURBINE GENERATORS	
AOE 6 Class	ALLISON 501 2190	H41Y
AOE 6 Class	ALLISON 501 23699	H41Z
CG 47 Class	ALLISON 501 2190	H80Y
CG 47 Class	ALLISON 501 23699	H80Z
DD 963 Class	ALLISON 501 2190	HF0Y
DD 963 Class	ALLISON 501 23699	HF0Z
DDG 51 Class	ALLISON 501 2190	HF1Y
DDG 51 Class	ALLISON 501 23699	HF1Z
DDG 993 Class	ALLISON 501 2190	HF2Y
DDG 993 Class	ALLISON 501 23699	HF2Z
FFG 7 Class	ALLISON 501 2190	HG0Y
FFG 7 Class	ALLISON 501 23699	HG0Z
LCAC Class	ALLISON 501 2190	HH0Y
LCAC Class	ALLISON 501 23699	HH0Z
MCM 1 Class	ALLISON 501 2190	HR0Y
MCM 1 Class	ALLISON 501 23699	HR0Z
WHEC	WHEC GTG	HV00
	FANS	
ALL	SCAVENGER FAN HYDRAULIC	I001
	GEARS	
ALL	GEARS 2190	J001
ALL	GEARS 80-90	J002
ALL	GEARS 23699	J003
ALL	GEARS HYDRAULIC	J004
ALL	GEARS 9250	J005
	ROCKER ARMS	
LSD 36 CLASS	COLTEC IND. INC. DIESEL ENG ROCKER ARMS	KM03
LSD 41 CLASS	COLTEC IND. INC. DIESEL ENG ROCKER ARMS	KN03
LSD 49 CLASS	COLTEC IND. INC. DIESEL ENG ROCKER ARMS	KP03
	ELEVATORS NON HYDRAULIC	
CG 47 CLASS	CG 47 ELEVATOR-NON HYDRAULIC	L800
CV 63 CLASS	WESTINGHOUSE	LB07
CV 63 CLASS	JARED INDUSTRIES INC	LB0A
CV 63 CLASS	OTIS ELEVATOR CO	LB0D
CVN 65	WESTINGHOUSE	LD07
CVN 68 CLASS	JARED INDUSTRIES INC	LE0A
CVN 68 CLASS	RUCKER	LE0E
DD 963 CLASS	DD 963 ELEVATOR NON HYDRAULIC	LF00
FFG 7 CLASS	FFG7 ELEVATOR NON HYDRAULIC	LG00

End Item	Component	TEC
LHA 1 CLASS	JARED INDUSTRIES INC	LI0A
LHA 1 CLASS	LHA1 ELEVATOR NON HYDRUALIC	LI00
LHD 1 CLASS	SCHINDLER ELEVATOR CORP	LI0S
LPD 7 CLASS	LPD 7 ELEVATOR-NON HYDRAULIC	LK00
MCS 12 CLASS	JARED INDUSTRIES INC	LR1A
	ELEVATORS HYDRAULIC	
CG 47 CLASS	CG 47 ELEVATOR HYDARULIC	L8A0
CV 63 CLASS	WESTINGHOUSE	LBA7
CV 63 CLASS	OTIS ELEVATOR CO	LBAA
CV 63 CLASS	JARED INDUSTRIED INC	LBAD
CVN 65	WESTINGHOUSE	LDA7
CVN 68 CLASS	RUCKER	LEAA
CVN 68 CLASS	JARED INDUSTRIED INC	LEAE
DD 963	DD 963 ELEVATOR HYDRAULI	LFA0
FFG 7	FFG 7 ELEVATOR HYDRAULIC	LGA0
LHA 1 CLASS	JARED INDUSTRIED INC	LIAA
LHD 1 CLASS	SCHINDLER ELEVATOR CORP	LIBS
LPD 7	LPD 7 ELEVATOR HYDRAULIC	LKA0
MSC 12	JARED INDUSTRIED INC	LRAS
	MAIN DIESEL ENGINES	
AE 26 CLASS	CATERPILLER INC. D398	M102
AGSS 555 CLASS	DETROIT DIESEL CORP. 7124-3202-12V71	M221
AOE 1 CLASS	AOE 1 MDE	M400
ARS 50 CLASS	CATERPILLER INC. D399B-TA	M502
CG 47 CLASS	CG 47 MDE	M800
DD 963 CLASS	DD 963 MDE	MF00
LCU CLASS	LCU MDE	MH20
LHA 1 CLASS	LHA 1 MDE	MI00
LHD 1 CLASS	LHD 1 MDE	MI10
LPD 1 CLASS	LPD 1 MDE	MJ00
LPD 7 CLASS	LPD 7 MDE	MK00
LSD 36 CLASS	DETROIT DIESEL CORP. 7123-7305-12V71T	MM01
LSD 41 CLASS	COLTEC INDUSTRIES INC. PC2.5V-LL1	MN03
LSD 41 CLASS	COLTEC INDUSTRIES INC. PC2.5V-LR1	MNA3
LSD 41 CLASS	COLTEC INDUSTRIES INC. PC2.5V-RL1	MNB3
LSD 41 CLASS	COLTEC INDUSTRIES INC. PC2.5V-RR1	MNC3
LST 1179 CLASS	ALCO PRODUCTS INC. 16-251C	MQ00
LST 1179 CLASS	ALCO PRODUCTS INC. 8-251E	MQA0
MCM 1 CLASS	ISOTTA FRASCHINI SPA. 36SS6V-AM	MR0F
MCM 1 CLASS	WAUKESHA L1616DSIN	MR0G
MHC 51 CLASS	ISOTTA FRASCHINI SPA. ID36SS8V-AM	MS0F
TWR CLASS	CATERPILLAR INC. 3512	MT62
MISC	MISC MDE	MH50
PC	PC MDE	MH30
WAGB 10 CLASS	ALCO PRODUCTS INC. 16-251-F	MU00
WAGB 10 CLASS	DETROIT DIESEL CORP. 6V53	MU01
WAGB 10 CLASS	CUMMINS ENGINE CO. INC. 4BT3.9M	MU04
WAGB 10 CLASS	FAIRBANKS MORRIS 12-38D8-1/8	MU09
WAGB 10 CLASS	SULZER 12ZA40S	MU0H
WHEC 715 CLASS	CUMMINS ENGINE CO. INC. 4BT3.9M	MV04

End Item	Component	TEC
WHEC 715 CLASS	VOLVO PENTA OF AMERICA INC. B31B	MV06
WHEC 715 CLASS	FAIRBANKS MORRIS 12-38TD8-1/8	MV09
WHEC 716 CLASS	DETROIT DIESEL CORP. #3-53	MV01
WLB 200 CLASS	CATERPILLER INC. 3608	MW02
WLB 200 CLASS	CUMMINS ENGINE CO. INC. 6BT5.9M	MW04
WLB 277 CLASS	DETROIT DIESEL CORP. #3-53	MW11
WLB 277 CLASS	VOLVO PENTA OF AMERICA INC. B31B	MW16
WLB 277 CLASS	GENERAL MOTORS CORP. R8645E6	MW18
WLI 313 CLASS	CATERPILLER INC. D-353	MW32
WLI 65303 CLASS	DETROIT DIESEL CORP. 8V-71N	MW41
WLIC 298 CLASS	CATERPILLER INC. D-353D	MW52
WLIC 75301 CLASS	CATERPILLER INC. D-353E	MW62
WLIC 800 CLASS	CATERPILLER INC. D-379	MW72
WLM 540 CLASS	CATERPILLER INC. D-353	MW82
WLM 540 CLASS	CATERPILLER INC. D398LH	MWB2
WLM 540 CLASS	CATERPILLER INC. D398RH	MWC2
WLM 685 CLASS	CATERPILLER INC. 3508	MWA2
WLR 311 CLASS	CATERPILLER INC. D-379	MW92
WLR 65501 CLASS	CATERPILLER INC. D-353	MWX2
WLR 75401 CLASS	CATERPILLER INC. D-353	MWY2
WMEC CLASS	ALCO PRODUCTS INC. 16MS-251CE	MX00
WMEC CLASS	CUMMINS ENGINE CO. INC. 4BT3.9M	MX04
WMEC CLASS	VOLVO PENTA OF AMERICA INC. B31B	MX06
WMEC CLASS	GENERAL MOTORS CORP. 645	MX08
WMEC CLASS	FAIRBANKS MORRIS 38D8-1/8	MX09
WMEC CLASS	ALCO PRODUCTS INC. 251F18MS	MXA0
WPB 1301 CLASS	CATERPILLER INC. 3516	MY02
WPB 1301 CLASS	PAXMAN 16RP200M	MY0I
WPB 82333 CLASS	CATERPILLER INC. 3412	MY12
WTGB 101 CLASS	FAIRBANKS MORRIS 8-38D8-1/8	MZ09
WYTL 65601 CLASS	CATERPILLER INC. 3412	MZ12
YTB	YTB MDE	MH40
	NITROGEN GENERATION PLANT	
ALL	NITRO PLANT 2190	N001
	SMALL BOYS DIESEL ENGINES	
AE 26 CLASS	DETROIT DIESEL CORP. 5042-40004-53LD	O101
AE 26 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	O104
AE 26 CLASS	WESTERBEKE CORP. 108O-14088	O105
AE 26 CLASS	DETROIT DIESEL CORP. 5062-70006V53N	O1A1
AE 26 CLASS	WESTERBEKE CORP.4 –107	O1A5
AE 26 CLASS	DETROIT DIESEL CORP. 6087M-ALUM	O1B1
AE 26 CLASS	DETROIT DIESEL CORP. 6-71RD706087M	O1C1
AGF 11 CLASS	DETROIT DIESEL CORP. 6121T6-71LC	O211
AGF 11 CLASS	WESTERBEKE CORP. 108U-14088	O215
AGF 3 CLASS	DETROIT DIESEL CORP. 1062-7000	O201
AGF 3 CLASS	WESTERBEKE CORP. 108O-14088	O205
AGF 3 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	O2A1
AGF 3 CLASS	DETROIT DIESEL CORP. 7082-7399	O2B1
AO 177 CLASS	DETROIT DIESEL CORP. 1062-7000	O301

End Item	Component	TEC
AO 177 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	O304
AO 177 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	O306
AO 177 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	O3A1
AOE 1 CLASS	DETROIT DIESEL CORP. 1062-7000	O401
AOE 1 CLASS	CUMMINS ENGINE CO. INC. 6BTA5 9-M	O404
AOE 1 CLASS	WESTERBEKE CORP. 108U-14088	O405
AOE 1 CLASS	DETROIT DIESEL CORP. 5062-70006V53N	O4A1
AOE 1 CLASS	CUMMINS ENGINE CO. INC. 6BTA5 9-M2	O4A4
AOE 1 CLASS	WESTERBEKE CORP. 14088 SPEC B	O4A5
AOE 1 CLASS	DETROIT DIESEL CORP. 64HN9HTEXCH	O4B1
AOE 1 CLASS	DETROIT DIESEL CORP. 64HN9KCLG	O4C1
AOE 6 CLASS	DETROIT DIESEL CORP. 1062-7000	O411
AOE 6 CLASS	CUMMINS ENGINE CO. INC. 4B3.9-M	O414
AOE 6 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	O416
AOE 6 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	O4B4
AOE 6 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M2	O4C4
AOE 6 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	O4D1
ARS 50 CLASS	DETROIT DIESEL CORP. 5042-40004-53LD	O501
ARS 50 CLASS	DETROIT DIESEL CORP. 5042-40004-53RB	O5A1
AS 33 CLASS	DETROIT DIESEL CORP. 1062-5000	O601
AS 33 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M2	O604
AS 33 CLASS	WESTERBEKE CORP. 4-107	O605
AS 33 CLASS	ONAN CORP. 1.5OMDJF4R4686D	O60C
AS 33 CLASS	DETROIT DIESEL CORP. 1062-5099	O6A1
AS 33 CLASS	ONAN CORP. DJC-MS/2450V	O6AC
AS 33 CLASS	DETROIT DIESEL CORP. 1062-7000	O6B1
AS 33 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	O6C1
AS 33 CLASS	DETROIT DIESEL CORP. 64HN9HTEXCH	O6D1
AS 39 CLASS	DETROIT DIESEL CORP. 1043-7005	O701
AS 39 CLASS	COLTEC INDUSTRIES INC. 38D8 1/8AR3	O703
AS 39 CLASS	WESTERBEKE CORP. 14088 SPEC B	O705
AS 39 CLASS	DETROIT DIESEL CORP. 1043-7005-4-71N	O7A1
AS 39 CLASS	WESTERBEKE CORP. 4-107	O7A5
AS 39 CLASS	DETROIT DIESEL CORP. 1062-5099	O7B1
AS 39 CLASS	DETROIT DIESEL CORP. 1062-6001	O7C1
AS 39 CLASS	DETROIT DIESEL CORP. 5062-7000	O7D1
AS 39 CLASS	DETROIT DIESEL CORP. 5062-70006V53N	O7E1
AS 39 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	O7F1
AS 39 CLASS	DETROIT DIESEL CORP. 6088M	O7G1
CG 47 CLASS	DETROIT DIESEL CORP. 5062-3000	O801
CG 47 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	O804
CG 47 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	O806
CG 47 CLASS	DETROIT DIESEL CORP. 5062-70006V53N	O8A1
CGN 36 CLASS	DETROIT DIESEL CORP. 1062-7000	O901
CGN 36 CLASS	CUMMINS ENGINE CO. INC. 8BTA5.9-M	O904
CGN 36 CLASS	WESTERBEKE CORP. 108D-14088	O905
CGN 36 CLASS	DETROIT DIESEL CORP. 5062-70006V53N	O9A1
CGN 36 CLASS	WESTERBEKE CORP. 14088 SPEC B	O9A5
CGN 38 CLASS	DETROIT DIESEL CORP. 5042-3000	O001
CGN 38 CLASS	WESTERBEKE CORP. 4-107	O005
CGN 38 CLASS	DETROIT DIESEL CORP. 5042-40004-53LD	O0A1
CV 59 CLASS	DETROIT DIESEL CORP. 6087M-STBD	OA01
CV 59 CLASS	WESTERBEKE CORP. 108U-14088	OA05

End Item	Component	TEC
CV 59 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	OA06
CV 59 CLASS	DETROIT DIESEL CORP 6088M PORT	OAA1
CV 59 CLASS	WESTERBEKE CORP. 4-107	OAA5
CV 59 CLASS	DETROIT DIESEL CORP. 64HNTEXCH	OAB1
CV 59 CLASS	DETROIT DIESEL CORP. 6-71RA6071MB	OAC1
CV 63 CLASS	DETROIT DIESEL CORP. 1062-7000	OB01
CV 63 CLASS	WESTERBEKE CORP. 4-107	OB05
CV 63 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	OB06
CV 63 CLASS	DETROIT DIESEL CORP. 5033-60023-53	OBA1
CV 63 CLASS	DETROIT DIESEL CORP. 6072M6-71LC	OBB1
CV 63 CLASS	DETROIT DIESEL CORP. 6072M6-71RA	OBC1
CV 63 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	OBD1
CV 63 CLASS	DETROIT DIESEL CORP. 6088M-ALUM-6-71	OBE1
CV 63 CLASS	DETROIT DIESEL CORP. 6088MCI	OBF1
CV 63 CLASS	DETROIT DIESEL CORP. 6088MPORT	OBG1
CV 63 CLASS	DETROIT DIESEL CORP. 64HN9HTEXCH	OBH1
CV 63 CLASS	DETROIT DIESEL CORP. 6-71RD706087M	OBI1
CVN 65	DETROIT DIESEL CORP. 6072M6-71RC	OD01
CVN 65	WESTERBEKE CORP. 4-107	OD05
CVN 65	DETROIT DIESEL CORP. 64HN106-71RC19H	ODA1
CVN 65	DETROIT DIESEL CORP. 64HN9KCLG	ODB1
CVN 68 CLASS	DETROIT DIESEL CORP. 1062-6001	OE01
CVN 68 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	OE04
CVN 68 CLASS	WESTERBEKE CORP. 10488 SPEC B	OE05
CVN 68 CLASS	DETROIT DIESEL CORP. 1062-7000	OEA1
CVN 68 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M2	OEA4
CVN 68 CLASS	WESTERBEKE CORP. 108U-14088	OEA5
CVN 68 CLASS	DETROIT DIESEL CORP. 6072M6-71LC	OEB1
CVN 68 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	OEC1
CVN 68 CLASS	DETROIT DIESEL CORP. 64HN9HTEXCH	OED1
CVN 68 CLASS	DETROIT DIESEL CORP. 64HN9KCLG	OEE1
DD 963 CLASS	DETROIT DIESEL CORP. 1062-6001	OF01
DD 963 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	OF04
DD 963 CLASS	WESTERBEKE CORP. 4-107	OF05
DD 963 CLASS	DETROIT DIESEL CORP. 5062-3000	OFA1
DD 963 CLASS	DETROIT DIESEL CORP. 5062-7000	OFB1
DD 963 CLASS	DETROIT DIESEL CORP. 5062-70006V53N	OFC1
DDG 51 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	OF14
DDG 51 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	OF16
DDG 993 CLASS	DETROIT DIESEL CORP. 1062-6001	OF21
DDG 993 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	OF24
DDG 993 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	OF26
FFG 7 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	OG04
FFG 7 CLASS	WESTERBEKE CORP. 108U-14088	OG05
FFG 7 CLASS	VOLVO PENTA OF AMERICA INC 6AQAD40-867734	OG06
FFG 7 CLASS	WESTERBEKE CORP. 4-107	OGA5
FFG 7 CLASS	VOLVO PENTA OF AMERICA INC AQAD41A-DP290A	OGA6
LCC 19 CLASS	DETROIT DIESEL CORP. 5042-40004-53LD	OH11
LCC 19 CLASS	DETROIT DIESEL CORP. 6088M	OHA1
LCC 19 CLASS	DETROIT DIESEL CORP. 6088M-ALUM-6-71	OHB1
LCC 19 CLASS	DETROIT DIESEL CORP. 6121T6-71LC	OHC1
LCC 19 CLASS	DETROIT DIESEL CORP. 64HN9KCLG	OHD1
LHA 1 CLASS	DETROIT DIESEL CORP. 7082-7399-8V71TI	OI01

End Item	Component	TEC
LHA 1 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OIA1
LHA 1 CLASS	DETROIT DIESEL CORP. 7082-7399TI-8V71RC	OIB1
LHD 1 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	OI14
LHD 1 CLASS	VOLVO PENTA OF AMERICA INC 6AQAD40-867734	OI16
LHD 1 CLASS	VOLVO PENTA OF AMERICA 6AQAD40B-867936	OIA6
LHD 1 CLASS	DETROIT DIESEL CORP. 1062-7000	OIC1
LHD 1 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OID1
LHD 1 CLASS	DETROIT DIESEL CORP. 8062-7403RC	OIE1
LPD 1 CLASS	DETROIT DIESEL CORP. 5042-40004-53LD	OJ01
LPD 1 CLASS	WESTERBEKE CORP. 108U-14088	OJ05
LPD 1 CLASS	DETROIT DIESEL CORP. 64HN9KCLG	OJA1
LPD 1 CLASS	WESTERBEKE CORP. 4-107	OJA5
LPD 1 CLASS	DETROIT DIESEL CORP. 6-71LC6121T	OJB1
LPD 1 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OJC1
LPD 14 CLASS	WESTERBEKE CORP. 4-107	OL05
LPD 14 CLASS	DETROIT DIESEL CORP. 7082-7399-8V71TI	OL01
LPD 14 CLASS	CUMMINS ENGINE CO. INC. 6B5.9-M	OL04
LPD 14 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OLA1
LPD 7 CLASS	DETROIT DIESEL CORP. 5042-40004-53LD	OK01
LPD 7 CLASS	CUMMINS ENGINE CO. INC. 6B5.9-M	OK04
LPD 7 CLASS	WESTERBEKE CORP. 4-107	OK05
LPD 7 CLASS	DETROIT DIESEL CORP. 4HN9KCLG	OKA1
LPD 7 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OKB1
LPD 7 CLASS	DETROIT DIESEL CORP. 7082-7399TI-8V71RC	OKC1
LSD 36 CLASS	DETROIT DIESEL CORP. 64HN9KCLG	OM01
LSD 36 CLASS	DETROIT DIESEL CORP. 7082-30008V71	OMA1
LSD 36 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OMB1
LSD 41 CLASS	DETROIT DIESEL CORP. 1062+D417-7000	ON01
LSD 41 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M	ON04
LSD 41 CLASS	DETROIT DIESEL CORP. 6072M6-71RC	ONA1
LSD 41 CLASS	DETROIT DIESEL CORP. 7082-7399-8V71TI	ONB1
LSD 41 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	ONC1
LSD 41 CLASS	DETROIT DIESEL CORP. 7122-7000	OND1
LSD 41 CLASS	DETROIT DIESEL CORP. 8062-7403RC	ONE1
LST 1179 CLASS	DETROIT DIESEL CORP. 64HN9KCLG	OQ01
LST 1179 CLASS	DETROIT DIESEL CORP. 7082-7399RC-8V71TI	OQA1
MCS 12	CUMMINS ENGINE CO. INC. 4B3.9-M	OR14
MCS 12	CUMMINS ENGINE CO. INC. 6BTA5.9-M	ORA4
ALL	MISC DIESEL ENGINE	OH50
	PUMPS	
ALL	PUMP 2190 LUBE	P001
ALL	PUMP 2190	P002
ALL	PUMP 9250	P003
	DAVIT	
ALL	DAVIT 2190 LUBE	Q001
ALL	DAVIT HYDRAULIC	Q002

End Item	Component	TEC
	REDUCTION GEAR	
AGF 11 CLASS	REDUCTION GEAR 9250	R21W
AOE 6 CLASS	REDUCTION GEAR 2190	R41Y
ARS 50 CLASS	REDUCTION GEAR 9250	R50W
CG 47 CLASS	REDUCTION GEAR 2190	R80Y
CG 47 CLASS	REDUCTION GEAR 23699	R80Z
CV 63 CLASS	REDUCTION GEAR 9250	RB0W
CVN 65 CLASS	REDUCTION GEAR 2190	RD0Y
DD 963 CLASS	REDUCTION GEAR 2190	RF0Y
DD 963 CLASS	REDUCTION GEAR 23699	RF0Z
DDG 51 CLASS	REDUCTION GEAR 23699	RF1Z
DDG 993 CLASS	REDUCTION GEAR 2190	RF2Y
FFG 7 CLASS	REDUCTION GEAR 2190	RG0Y
FFG 7 CLASS	REDUCTION GEAR 23699	RG0Z
LCAC	REDUCTION GEAR 23699	RH0Z
LCC 19 CLASS	REDUCTION GEAR 2190	RH1Y
LCU CLASS	REDUCTION GEAR 9250	RH2W
LHA 1 CLASS	REDUCTION GEAR 2190	RI0Y
LHD 1 CLASS	REDUCTION GEAR 2190	RI1Y
LPD 1 CLASS	REDUCTION GEAR 2190	RJ0Y
LPD 7 CLASS	REDUCTION GEAR 2190	RK0Y
LSD 36 CLASS	REDUCTION GEAR 2190	RM0Y
LSD 41 CLASS	REDUCTION GEAR 2190	RN0Y
LSD 49 CLASS	REDUCTION GEAR 2190	RP0Y
LST 1179 CLASS	REDUCTION GEAR 9250	RQ0W
MCM 1 CLASS	REDUCTION GEAR 9250	RR0W
MCM 1 CLASS	REDUCTION GEAR 23699	RR0Z
MHC 51 CLASS	REDUCTION GEAR 2190	RS0Y
TWR CLASS	REDUCTION GEAR 7241	RT62
ALL	REDUCTION GEAR 2190	R50Y
ALL	REDUCTION GEAR 23699	R50Z
ALL	REDUCTION GEAR 9250	R50W
PC CLASS	REDUCTION GEAR 9250	RH3W
SSN 688 CLASS	REDUCTION GEAR	RT50
WAGB CLASS	REDUCTION GEAR 9250	R40W
WAGB 10CLASS	REDUCTION GEAR 9250	RU0W
WHEC CLASS	REDUCTION GEAR 9250	RV0W
WHEC 715 CLASS	REDUCTION GEAR 23699	RV0Z
WIX CLASS	REDUCTION GEAR 9250	RV1W
WLB 200 CLASS	REDUCTION GEAR 9250	RW0W
WLB 277 CLASS	REDUCTION GEAR 9250	RW1W
WLIC 75401 CLASS	REDUCTION GEAR 9250	RW6W
WLM 540 CLASS	REDUCTION GEAR 9250	RW8W
WLR 311 CLASS	REDUCTION GEAR 9250	RW9W
WLR 65501 CLASS	REDUCTION GEAR 9250	RWXW
WMEC CLASS	REDUCTION GEAR 9250	RX0W
WPB 1301 CLASS	REDUCTION GEAR 9250	RY0W
WPB 82312 CLASS	REDUCTION GEAR 9250	RY1W
WYTL 65501 CLASS	REDUCTION GEAR 9250	RZ1W
YTB CLASS	REDUCTION GEAR 9250	RH4W

End Item	Component	TEC
	SHIP SERVICE DIESEL GENERATORS	
AOE 6 CLASS	AOE 6 SSDG	S410
ARS 50 CLASS	CATERPILLER INC. D399-TA	S502
FFG 7 CLASS	STEWART & STEVENSON SERVICE 114D001	SG0J
LCC 19 CLASS	COLTEC INDUSTRIES INC. 6-38D8 1/8	SH13
LCU CLASS	LCU SSDG	SH20
LHD 1 CLASS	LHD1 SSDG	SI10
LSD 41 CLASS	COLTEC INDUSTRIES INC. 38ND8 1/8	SN03
LST 1179 CLASS	ALCO PRODUCTS INC. 8-251-E	SQ00
MCM CLASS	MCM SSDG	SR00
TWR CLASS	CATERPILLAR INC. 3304	ST62
ALL	MISC SSDG	S500
PC CLASS	PC SSDG	SH30
WAGB 10 CLASS	ALCO PRODUCTS INC. 8-251-E	SU00
WAGB 10 CLASS	CATERPILLER INC. D-379	SU02
WHEC 715 CLASS	GENERAL MOTORS CORP. 8-645-E2	SV08
WHEC 715 CLASS	GENERAL MOTORS CORP. 8-645-E2	SVA8
WHEC 715 CLASS	GENERAL MOTORS CORP. 8-645-E2	SVB8
WHEC 715 CLASS	GENERAL MOTORS CORP. 8-645-E2	SVC8
WLB 225 CLASS	CATERPILLER INC. 3508	SW02
WLB 277 CLASS	DETROIT DIESEL CORP. 6V-92	SW11
WLB 297 CLASS	DETROIT DIESEL CORP. #6-71	SWA1
WLI 313 CLASS	DETROIT DIESEL CORP. #3-71	SW31
WLI 65303 CLASS	DETROIT DIESEL CORP. #2-71	SW41
WLIC 298 CLASS	DETROIT DIESEL CORP. #3-71	SW51
WLIC 298 CLASS	CATERPILLER INC. 3304	SW52
WLIC 800 CLASS	DETROIT DIESEL CORP. #4-71	SW71
WLM 540 CLASS	DETROIT DIESEL CORP. #6-71	SW81
WLM 540 CLASS	CATERPILLER INC.340TA	SW82
WLR 311 CLASS	DETROIT DIESEL CORP. #4-71	SW91
WLR 65501 CLASS	DETROIT DIESEL CORP. #3-71	SWX1
WLR 65501 CLASS	CATERPILLER INC. 3304	SWX2
WLR 75401 CLASS	DETROIT DIESEL CORP. #3-71	SWY1
WLR 75401 CLASS	CATERPILLER INC. 3304	SWY2
WMEC CLASS	CATERPILLER INC. 3406BDT	SX02
WMEC CLASS	CATERPILLER INC. D398B(TA)	SXA2
WPB 1301 CLASS	CATERPILLER INC. D3304BT	SY02
WPB 82333 CLASS	CUMMINS ENGINE CO. INC. 4B3.9GM	SY14
WTGB 101 CLASS	CATERPILLER INC. 3306B	SZ02
WTGB 101 CLASS	CUMMINS ENGINE CO. INC. 6BTA5.9-M2	SZ04
WTGB 101 CLASS	MURPHY MP-24T	SZ0K
WYTL 65601 CLASS	CATERPILLER INC. D-311	SZ12
YTB CLASS	YTB SSDG	SH40
	TANKS	
ALL	TANK 9250	T001
ALL	TANK 2190	T002
ALL	TANK 23699	T003
ALL	TANK HYDRAULIC	T004

End Item	Component	TEC
	GUN MOUNT	
ALL	GUN MOUNT HYDRAULIC	U001
	BOW THRUSTERS	
ALL	BOW THRUSTER HYDRAULIC	V001
	WINCHES	
ALL	WINCH HYDRAULIC	W001
ALL	WINCH 80-90	W002
ALL	WINCH 23699	W003
	STEAM TURBINE GENERATORS	
AE 26 CLASS	AE 26 STEAM TURBINE GENERATORS	Y101
AGF 11 CLASS	AGF 11 STEAM TURBINE GENERATORS	Y211
AO 177 CLASS	AO 177 STEAM TURBINE GENERATORS	Y301
AOE 1 CLASS	AOE 1 STEAM TURBINE GENERATORS	Y401
AS 33 CLASS	S33 STEAM TURBINE GENERATORS	Y601
AS 39 CLASS	AS 39 STEAM TURBINE GENERATORS	Y701
CGN 36 CLASS	CGN 36 STEAM TURBINE GENERATORS	Y901
CGN 38 CLASS	CG 38 STEAM TURBINE GENERATORS	Y001
CV 63 CLASS	CV 63 STEAM TURBINE GENERATORS	YB01
CVN 65	CV 65 STEAM TURBINE GENERATORS	YD00
CVN 68 CLASS	CV68 STEAM TURBINE GENERATORS	YE01
LCC 19 CLASS	LCC 19 STEAM TURBINE GENERATORS	YH11
LHA 1 CLASS	LHA 1 STEAM TURBINE GENERATORS	YI01
LHD 1 CLASS	LHD 1 STEAM TURBINE GENERATORS	YI11
LPD 1 CLASS	LPD1 STEAM TURBINE GENERATORS	YJ01
LPD 7 CLASS	LPD7 STEAM TURBINE GENERATORS	YK01
LSD 36 CLASS	LSD 36 STEAM TURBINE GENERATORS	YM01
MCS 12	MCS 12 STEAM TURBINE GENERATORS	YR11
SSBN 726 CLASS	SSBN 726 STEAM TURBINE GENERATORS	YT01
SSN 640 CLASS	SSN 640 STEAM TURBINE GENERATORS	YT31
SSN 671 CLASS	SSN 671 STEAM TURBINE GENERATORS	YT41
SSN 688 CLASS	SSN 688 STEAM TURBINE GENERATORS	YT51
	AIR SUPPLY SYSTEMS	
ALL	AIR SUPPLY SYTEM 2190	Z001

APPENDIX C

MAJOR COMMAND CODES

CODE	ACRONYM	COMMAND NAME
AC	IOC	Industrial Operations Command
AB	AMCOM	U.S. Army Aviation and Missile Command
A7	USAREUR	U.S. Army Europe
A4	FORSCOM	U.S. Army Forces Command
AD	USAJ	U.S. Army Japan
Al	AMC	U.S. Army Materiel Command
A5	USANGB	U.S. Army National Guard
A6	USAR	U.S. Army Reserves
AK	TACOM	U.S. Army Tank-Automotive and Armaments Command
A3	TRADOC	U.S. Army Training and Doctrine Command
AY	CECOM	U.S. Army Communication and Electronic Command
A8	USARPAC	U.S. Army Pacific Command
A2	EUSA	U.S. Eighth Army Korea
A9	USARSO	U.S. Army South
AG	USACE	U.S. Army Corps of Engineers
FF	AFMC	Air Force Material Command
FZ	AFNGB	Air Force National Guard
FU	AFRES	Air Force Reserves
FJ	AETC	Air Education and Training Command
FQ	AMC	Air Mobility Command
FR	PACAF	Pacific Air Force
FT	ACC	Air Combat Command
FD	USAFE	U.S. Air Force Europe
FS	AFSOC	Air Force Special Operations
NH	MSC	Military Sealift Command
NIF	AIRLANT	Naval Air Forces Atlantic Fleet
NR	AIRPAC	Naval Air Forces Pacific Fleet
NN	NAVAIR	Naval Air Systems Command
NX	NAVSEA	Naval Sea Systems Command
NA	SUBLANT	Naval Submarine Forces Atlantic Fleet
NB	SUBPAC	Naval Submarine Forces Pacific Fleet
NC	SURFLANT	Naval Surface Forces Atlantic Fleet
ND	SURFPAC	Naval Surface Forces Pacific Fleet
NG	CGAIR	U.S. Coast Guard (Aeronautical)
NL	CGCUTTER	U.S. Coast Guard (Cutters)
NM	USMC	U.S. Marine Corps
NJ	USMCR	U.S. Marine Corps Reserves
XW	CONTRAC	Contractor
XV	FOREIGN	Foreign
XE	OTHER	Other

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APPENDIX D

JOAP LABORATORY CODES / SPECTROMETER CODES

This information changes often. Refer to the most recent JOAP directory. If a directory is needed, send a request by e-mail to corr@joaptsc.navy.mil

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APPENDIX E

DATA INDEX CODES

CODE	FILE MAINTENANCE ACTION
(Blank)	Detail Input
R	Sample Detail Revision
N	Sample Detail Deletion
T	Maintenance Feedback Revision
J	Maintenance Feedback Deletion
F	Maintenance Feedback

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APPENDIX F

REASON FOR SAMPLE CODES

CODE	REASON SAMPLE SUBMITTED
A	Accident/Incident
C	Customer Requested
J	Equipment Failure
F	Functional Check Flight
L	Lab Request
H	Metal in Sump/Screen/Filter
P	Physical Test (Not for Air Force use)
M	Post Maintenance Check
I	Pre-Shop Inspection (Not for Air Force use)
K	Prior to Maintenance - Removal
R	Routine
D	Sample Prior to Deployment
T	Test Cell
E	Test Cell - Reconditioned (Not for Air Force use)
U	Test Track (for Army depot use)
G	Test Track - Reconditioned (Not for Air Force use)
V	Vibration
W	Warning Light or Abnormal Gage Indication

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APPENDIX G

STANDARD LAB RECOMMENDATION CODES - AERONAUTICAL FOR SPECTROMETRIC ANALYSIS

CODE	GENERAL LAB RECOMMENDATIONS
A	Sample results Normal, continue routine sampling.
X	Analysis results supplied to customer; no recommendation required.
Z	Previous recommendation still applies.

CODE	INSPECTION RECOMMENDATIONS (Requires Feedback)
H**	Inspect unit and advise lab of finding. Abnormal wear indicated by *** PPM (element).
R**	Do not fly or operate; inspect filters, screens, chip detector and sumps; advise laboratory of results.
T**	Do not fly or operate. Examine for discrepancy and advise laboratory of results and disposition. If discrepancy found and corrected, continue operation and submit resample after *** hours of operation. If discrepancy is not found, recommend remove component from service and send to maintenance.

CODE	OIL CHANGE RECOMMENDATIONS (Requires Resample)
J	Contamination confirmed. Change oil, sample after *** minute run-up and after *** operating hours. NOTE: Contamination is defined as water, coolant, silicon, etc. and not wear metals. Use the appropriate recommendation codes for increasing treads or elevated wear metal conditions.
W	Contamination suspected. Change oil; run for *** additional hours, take samples hourly. (This code for Air Force ALC Depot use only.)

CODE	LAB REQUESTED RESAMPLES (Requires Resample)
B*	Resample ASAP, do not change oil.
C*	Resample after *** hours, do not change oil.
E*	Do not change oil. Restrict operations to local flights or reduced load operation, maintain close surveillance and submit check samples after each flight or *** operating hours until further notice.
F*	Do not change oil. Submit resample after ground or test run. Do not operate until after receipt of laboratory result or advice.

G*	Contamination suspected, do not change oil, resample unit and submit sample from new oil servicing this unit.
P*	Do not fly or operate; do not change oil; submit resample ASAP.
Q*	Normal PPM reading was obtained from test cell run after complete P.E. where oil lubricated parts were changed/removed/replaced. Monitor engine closely after installation to ensure a normal trend before release to routine sampling.

NOTES:

* Resample (red cap) required
** Maintenance feedback required, advise laboratory of findings
*** Laboratory will specify time limit

STANDARD LAB RECOMMENDATION CODES - NOT AERONAUTICAL FOR SPECTROMETRIC ANALYSIS
(Not For Air Force Use)

CODE	GENERAL LAB RECOMMENDATIONS
A	Sample results Normal, continue routine sampling.
X	Analysis results supplied to customer, no recommendation required.
Z	Previous recommendation still applies.

CODE	INSPECTION RECOMMENDATIONS **(Required Feedback)**
H**	Inspect unit and advise lab of findings. Abnormal wear indicated by (element) (PPM). Resample after (maintenance/***hours/etc.).
K**	Impending failure, critical wear indicated by (element). Inspect unit and advise lab of findings. Resample after (maintenance/***hours/etc.).
L**	Inspect brake and clutch plate adjustments, change oil service filters, resample after *** hours of operation.
M**	Perform engine coast-down check. If engine fails test, examine for discrepancy and advise lab of results, else resample after*** hours of operation.
U**	Cooling system leak indicated by (Mg/Cr/Na/B). Inspect unit and advise lab of findings. Resample after (maintenance/***hours/etc.).

CODE	OIL CAHNGE RECOMMENDATIONS **(Requires Resample)**
D	Change oil and service filters. Resample after *** hours of operation.

CODE	LAB REQUESTED RESAMPLES **(Requires Resample)**
B*	Resample ASAP, do NOT change oil.
C*	Resample after *** hours.
F*	Do not change oil, submit special sample after test run. Do not operate until after receipt of laboratory results or advice.
G*	Contamination suspected, do not change oil resample unit and submit sample from new oil servicing this unit.
I*	Stop purification, resample each engine after 4 hours of operation.
N*	Unit 'wear-in' indicated, resample in accordance with break-in schedule or after *** hours.
P*	Do not operate; do not change oil; submit resample ASAP.

NOTES:

* Resample (red cap) required
** Maintenance feedback required, advise laboratory of findings
*** Laboratory will specify time limit

STANDARD LAB RECOMMENDATION CODES - PHYSICAL TEST RECOMMENDATIONS
(Not For Air Force Use)

CODE	RECOMMENDATION
AA	Oil condition normal, continue routine sampling.
DN	Do not operate.
ER	Evaluate and repair component.
TS	Check oil type and source.
ZZ	Previous recommendation still applies
XX	Analysis results supplied to customer; no recommendation required.

CODE	OIL CONDITION STATEMENTS
FD	Fuel Dilution.
NN	Neutralization or acid number.
PC	Particle count excessive.
PN	Precipitation number.
SA	Solid or abrasive material.
VS	Viscosity (high/low/change).
WA	Water

CODE	OIL CHANGE RECOMMENDATIONS
CS	Change oil and service filter.
CP	Purify, renovate or change oil and service filters.

CODE	LAB REQUESTED SAMPLES **(Requires Resample).**
RB*	Resample ASAP.
RC*	Resample after *** hours.
RH*	Submit hot sample.
RI*	Resample, insufficient amount of sample received.
RS*	Submit sample of new oil servicing this unit.

CODE	INSPECTION RECOMMENDATIONS (Requires Feedback)
IA**	Inspect and repair air induction system.
IC**	Inspect and repair cooling system.
IF**	Inspect and repair fuel system, change/service filters and oil.
IW**	Inspect for source of water.

NOTES:

* Resample (red cap) required
** Maintenance feedback required, advise laboratory of findings
*** Laboratory will specify time limit

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APPENDIX H

ACTION TAKEN CODES

CODE	DESCRIPTIONS
D	Removed and Returned to Depot
E	Complied with Oil Lab Recommendation
G	Repair/Replace Minor Parts, Hardware and Softgoods
H	Equipment Checked - No Repair Required
R	Removed and Replaced
S	Removed, Repaired and Reinstalled

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APPENDIX I

DISCREPANT ITEM CODES

NOTE

The Discrepant Item Codes shown are general in nature and are designed to be applicable to all equipment entered in the oil analysis program. Due to the general nature of these codes, descriptions may not always be precise. Select the description that most closely fits for the discrepant item being reported. These codes are intended for use on oil analysis documentation only. Report errors or omissions on this listing to the JOAP-TSC, Pensacola, FL.

CODE	DISCREPANT ITEM
AA	A-Sump Scavenge Pump Rotor Vanes and liners
AB	Accessory Gearbox Bearing Housing
AC	Adapter Cover
AD	Air Filter
AE	Bands
AF	Basic Engine (no other item applies)
AG	Bearings (no other bearings apply)
AH	Block
AI	Brake Plates
AJ	Bushings
AK	Camshaft
AL	Camshaft Bearing
AM	Case/Main Housing
AN	Center and Counter Shafts
AO	Clutch Plates
AP	Connecting Rod
AQ	Connecting Rod Bearings
AR	Constant Speed Drive
AS	Core Engine Module
AT	Core Engine Module Number 2 Bearing
AU	Core Engine Module Number 3 Bearing
AV	Core engine Module Number 4 Bearing
AW	Crankshaft
AX	Crankshaft Bearing
AY	Cylinder
AZ	Cylinder Head
BA	Cylinder Liners
BB	Ducting/Hoses
BC	Fan Drive Turbine Module
BD	Fan Drive Turbine Module Number 5 Bearing
BE	Fittings
BF	Fuel Connectors
BG	Fuel Injectors

CODE	DISCREPANT ITEM
BH	Fuel/Injector Pump
BI	Fuel Lines
BJ	Gasket
BK	Gears
BL	Inlet Fan Module
BM	Inlet Fan Module Number 1 Bearing
BN	Lifter
BO	Number 0 Bearing and Housing
BP	Number 1 Bearing and Housing
BQ	Number 2 Bearing and Housing
BR	Number 3 Bearing and Housing
BS	Number 4 Bearing and Housing
BT	Number 5 Bearing and Housing
BU	Number 6 Bearing and Housing
BV	Number 7 Bearing and Housing
BW	"O" Ring
BX	Oil Cooler/Heat Exchanger
BY	Oil Filter
BZ	Oil Pump
CA	Piston
CB	Piston Rings
CC	Planetary Gears
CD	Power Take-Off
CE	Pump
CF	Reservoir
CG	Rocker Arm
CH	Rocker Arm Bushing
CI	Seals
CJ	Servo
CK	Starter Retainer
CL	Support Bushing
CM	Thrust Washer
CN	Timing Gear
CO	Torque Converter
CP	Turbo Charger/Blower
CQ	Valve
CR	Wrist Pin
CS	Wrist Pin Bushing

APPENDIX J

HOW MALFUNCTIONED CODES

CODE	HOW MALFUNCTIONED
A	Accident
B	Adjustment of Alignment Improper
C	Backlash Excessive
D	Bearing Failure or Faulty
E	Bent, Buckled, Collapsed, Dented, Distorted or Twisted
F	Binding, Stuck or Jammed
G	Broken
H	Broken, Faulty or Missing Safety Wire or Key
J	Bushing Worn or Damaged
K	Chipped
L	Corroded - Mild to Moderate
M	Corroded - Severe
N	Cracked
P	Defects Unknown
Q	Defects Unknown - Unit shipped to SRA - Depot
R	Dirty, Contaminated or Saturated by Foreign Material
S	Improper or Faulty Maintenance
T	Keyway or Spline Damage or Worn
U	Loose
V	Loose or Damaged Bolts, Nuts, Screws, Rivets, Fasteners or Clamps
W	Missing Bolts, Nuts, Screws, Rivets, Fasteners, Clamps, other Hardware
X	Nicked
Y	No Defects
Z	Pitted
3	Removal Not Associated with OAP
4	Scored or Scratched
5	Sheared
6	Worn Beyond Limits
7	Leaking, Internal or External
8	Low Compression

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APPENDIX K

HOW FOUND CODES

CODE	HOW FOUND
A	Air or Ground Crew Unscheduled Maintenance
G	Air/Ground Crew Scheduled Maintenance
S	Impending/Incipient Failure Indicated by OAP

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APPENDIX L

SAMPLE MESSAGE FORMAT
DIAGNOSITC DATA AND REQUEST FOR ASSISTANCE

FROM: LABORATORY

TO: DIRJOAP TSC PENSACOLA FL (Army only)
APPROPRIATE NATEC DET (Navy only)

INFO: (as required by paragraph 3-10 and parent commands)

UNCLAS

SUBJ: SPECTROIL M/N SPECTROMETER

REF: (a) SPECTROMETRIC LABORATORY MANUAL NAVAIR 17-15-50/TM 38-301/T.O. 33-1-37

(b) NAVAIR 17-15BF-95

1. Brief narrative of problem.

2. Is the Mercury lamp lit with the spectrometer in the ready mode and the sample stand door open? (Refer to paragraph 4-31 of reference (b).) YES/NO (as applicable).

3. Is there an indication on the optical alignment meter with the sample stand door open? YES/NO (as applicable).

4. Perform the optical alignment adjustment and record the counter setting (refer to paragraph 4-35 of reference (b)) NA/185 (use NA only when paragraph 3 is 'NO').

5. Is the optical alignment meter reading zero microamps with the sample stand door closed? YES/NO/NA (use NA only when paragraph 3 is 'NO').

6. (Complete only if answer to paragraph 5 is 'NO', use NA if paragraph 5 is 'YES'.) Is the optical alignment meter reading zero microamps with a piece of cardboard in front of the quartz window? YES/NO/NA

7. Are the readings for all elements within the tolerance of 50.1 $\pm$ 0.1 upon two completions of the PREOPERATIONAL CHECK? (Refer to paragraph 4-32 of reference (b).) If the answer is 'NO', identify the elements and reading. YES/NO - AL-47.3.

8. Identify the values and corresponding test points for any voltage check not within tolerances specified in table 3-7 of reference (b).
+14.2 at TP 2 and 11; -460 at TP 9 and 11.

9. Record the burn cycle duration time required to analyze one sample of zero oil. (Refer to paragraph 4-45 of reference (b).)

29 seconds

10. List the standardization points for Fe, Ag, Al, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Mo, Zn for the spectrometer in #1.

Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn
100	60	70	99	96	94	68	100	106	100	59	90	71	45

11. Record the results and burn time of five analyses of zero oil for the OFFSET CHECK AND ADJUSTMENT for Fe, Ag, Al, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Mo, Zn. Perform the adjustments as required (refer to paragraph 4-46 of reference (b)).

	Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
A	49.9	49.9	49.3	53.1	51.4	50.1	50.8	49.8	49.9	50.2	50.5	50.1	43.7	50.3	29
B	49.9	50.0	49.4	53.1							49.5	50.0	55.4	49.4	29
C	50.1	50.0	49.4	53.1	RECORD		READOUT	IN	TENTHS		49.9	50.1	55.1	50.1	30
D	49.4	49.8	48.6	53.0							49.7	49.5	54.0	49.9	29
E	50.3	50.0	49.5	53.1	51.4	50.2	50.9	50.5	50.0	50.2	50.7	50.0	56.1	49.9	29

*

12. Record the results and burn time of five analyses of 100 PPM oil for ADJUSTMENT AT 100 PPM for Fe, Ag, Al, Cr, cu, Mg, Na, Ni Pb, Si, Sn, Ti, Mo, Zn. Perform adjustments as required (refer to paragraph 4-47 of reference (b)).

	Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
A	102	64	73	101	94	91	68	102	106	100	59	89	78	41	30
B	100	62	71									89	76	45	30
C	103	63	74		RECORD		READOUT	IN	WHOLE	NUMBERS		88	77	42	30
D	101	62	69									89	76	44	30
E	99	64	72	99	92	90	67	103	105	101	56	87	78	43	30

13. Record the results and burn time of five analyses of a 50 PPM standard for Fe, Ag, Al, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Mo, Zn. First record the results in "0-100" range with the CALIBRATE switch off and in the PPM NORM mode, (1) then in the PPM OFF mode (2). Then record the results in the "0-1000" range first in the PPM NORM mode (3) and finally in the PPM OFF mode (4). (Readouts for each of the four switch positions can be obtained from a single analysis using the reset switch thus only a total of five analyses is requried.)

	Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
A	(1)54.1	53.1	49.1	47.6	52.3	50.0	51.3	49.3	49.0	51.3	50.4	49.8	54.2	52.3	30
	(2)54.0	35.0	48.3			RECORD (1) & (2) IN TENTHS						48.9	53.2	51.4	
	(3)54	53	37		RECORD (3) & (4) IN WHOLE NUMBERS							47	44	34	
	(4)54	35	31	48	52	50	40	49	49	51	26	50	42	30	

Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
B (1)51.1	52.3	49.9	49.1	50.2	49.2	50.1	52.1	50.9	52.6	51.1	53.6	52.2	50.9	30
(2)51.1	34.6	48.7		RECORD (1) & (2) IN TENTHS							52.9	51.3	50.7	
(3)51	52	34		RECORD (3) & (4) IN WHOLE NUMBERS							47	44	34	
(4)51	31	31	49	50	49	39	52	51	52	26	54	40	29	
C (1)53.8	51.1	41.6	49.9	51.3	52.1	50.6	50.9	51.2	50.9	49.0	50.3	53.8	51.1	30
(2)53.8	33.5	40.1		RECORD (1) & (2) IN TENTHS							51.2	52.7	50.9	
(3)53	51	32		RECORD (3) & (4) IN WHOLE NUMBERS							51	43	27	
(4)54	33	30	50	52	52	39	50	51	51	25	50	42	29	
D (1)52.2	50.9	48.6	50.9	49.9	48.9	51.8	48.7	49.9	49.9	51.6	47.2	51.1	52.3	30
(2)52.2	32.6	31.1		RECORD (1) & (2) IN TENTHS							46.8	50.2	51.1	
(3)52	51	49		RECORD (3) & (4) IN WHOLE NUMBERS							48	38	32	
(4)52	33	30	51	50	49	41	48	50	50	26	47	39	30	
E (1)54.2	52.3	48.6	48.6	52.2	50.3	50.3	48.9	51.5	49.2	49.9	54.3	54.1	53.1	30
(2)54.2	34.6	47.2		RECORD (1) & (2) IN TENTHS							51.1	52.1	51.2	
(3)54	52	32		RECORD (3) & (4) IN WHOLE NUMBERS							53	44	31	
(4)54	33	31	48	52	50	39	49	52	49	25	54	42	32	

14. Record the results and burn time of five analyses of 100 PPM standard for Fe, Ag, Al, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Mo, Zn. Record the results in the 0-1000 range first in the PPM OFF mode then in the PPM NORM mode. (Readouts for both the PPM OFF mode and the PPM NORM mode can be obtained on a single analysis thus only a total of five analyses is requried.)

Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
A (1)97	101	102									93	105	91	31
(2)97	60	61	RECORD	RESULTS	IN	WHOLE	NUMBERS				94	72	41	
B (1)105	103	101									98	107	109	31
(2)105	61	60	RECORD	RESULTS	IN	WHOLE	NUMBERS				96	76	47	
C (1)101	102	101									97	96	110	31
(2)101	61	60	RECORD	RESULTS	IN	WHOLE	NUMBERS				95	67	47	
D (1)104	106	100									103	111	93	31
(2)104	63	70	RECORD	RESULTS	IN	WHOLE	NUMBERS				97	76	42	
E (1)103	106	101									101	106	102	31
(2)103	63	71	RECORD	RESULTS	IN	WHOLE	NUMBERS				91	72	45	

15. Record the results and burn time of five analyses for Fe, Ag, Al Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Mo, Zn in the unmodulated mode. (Refer to paragraph 4-73 of reference (b).)

	Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
A	53.3	50.7	52.1	51.4	52.4	52.7	54.8	51.2	51.6	54.0	52.3	52.8	52.5	53.8	32
B	53.2	51.3									50.1	51.1	52.7	53.1	32
C	53.3	51.1			RECORD	RESULTS	IN	TENTHS			52.1	52.1	53.2	53.0	32
D	52.7	50.8									51.2	51.3	53.8	54.4	32
E	53.0	51.3	52.2	51.3	52.1	53.0	54.4	51.0	51.3	53.8	52.3	52.5	53.3	54.0	32

16 Record the results and burn time of five analyses for Fe, Ag, al, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Mo, Zn in the MODULATED mode. (Refer to paragraph 5-73 of reference (b).)

	Fe	Ag	Al	Cr	Cu	Mg	Na	Ni	Pb	Si	Sn	Ti	Mo	Zn	TIME
A	641	671	557	392	477	538	657	785	844	680	814	650	305	420	30
B	641	671										648	305	419	30
C	641	670			RECORD	RESULTS	IN	WHOLE	NUMBERS			649	304	417	30
D	641	671										650	305	420	30
E	641	671	557	391	477	537	657	785	844	680	814	650	305	420	30

17. REMARKS/ADDITIONAL INFORMATION. (Report any other symptoms you consider abnormal during the other phase of the operation.)

18. REQUEST ASSISTANCE. POINT OF CONTACT IS (name/telephone #).

(end of message)

APPENDIX M

PREPARATION INSTRUCTIONS - DA FORM 3254-R
OIL ANALYSIS RECOMMENDATION AND FEEDBACK

M-1. DA 3254-R will be produced locally on 8 1/2 x 11 inch paper. The laboratory will complete blocks 1 through 11.

a. Enter the filed unit's name, address and telephone number.

b. Enter the name and address of the laboratory making the recommendation.

c. Enter lab recommendation number. Example: 04-1 for year 04 and first recommendation of the year.

d. Enter end-item model number. Example: UH-1H, OH-58A, etc.

e. Enter complete end-item serial number.

f. Enter component type. Example: Main transmission, 90 degree gearbox, engine, etc.

g. Enter complete serial number of component.

h. Enter hours/miles on component.

i. Enter the recommendation and reason for action.

j. Laboratory personnel making recommendation will sign in block 10 and enter title.

k. Enter date. Example: 17 Feb 04.

M-2. The laboratory will prepare and forward one copy to the field activity, one copy to:

Army Oil Analysis Program Office
(AMXLS LA)
USAMC SUPPORT ACTIVITY
BLDG 3661
REDSTONE ARSENAL AL 35898-7466

and for aeronautical equipment, one copy to:

COMMANDER
ATTN SDSCC QTM STOP 270
CORPUS CHRISTI ARMY DEPOT
308 CRECY STREET
CORPUS CHRISTI TX 78419-5260

OIL ANALYSIS RECOMMENDATION AND FEEDBACK For use of this form, see TB 43-0106 and TB 43-0210; the proponent agency is DARCOM.	*REQUIREMENT CONTROL SYMBOL CSGLD-1818*
1. TO: FIELD (*Include ZIP Code and Telephone Number*)	**3. LAB RECOMMENDATION NUMBER**
	4. END ITEM MODEL
	5. END ITEM SERIAL NUMBER
2. FROM: LABORATORY *(Include ZIP code)*	**6. COMPONENT TYPE**
	7. COMPONENT SERIAL NUMBER
	8. COMPONENT TIME *(Hours/Miles)*
9. RECOMMENDATION AND REASON FOR ACTION	
10. SIGNATURE AND TITLE OF INIATOR	**11. DATE *(Day/Month/Year)***
12. NOTE FOR ARMY AVIATION ONLY: Quality Deficiency Report (QDR). SF 368 will be submitted when maintenance is performed due to impending or incipient failure indicated by oil analysis, Failure Code 916.	**13. QDR NUMBER**
14. FEEDBACK (Maintenance Performed/Action taken)	
15. FROM: FIELD DEPOT MAINTENANCE PERSONNEL	**16. DATE *(Day/Month/Year)***
17. TO: LABORATORY	**NOTE FOR ARMY AVIATION ONLY:** **Copy of this form with SF 368 (QDR) attached will be sent to:** **Commander, CCAD** **ATTN: DRSTS-MER Stop 55** **Corpus Christi, TX 78419** **NOTE: AMSAV-MRAT IS NEW ATTN ADDRESS**

DA FORM **3254-R** NOV 80 **EDITION OF JUN 78 IS OBSOLETE.**

APPENDIX N

ARMY LABORATORY EVALUATOR CERTIFICATION REQUIREMENTS

N-1. GENERAL. The role of the evaluator in Army oil analysis laboratories is to serve as the single determining authority for all analyses, which indicate the potential for a maintenance problem or concern for the continued reliability of a tested component. PM AOAP must certify all evaluators serving in Army laboratories.

N-2. CERTIFICATION. To be certified as an Army laboratory evaluator, an individual must be actively employed in a single Army Oil Analysis Program (AOAP) laboratory (see paragraph N-3).

a. Request for evaluator certification must:

(1) Be processed through the government office at installation responsible for the laboratory. The request must be signed by the person for whom certification is being requested, the laboratory chief, and the Contracting Officer's Representative (COR)/Installation Monitor. Signatures attest that the individual has received adequate training and acknowledges that those signing believe the individual is proficient in all areas required for certification as an Army oil analysis evaluator.

(2) Include a copy of the training completed by the applicant and any related information such as previous analytical experience and/or chemistry/petroleum background.

b. Requirements for evaluator certification are:

(1) Applicant must have the ability to be certified for both aeronautical and nonaeronautical equipment. Individuals in laboratories that analyze only nonaeronautical samples or only aeronautical samples will receive limited evaluator certification.

(2) Applicant must successfully pass a written test and a performance test administered by the AOAP Program Management Office or its designated representatives. If the applicant fails either test, the individual must wait at least 2 months before requesting certification again. The additional time will permit the applicant to receive additional training in those areas where additional knowledge is required.

c. When an applicant has successfully passed the evaluator written and performance examinations, PM AOAP will evaluate the outcome, applicant’s experience, and award the evaluator certification, if appropriate.

d. Requirements for evaluator certification in ferrography:

(1) In addition to the requirements outlined in paragraphs N-2 above, the following are applicable to Army laboratory personnel who are to be certified to evaluate grease samples through the use of ferrography.

(2) Must be a certified aeronautical AOAP evaluator and;

(a) Should have completed the ferrographic instrument manufacturer's 1 week Introduction to Ferrography Course and least 3 months on-the-job training preparing and evaluating ferrograms under the supervision of a certified ferrograph evaluator.

(b) Requests for attendance at either of the ferrography courses will be coordinated through the Program Manager. Expenses associated with attendance and completion of these training courses will be at the expense of the applicant or the applicant’s company. Written tests are not required for ferrography certification, however, the applicant will be required to successfully pass a performance test.

e. Test administration:

(1) Written test:

(a) Will normally be given during Laboratory Assistance and Assessment Review (LAAR) visits.

(b) Will be given at Redstone Arsenal, AL, or at the contract laboratory site. If certification testing is required at a time other than during a LAAR visit, the contractor is responsible for all travel costs of the testing representative to the laboratory site or for the applicant's to travel to Redstone Arsenal. In the case of government-operated laboratories, the installation will be responsible for all travel costs.

(c) The test will examine the applicant's capabilities and knowledge of Army oil analysis publications and procedures/protocols involved in the documentation and processing of lubricant samples and test finding data.

(2) Performance test. Will be given at the Redstone Arsenal, AL, or at the contract laboratory site. In the case of contractor-operated laboratories, the contractor is responsible for all travel costs of the testing representative or for employees to travel to Redstone Arsenal. In the case of government-operated laboratories, the installation will be responsible for all travel costs.

(a) The test will examine the applicant's capabilities and knowledge of Army oil analysis laboratory instruments, testing methodology, and laboratory procedures.

(b) Each applicant will be evaluated to determine their ability to arrive at a single and correct conclusion after reviewing the findings from each tests conducted on an oil sample. The applicant should be able to achieve a high level of accuracy on each oil sample analyzed.

N-3. Recommended Training or Experience.

a. Knowledge of AOAP publications, to include:

(1) AR 750-1, Army Material Maintenance Policies, published in the Maintenance Management UPDATE (Chapter 7, Army Oil Analysis Program).

(2) AR 700-132 Joint Oil Analysis Program (JOAP).

(3) TM 38-301, Joint Oil Analysis Program Manual, Volumes 1-4.

(4) TB 43-0106, Aeronautical Equipment Army Oil Analysis Program (AOAP).

(5) TB 43-0211, AOAP Guide for Leaders and Users.

(6) DA Pam 738-750, the Army Maintenance Management System, published in the Maintenance Management UPDATE (Chapter 4, Army Oil Analysis Program).

(7) DA Pam 738-751, the Army Maintenance Management System - Aviation, (Army Oil Analysis Program).

b. Training may be accomplished by general study of the manuals, research of questions posed by trainer, and daily application of procedures outlined in the publications.

c. Complete familiarity with the function of wear-metal parts per million evaluation criteria in the Oil Analysis Standard Interservice System (OASIS) or TM 38-301. This may be accomplished by review of the table but the information is best retained when used as a daily reference during evaluator training.

d. Physical Property Test Training. One month working closely with a laboratory technician on the performance of physical property tests and an additional 3 months performance of physical property tests.

Training should include standardization of the viscometer and procedures for adjustment when the viscometer requires calibration as well as procedures and basic principles behind each test.

e. Spectrometer Training. Two months working closely with a trained spectrometer operator and an additional 4 months of spectrometer operation. Training is to include proper sample and electrode handling, complete manual and automated spectrometer standardization, procedures for cleaning the sample stand, proper electrode sharpening, operator maintenance services and frequency required, procedures for calibration checks and frequency required, cleaning of quartz window and frequency required, and basic principles of spectrometer operation.

f. Evaluator Training. Three or more months working with a certified evaluator. This is to include techniques in evaluation of nonaeronautical and aeronautical samples. These techniques must include a study of trend development, interpretation of changes in individual elements as well as combinations of elements, and discussion of factors influencing evaluation. Certification is not to be requested until the individual is qualified to evaluate without supervision.

g. Individual may request a waiver from PM AOAP on the length of recommended training requirements if an individual has previous experience within the AOAP, or has experience acquired elsewhere. A minimum 2 months training in an AOAP laboratory is recommended to ensure familiarization with AOAP tests and evaluation techniques. However, the length and type of training required by PM, AOAP, will be based on the qualifications provided in the applicant’s request for training waiver.

N-4. DECERTIFICATION.

a. Decertification shall automatically occur if any of the following conditions exists:

(1) If an evaluator is employed/contracted to serve full-time in a single AOAP laboratory and is serving as an evaluator at multiple AOAP laboratories.

(2) If an evaluator is employed/contracted to serve full-time in a single AOAP laboratory and fails to accomplish laboratory evaluator duties 90 percent of the employment period. Normal absences for personal time off, jury duty, medical or military leave will not count against the individual.

NOTE

Contractor management officers, who hold evaluator status and serve to supplement or replace evaluators on temporary medical absence or military leave, etc, are not included in rules N-3a and N-3b. However, individuals in this status must refresh or supplement their experience by performing evaluator duties in an AOAP laboratory every three months.

(3) If an evaluator is not employed, full-time, in an AOAP laboratory for 6 consecutive months.

b. May be directed by the Program Manager, AOAP, based on, but not limited to, the following reasons:

(1) Evaluator's willful disregard of AOAP policies or procedures.

(2) Evaluator's removal from the laboratory or military installation for cause, by any authorized government official.

(3) Evaluator's willful entry of false test or analytical data into the AOAP computer.

(4) Evaluator's willful falsification of any AOAP sample record.

(5) Evaluator's willful communication of false information concerning the processing or evaluation of a sample.

N-5. RECERTIFICATION: Shall be required for all individuals who were certified evaluators at one time, were decertified, and desire to be certified again.

a. Applicants requesting recertification must meet the requirements outlined in paragraph N-2.

b. For those whose decertification was directed by the Program Manager, AOAP:

(1) Recertification may not be requested until 1 year after decertification.

(2) The reason for decertification must be mitigated and satisfactorily resolved.

(3) Applicant must meet the requirements outlined in paragraph N-2.

c. Request for recertification (for all individuals) must:

(1) Be processed through the government office at installation responsible for the laboratory where the applicant will be employed and be signed by the person for whom certification is being requested, the laboratory chief, and the COR/Installation Monitor.

(2) Include a copy of the initial certification letter, along with a description of recent training or experience and any other pertinent information.

N-6. GENERAL NOTES:

a. If an evaluator originally receives limited certification (to evaluate only nonaeronautical samples or only aeronautical samples) and later wants to be fully certified, he/she must take written and performance tests to qualify for full certification (both aeronautical and nonaeronautical evaluation). Procedures for requesting the administering the tests are the same as those for initial certification described in this appendix.

b. If an evaluator originally receives full certification to evaluate both nonaeronautical and aeronautical samples, and continues to be employed as an evaluator but evaluates either only nonaeronautical or only aeronautical samples, he/she does not lose full certification. He/she previously demonstrated his/her proficiency in full evaluation capabilities, continued to use evaluator skills on a daily basis, and remained familiar with laboratory test procedures and manuals. It is the responsibility of the evaluator to hone his/her skills as necessary when the occasion to evaluate the type of samples not routinely evaluated arises.

APPENDIX O

FERROGRAM ANALYSIS REPORT SHEET

Ferrogram Number:_____ Date:_____

Organization: _____ Sample No.:_____

Equipment Type: _____ Equipment Serial No.:_____

Sample Date: _____ Total Operating Hours:_____

D.R. Reading (per mL) L:_____ S:_____

Oil Type: _____

Time on Oil:_____

Volume of Undiluted Sample to Make Ferrogram:_____

TYPES OF PARTICLES	NONE	FEW	MODERATE	HEAVY
Normal Rubbing Wear Particles				
Severe Wear Particles				
Cutting Wear Particles				
Chunks				
Laminar Particles				
Spheres				
Dark Metallo-Oxide Particles				
Red Oxide Particles				
Corrosive Wear Debris				
Non-Ferrous Metal Particles				
Non-Metallic Birefringent } Inorganic / Organic				
Non-Metallic, Amorphous				
Friction Polymers				
Fibers				
Other, Specify				
Considered Judgement of Wear Situation: ☐ Normal ☐ Caution ☐ Very High (Red Alert)				

COMMENTS:

APPENDIX O

DIRECT READ ANALYSIS REPORT REGISTER

DR NUMBER: _____
ORGANIZATION: _____
EQUIPMENT TYPE: _____
SAMPLE DATE: _____
REASON FOR D/R: _____
FERRO DONE: YES_____ NO_____
DR READING L: _____
(PER ML) S: _____

DATE: _____
SAMPLE #: _____
TAIL NUMBER: _____
TOTAL OVERHAUL HRS: _____
TIME ON OIL: _____
OIL TYPE: _____

RECOMMENDATION/COMMENTS: _____

_____

_____

DIRECT READ ANALYSIS REPORT REGISTER

DR NUMBER: _____
ORGANIZATION: _____
EQUIPMENT TYPE: _____
SAMPLE DATE: _____
REASON FOR D/R: _____
FERRO DONE: YES_____ NO_____
DR READING L: _____
(PER ML) S: _____

DATE: _____
SAMPLE #: _____
TAIL NUMBER: _____
TOTAL OVERHAUL HRS: _____
TIME ON OIL: _____
OIL TYPE: _____

RECOMMENDATION/COMMENTS: _____

_____

_____

DIRECT READ ANALYSIS REPORT REGISTER

DR NUMBER: _____
ORGANIZATION: _____
EQUIPMENT TYPE: _____
SAMPLE DATE: _____
REASON FOR D/R: _____
FERRO DONE: YES_____ NO_____
DR READING L: _____
(PER ML) S: _____

DATE:_____

SAMPLE #:_____

TAIL NUMBER:_____

TOTAL OVERHAUL HRS:_____

TIME ON OIL:_____

OIL TYPE:_____

RECOMMENDATION/COMMENTS:_____

_____

_____

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