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BOEING SPECIFICATION
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HYDRAULIC FLUID CONTAMINATION LIMITS

THE BOEING COMPANY
COMMERCIAL AIRPLANE GROUP

DOCUMENT NUMBER	MODEL NUMBER	PURCH. AGREEMENT/W.O. NO.
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TITLE

HYDRAULIC FLUID CONTAMINATION LIMITS

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REVISIONS

REV SYM	DESCRIPTION	DATE	APPROVAL
	Original Release	2/27/79	
A	1. Scope Revised to change "Standard Control Drawings" to "Specification Control Drawings." 2. Revised Table II to add specific E-3A requirements.	7/9/79	Prepared by 7/9/79 Approved by 7-9-79 Approved by 7-10-79 Approved by 7-10-79 Approved by HCR for E.R. PETERSEN 7-10-79
B	1. Added BMS 3-11 (Tributyl Phosphate) contamination limits to Table II. 2. Added an analytical technique for determining BMS 3-11 contamination concentration in MIL-H-5606 or MIL-H-6083 fluid. 3. Change the title of test method 12.8.	9/10/80	Prepared by 9/24/80 Approved by 9-24-80 Approved by 11/19/80 Approved by 11/14/80 Approved by

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1. SCOPE

This document establishes the contamination limits for hydraulic fluid in components, test benches, factory central systems, carts, new and mod. airplanes at the Boeing Commercial Airplane Co.

The requirements of the document are applicable to components and component suppliers when imposed by Specification Control Drawing, Purchase Order Note or Contract.

The document specifies sampling procedures, equipment, facilities and test methods to be used for the contamination evaluation by Boeing and component suppliers as applicable.

2. CLASSIFICATION - None

3. REFERENCES

Except where a specific issue is indicated, the current issue of the following references shall be considered a part of this document to the extent indicated herein:

a. BMS 3-11, Hydraulic Fluid, Fire Resistant.

b. NAS-1638, Cleanliness requirements of parts used in Hydraulic Systems.

c. ASTM F 312 "Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters."

d. ASTM D-2709, "Water and Sediment in distillate fuels by centrifuge, Test for."

e. MIL-H-5606, Hydraulic Fluid, Petroleum base; aircraft, missile and ordinance.

f. ASTM D 445, "kinematic viscosity of transparent and opaque liquids (and the calculations of dynamic viscosity), determination of,."

g. ASTM D 941, "Density and Specific Gravity of Liquids by Lipkin Bicapillary Pycnometer, Test for,."

h. ASTM D 974, "Neutralization Number by Color-Indicator Titration, Test for,."

i. ASTM D 1744, "Water in Liquid Petroleum Products by Karl Fischer Reagent, Test for,."

j. ASTM D 92, "Method of Test for Flash and Fire Points by Cleveland Open Cup."

4. CONTENTS

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5. MATERIALS CONTROL

The following materials will be required in addition to those specified in each ASTM test method.

a. Distilled water.

b. Isopropyl Alcohol, Reagent Grade.

c. Freon, PCA Grade, E. I. Dupont.

6. FACILITIES CONTROL

6.1 PERSONNEL

a. All personnel obtaining hydrualic fluid samples for contamination level determinations shall be trained in accordance with applicable documented procedures.

b. Laboratory testing and evaluation of hydraulic fluid samples shall be performed by approved laboratory personnel.

6.2 EQUIPMENT

a. Farr Laminar Flow Clean Bench, or equivalent.

b. Vacuum pump capable of pulling 20 inches of mercury.

c. Microscope with mechanical stage, approximate 35X and 125X magnifications, calibrated micrometer eyepiece.

d. Microscope lamp, high intensity, variable.

e. Associated laboratory equipment to perform chemical analysis as specified herein.

7. DEFINITIONS

Following are definitions of the word or phrase as used in this document:

a. Contamination - Particulate or chemical material which is foreign to the basic formulation of the hydraulic fluid.

b. Factory Central Hydraulic System - The hydraulic system in the plant which is supplying BMS 3-11 hydraulic fluid to the factory buildings under pressure to activate new airplane hydraulic systems.

7. Cont.

c. Micron - one millionth of a meter or .00004 inches.

d. Mod - Modification.

e. Particles - Small un-dissolved organic or inorganic matter contaminating hydraulic fluid.

f. Test Benches - Permanent installations of motors, pumps, valves, gauges, flow meters and filtration. May have its own fluid reservoir or use the central system.

g. Test Carts - Portable self-contained hydraulic bench having its own hydraulic reservoir, motors, pumps, gauges, flow meters and filtration.

h. Service Cart - Wheel mounted steel reservoir with pump to supply hydraulic fluid for servicing airplanes.

8. MANUFACTURING CONTROL

Assure that documented procedures are followed in using the hydraulic systems covered by this document to preclude hydraulic fluid and system contamination.

9. MAINTENANCE CONTROL

9.1 PORTABLE TEST CARTS AND SERVICE CARTS

a. All equipment shall be certified periodically per its respective facilities document. Equipment shall be operated for 15 minutes before sampling.

b. During certification a 200 ml. sample shall be taken, appropriately labeled, and delivered to the Quality Control chemical lab. for analysis.

c. If the chemical lab. notifies the sample was acceptable, the equipment reservoir shall be re-sealed and can be certified for manufacturing use.

d. If the chemical lab. notifies the sample was rejectable, appropriate action shall be taken to obtain acceptable fluid by filtering or replacing contaminated fluid.

e. A sample shall be taken each time hydraulic fluid is added to the reservoir. Sample shall be taken after fluid has been circulated through unit. Follow steps 9.1.b thru d.

9.2 CENTRAL HYDRAULIC SYSTEM

a. A sample shall be taken each month. (At least 200 milliliters).

b. Deliver sample to Quality Control Chem. Lab. for analysis.

c. Follow 9.1.c., d., and e. as applicable.

10. REQUIREMENTS.

10.1 PROPERTIES AND PARTICULATES.

a. The types of hydraulic oil covered by this document shall meet the requirements specified in Tables I and II for each noted application.

b. Testing for properties and particulates shall be performed in accordance with the applicable method specified in Section 12.

REV SYM

TABLE I

BMS 3-11 REQUIREMENTS

PROPERTIES	NEW FLUID	CENTRAL SYSTEMS, TEST CARTS SERVICE CARTS.	RECEIVING FUNCT. TEST BENCHES, MOD.CARTS,MOD. AIRPLANES, INCOMING COMPONENTS, SUPPLIER TEST BENCHES.	NEW AIRPLANES AT DELIVERY 1
Viscosity, CS @ 100°F	9 Min.	8 Min.	6 Min.	8 Min.
Sp. Gravity 77°F/77°F	.995 to 1.066	.995 to 1.066	.995 to 1.066	.995 to 1.066
Neutralization No. mg KOH per gram.	0.20 Max.	0.40 Max.	1.50 Max.	0.50 Max.
Water % by Weight	0.1 to 0.3	0.1 to 0.4	0.1 to 0.8	0.1 to 0.4
Particulates	NAS 1638 Class 7	NAS 1638 Class 8	NAS 1638 Class 8 3	NAS 1638 Class 9
Total Chlorine (ppm)		100 Max.	200 Max.	100 Max.
MIL-H-5606 % by Volume		2	2	

1 Particle Contamination Analysis is mandatory.

2 Analysis required only when contamination suspected. If contamination is equal to or greater than 1.0%, system must be flushed until below 1.0%.

3 Mod Airplanes Requirement NAS 1638 Class 9

TABLE II

MIL-H-5606 REQUIREMENTS

PROPERTIES	NEW FLUID	TEST CARTS-SERVICE CARTS	RECEIVING FUNCTIONAL TEST BENCHES	
Viscosity, CS @ 100° F.	14 Min.	11.0 Min.	11.0 Min.	
Flash Point °F.	200 Min.	200 Min.	200 Min.	
Acid or Base No. mg KOH per gram	0.20 Max.	0.40 Max.	0.40 Max.	
Water Parts/Million (Commercial Airplanes)	100	ASTM D-2709 No Free Water	ASTM D-2709 No Free Water	A
Particulates (Commercial Airplanes)	MIL-H-5606	NAS 1638 Class 8	NAS 1638 Class 9	A
Water Parts/Million (E-3A Airplanes)	100	ASTM D-1744 200 Max.	ASTM D-1744 200 Max.	A
Particulates (E-3A Airplanes)	MIL-H-5606 B, C or D	NAS 1638 Class 6	NAS 1638 Class 6	A
BMS 3-11 % by Volume (1)	(2)	(2)	(2)	B

(1) Vol. % phosphate ester contaminant as BMS 3-11. B

(2) Analysis required only when contamination suspected. If contamination is equal to or greater than 1.0%, system must be flushed until below 1.0%. B

11. QUALITY CONTROL

11.1 FACTORY PERSONNEL

a. Maintain test bench or cart servicing records for each filling of cart and hookup to airplane.

b. Verify that only certified test benches or carts are used in production.

c. Assure that procedures are followed per applicable documents and operating instructions.

d. Assure that mod. test and service carts are not used interchangeably with their production counterparts.

11.2 FUNCTIONAL TEST LAB. PERSONNEL

a. The test benches shall be sampled each 60 calendar days.

b. Prior to taking samples, operate test benches for 15 minutes.

c. Obtain clean sample bottles from the chemical lab.

d. Draw a fluid sample 200 mls. minimum from each work station.

e. Label each bottle.

f. Return fluid sample with maintenance log to chemical lab for analysis.

g. When the maintenance log is returned and the chemical lab. notifies analytical results, determine if maintenance is required.

h. Component sampling upon receival at Boeing will be performed by Functional Test Lab. Personnel and the sample submitted to the chemical lab. for analysis.

Note: Tests, other than particle count, shall be conducted on the fluid as removed from the component. For particle count, a composite sample may be obtained from the component(s) by flushing with a suitable quantity of clean (NAS 1638 Class 7 or better) BMS 3-11 fluid. A blank count, proportional to the volume of flushing fluid used, shall be subtracted from the total count on the composite sample.

11.3 COMPONENT SUPPLIER TEST PERSONNEL

Assure that only fluid meeting the requirements of this document is used in component test benches and is used to fill components prior to and during shipment to Boeing or applicable sub-contractors.

11.4 CHEMICAL LABORATORY PERSONNEL

a. Conduct analyses on submitted samples as required by this document.

b. Report test results as "acceptable" or "rejectable" based on the criteria contained herein.

12. TEST METHODS

12.1 PARTICULATE CONTAMINATION

12.1.1 Perform test per ASTM F 312 or Method 3009-T of Fed. Test Method Std. No. 791a except freon shall be substituted for petroleum ether.

12.1.2 Apparatus required.

a. Pyrex filter holder and vacuum flask assembly, Millipore Cat. No. XX1504700 or equivalent.

b. Membrane filter, 0.80 micron, type DM-800, white grid, 047 mm. diameter, metricel, Gelman Cat. No. 64540 or equivalent.

c. Plastic Petri dishes, disposable, Millipore Cat. No. PD 1084700 or equivalent.

d. Forceps with unserrated tips.

e. Sample bottles, small mouth, glass, 200 ml. volume size.

f. Wash bottle, pyrex glass, optional equipment is Gelman Liquid Dispenser, Cat. No. 7074.

12.1.3 Optionally automatic particle counters, e.g., HiAc Model PC-203, PC-202 or equivalent may be used counting to the limits specified in Tables I and II. Directions for use shall be as specified by the instrument manufacturer.

12.2 VISCOSITY

12.2.1 Perform Test per ASTM D 445.

12.2.2 Apparatus and materials required are per ASTM D 445.

12.3 SPECIFIC GRAVITY

12.3.1 Perform Test per ASTM D 941.

12.3.2 Apparatus and materials required are per ASTM D 941.

12.4 ACIDITY

12.4.1 Perform test per ASTM D 974.

12.4.2 Apparatus and materials required are per ASTM D 974.

12.5 WATER

12.5.1 Perform test per ASTM D 1744.

12.5.2 Apparatus and materials required are per ASTM D 1744.

12.6 TOTAL CHLORINE

12.6.1 Perform analysis with X-ray fluorescence, coulometry or equivalent. Method must be capable of detecting total chlorine with an accuracy of $\pm$ 20 ppm.

12.7 FLASH POINT

12.7.1 Perform test per ASTM D 92.

12.7.2 Apparatus and materials required are per ASTM D 92.

12.8 DETECTION OF MIL-H-5606 HYDROCARBON CONTAMINATION IN EMS 3-11 HYDRAULIC FLUIDS.

12.8.1 Perform test as described herein.

12.8.2 Instrumentation

Waters Assoc. Liquid Chromatograph with differential refractive index detector and μPorasil (Waters) porous silica LC column.

12.8.3 Details of Analytical Method (QCR&D #F20855-1)

a. Preparation of calibration solutions: Using a 1.00 ml. glass syringe, increasing amounts of MIL-H-5606 are diluted with Hyjet IV in a 10 ml. volumetric flask to give 0.5, 1.0, 1.5, 2.0, 3.0, 4.0 and 5.0% (V/V) solutions of MIL-H-5606 in Hyjet IV. Then 5.0 mls of each solution is diluted to 10 mls with UV grade 2, 2, 4-Trimethylpentane. Prior to injection into the LC, each diluted calibration solution is filtered through a 0.5 micron Millipore filter to remove column damaging particulate matter.

b. Instrument Parameters:

Column	µPorasil (Waters Assoc.)
Flow rate	2.0 ml/minute
Chart speed	1.0 cm/minute
Detector	Refractive index
Attenuation	8X
Sample Sizes	10 and 20 microliters
Mobile phase	2, 2, 4-Trimethylpentane (isooctane)

c. Column regeneration: After each run, retained polar compounds are removed from the column by switching to THF mobile phase for 5 minutes at a flow rate of 4.0 mls/minute. Then, the isooctane solvent is returned to the column at 4.0 mls/minute until the RI baseline stabilizes (ca 15 minutes) at which time the flow rate is lowered to 2.0 mls/minute.

d. Inject 20 microliter samples for the 0.5 through 2.0% solutions; 10 µl for the others.

e. Measure the height of the first peak (hydrocarbon) eluting at the void volume (ca 100 seconds). Generate calibration curve by plotting peak height vs. % MIL-H-5606. Divide the 20 µl peak heights by 2 to normalize the data.

f. For unknowns inject 20 µl of a suitably prepared sample and note peak height. Using calibration curve determine the percent of MIL-H-5606 in the sample.

12.8.4 Optionally D6-24429 "An Analytical Method for Contaminants in EMS 3-11 Hydraulic Fluid and Their Mixtures Using Differential Infra-Red Spectroscopy" may be used in lieu of the above method.

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12.9 DETERMINATION OF BMS 3-11 HYDRAULIC FLUID CONTAMINATION IN MIL-H-5606 OR MIL-H-6083 FLUID

12.9.1 Perform test as described herein.

12.9.2 Instrumentation/Equipment

a. Dispersive type dual beam infra-red spectrophotometer.

b. Two variable path length cells with either sodium chloride or potassium bromide windows.

c. Optionally, matched .05 mm fixed path length cells with sodium chloride or potassium bromide windows.
NOTE: Follow paragraph 12.9.4 when using fixed path length cells.

12.9.3 Analytical Method Using Two Variable Path Length Cells

a. Spectrophotometer settings shall be as follows:

1. 200 to 600 cm^{-1}/minute scan rate.

2. Less than 2 second period.

3. Less than 2% noise level at 100% transmission, air vs. air.

4. No grating interchanges between 1850 cm^{-1} and 900 cm^{-1}.

5. Operate in double beam mode.

b. Thoroughly flush and clean both variable path length cells with reference fluid (either MIL-H-5606 or MIL-H-6083) several times. (Keep other solvents out of cells after they are flushed and before use).

c. Designate one variable path length cell as the reference and fill it with reference fluid while the cell is opened to more than 2 mm path length.

d. In order to adjust the path length of the reference cell, place the cell in the sample beam of the spectrophotometer. While in the double beam mode, use the slit and cell path length adjustments to obtain a transmittance reading of 12.5 $\pm$ 0.5% of the peak at 1372 cm^{-1} while the transmittance of the spectral window at 1850 cm^{-1} is maintained at 99 $\pm$ 1%. Remove cell from sample beam.

e. Designate the other variable path length cell as the sample cell and fill it with unknown sample while the cell is opened to more than 2 mm.

f. Repeat paragraph 12.9.3 d for adjusting the path length of the sample cell in the sample beam.

g. Place the reference cell containing the reference fluid in the reference beam of the spectrophotometer. Make adjustments with the slit control and the sample cell path length so that the transmittances at 1800 cm^{-1} and 1372 cm^{-1} are 99 $\pm$ 1%. Check the transmittance at 1100 cm^{-1} to verify that it is at 100 $\pm$ 2%. If not adjust the path length of the sample cell so that it is.
NOTE: The transmittance at 1372 cm^{-1} will alter. Do not make additional corrections at 1372 cm^{-1}.

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12.9.3 h. Scan the spectral regions from 950 cm^{-1} to 1150 cm^{-1} at the specified rate noting the base transmittance at 1100 cm^{-1} and minimum transmittance value between 1020 cm^{-1} and 1055 cm^{-1}.

NOTE: If there is a peak (due to the presence of Molykote Fluid Concentrate or Molykote M Gearguard additive in the hydraulic fluid) at 1000 cm^{-1}, the base transmittance value shall be determined by drawing a baseline from the peak at 1000 cm^{-1} to intersect the curve at 1100 cm^{-1}. The true baseline transmittance reading for the phosphate is directly under the phosphate peak.

i. The percent phosphate ester in the sample fluid, in excess of the reference fluid, is given by:

$$\% \text{ phosphate ester} = \left[\text{Log}_{\text{base}} (\% \text{ Trans.}) - \text{Log}_{\text{phosphate}} (\% \text{ Trans.})\right] \times 10$$

12.9.4 Analytical Method Using Fixed Path Length Cells

a. Designate the cell with the shortest path length as the reference cell.

NOTE: A variable path length cell may be used as the sample cell with a fixed path length cell as a reference cell. The sample cell must not have a path length less than that of the reference cell.

b. Using reference fluid in both cells, establish a base line between 900 and 100 cm^{-1}.

c. Replace the reference fluid in the sample cell with sample fluid, and scan between 900 and 1100 cm^{-1}. Mark location and determine value of phosphate ester peak.

NOTE: The phosphate ester in high density BMS 3-11 fluids shows two bands at 950 cm^{-1} and 1025 cm^{-1} while low density BMS 3-11 fluids show one absorbance band at 1055 cm^{-1}. If a peak occurs at 1000 cm^{-1}, draw a corrected baseline from the peak to 1100 cm^{-1} and use this as the baseline in the calculations.

d. The percent phosphate ester in the unknown fluid, in excess of the reference fluid, can be obtained from a comparison of phosphate absorbancy to an absorbance vs. concentration plot obtained from a series of standards in the range of 0.5 to 3.0%.

NOTE: Subtract the corrected baseline absorbance of 12.9.4.b from the phosphate peak absorbance when comparison to the standard curve is made.