DOCKET NO: SA-510

EXHIBIT NO: 9V

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

BOEING MATERIAL SPECIFICATION BMS 3-11J
HYDRAULIC FLUID

THE BOEING COMPANY

MS 60 Volumes 1 - 12, Revision 1/94
01-06-94

TO: Holders of D-18888-3 Material Standards Manuals
60 Volumes 1 - 12

SUBJECT: Revision 1/94
Units in this revision.....114

Remove from your manual(s) and destroy the following specifications in their entirety.

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BMS 3-11H QPL
BMS 4-4T QPL
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BMS 5-44H QPL
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BMS 7-260G QPL
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BMS 8-133L QPL
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Insert in your manual(s) the following pages which accompany this letter and delete any like-numbered specifications.

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BMS 5-138C QPL
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(1)

1 SCOPE

a. This specification establishes the requirements of fluids for use in hydraulic systems where fire resistance is required. **FL 1**

b. One supplier's fluids shall be completely compatible with all other suppliers' fluids in all proportions of mixing.

c. This specification requires qualified products.

FL 1 This specification describes commercial products of the fluid suppliers.

2 CLASSIFICATION

2.1 TYPE

a. Type I - Obsolete

b. Type II - Obsolete

c. Type III - Obsolete

d. Type IV - Erosion Arresting, Fire Resistant Fluid

2.2 CLASS

Type IV fluids shall be divided into classes as follows:

a. Class 1 - Low Density Fluid, Specific Gravity 0.995 to 1.020 (formerly Type IV with no class designation)

b. Class 2 - High Density Fluid, Specific Gravity 1.020 to 1.066

2.3 GRADE

Type IV fluids shall be further divided into grades as follows:

a. Grade A - Erosion tested at elevated temp. (225 ± 10 F)

b. Grade B - Erosion tested at moderate temp. (100 ± 10 F)

NOTE: When Type IV with no fluid class is indicated on drawings, Class 1 applies. Reference to Type IV within this specification applies to both classes unless class is designated e.g., Type IV (1) or Type IV (2) as in Table I.

(2)

3 REFERENCES

The issue of the following references in effect on the date of invitation for bid or at time of qualification shall form a part of this specification to the extent herein indicated.

ASTM D 92	-	Test Method for Flash and Fire Points by Cleveland Open Cup
ASTM D 97	-	Test Method for Pour Point of Petroleum Oils
ASTM D 445	-	Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
ASTM D 892	-	Test Method for Foaming Characteristics of Lubricating Oils
ASTM D 941	-	Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer
ASTM D 974	-	Test Method for Acid and Base Number by Color Indicator Titration
ASTM D 1744	-	Test Method for Water in Liquid Petroleum Products by Karl Fischer Reagent
ASTM D 2155-66	-	Test Method for Autoignition Temperature of Liquid Chemicals
ASTM D 2266	-	Test Method for Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method)
ARP 598	-	Procedure for the Determination of Particulate Contamination of Hydraulic Fluids by the Particle Count Method
BAC5719	-	Chemical Conversion Coatings for Aluminum and Aluminum Alloys
BAC5736	-	Application of Chemical and Solvent Resistant Finishes
BAC5845	-	Automated Flow Coat Line-Cleaning Alodizing, Painting
D6-3614	-	Boeing Approved, BMS3-11 - Resistant Rubber Compounds for Fabrication of Packings and Gaskets
OSH 2-105-2	-	Hazard Communication Program
OSHA 1910.1200	-	Hazard Communication Standard

4 DEFINITIONS

Room temperature (RT) shall be 72 ± 5 F except when otherwise specified.

5 MATERIAL REQUIREMENTS

5.1 GENERAL

a. The material shall be clear, homogeneous, and free from solid matter as specified in Table I, Item k.

b. The material shall consist of a base fluid to which suitable additives may be incorporated.

c. Health hazard evaluation shall be performed for each new material qualified to this specificaction in accordance with OSH 2-105-2 to establish its usage precuations.

5.2 PHYSICAL AND CHEMICAL PROPERTIES

(Applies to all Classes and Grades unless otherwise stated.)

TABLE I PHYSICAL AND CHEMICAL PROPERTIES

PROPERTY	REQUIREMENTS	CLASSES	TEST METHOD
a. Viscosity at -65 F, cs	2000 max 4200 max	1 2	ASTM D 445 FL 1
b. Viscosity at 100 F, cs	9.00 to 12.50	All	ASTM D 445
c. Viscosity at 210 F, cs	3.00 to 4.00	All	ASTM D 445
d. Pour Point, F	-80 max	All	ASTM D 97
e. Specific Gravity at 77 F/77 F (25 C/25 C)	0.995 to 1.020 1.020 to 1.066	1 2	ASTM D 941
f. Acid No., mg KOH/g	0.20 max	All	ASTM D 974
g. Moisture Content, percent by wt	0.10 to 0.30	All	ASTM D 1744
h. Flash Point, F	320 min	All	ASTM D 92
i. Fire Point, F	350 min	All	ASTM D 92
j. Autoignition Temp., F	750 min	All	ASTM D 2155-66
k. Particle Count, Particles/ 100 mL	max FL 3	All	ARP 598 FL 2 FL 5
l. Toxicity	No health hazard (i.e., minimal irritant properties, low sensitization potential, No systematic effects resulting from skin absorption). Toxicity level to be acceptable to Boeing Medical and Industrial Hygiene departments.	All	As determined by a biological testing laboratory.
m. Foaming	FL 4	All	ASTM D 892
n. Anti-erosion additive content	FL 6	All	FL 7

5.2 PHYSICAL AND CHEMICAL PROPERTIES (Continued)

TABLE I PHYSICAL AND CHEMICAL PROPERTIES (Concluded)

FL 1 Let charged viscometer tube stand for 1 hour at -65 ± 0.1 F for purposes of reaching equilibrium.

FL 2 Use Millipore NR or equivalent phosphate ester resistant filter and trichloroethylene or trichlorotrifluoroethane as the solvent.

FL 3 NAS 1638, Class 7

SIZE RANGE (MICROMETER)	PARTICLES/ 100mL, (MAXIMUM)
5 TO 15	32,000
15 TO 25	5,700
25 TO 50	1,012
50 TO 100	180
>100	32

FL 4

SEQUENCE	FOAM VOLUME AT END OF 5 MINUTE BLOWING PERIOD (mL)	COLLAPSE TIME (SECONDS)
75 F	250 MAX	100 MAX
200 F	150 MAX	50 MAX
75 F (AFTER 200 F)	450 MAX	250 MAX

FL 5 Particulate contamination may also be measured by the use of automatic particle counters in lieu of the optical procedure detailed in ARP 598. HiAc counter, Model PC-203, PC-202, or equivalent, counting to the limits specified by **FL 3** may be used. Directions in the manual for respective instruments shall be followed.

FL 6 The nominal content shall be determined at the time of qualification and will be proprietary. Variation from the nominal content shall not exceed the algebraic sum of the manufacturing tolerance and the accuracy of the analytical determination. The manufacturing and analytical tolerances may be combined.

FL 7 The proprietary test method submitted by the fluid supplier (in accordance with Section 6.2c.) or an alternate method with comparable accuracy and detection limits as agreed between the supplier and The Boeing Company.

5.2.1 CONTAMINANTS

TABLE II ELEMENTAL CONTAMINANTS

CONTAMINANTS	LIMIT FL 1	NOMINAL VALUES FL 2				MAXIMUM VALUES ALLOWED FL 3				TEST METHOD SECTION
		HYJET IV-A	HYJET IV-A PLUS	LD4	500B4	HYJET IV-A	HYJET IV-A PLUS	LD4	500B4	
Calcium	10	120	110	1	1	130	120	11	11	8.11.1
Potassium	10	0	40	20	20	10	50	30	30	8.11.1
Sodium	10	0	0	3	3	10	10	13	13	8.11.2
Chlorine	75	0	0	13	13	75	75	88	88	8.11.1
Sulfur	150	250	230	1390	1310	400	380	1540	1460	8.11.1

FL 1 Elements introduced as part of the basestock or the additive package shall not be considered as contamination and shall be assigned a nominal value.

FL 2 Nominal values reflect basic content as qualified.

FL 3 These values to be taken as the maximum specification values allowed (for Receiving Inspection purposes). Values in excess of the posted maximum value constitute grounds for rejection of the material.

5.3 PERFORMANCE TESTS

5.3.1 HIGH TEMPERATURE EFFECTS ON METALS

Metal weight loss and hydrogen input shall not exceed the following values when tested in accordance with Section 8.1.

Metal	Weight Change (mg/cm^2)	Hydrogen Input (ppm)
Titanium	150 max	850 max
Stainless steel	50 max	N/A

5.3.2 SONIC SHEAR STABILITY

The sonic shear stability test shall be performed according to Section 8.2. The viscosity in centistokes at 100 F shall not have changed by more than 25 percent of the original value.

5.3.3 BULK MODULUS TEST

The average bulk modulus when determined according to Section 8.3 shall be equal to or greater than 210,000 psi at 100 F and 3000 psi pressure.

5.3.4 FLUID COMPATIBILITY

5.3.4.1 Miscibility

When mixed with each of the other qualified products and tested in accordance with Section 8.4 the fluid shall be completely miscible with no separation, precipitation, nor cloudiness. Color change is acceptable.

5.3.4.2 Foaming

Foaming tests shall be performed in accordance with ASTM D 892 on 25/75, 50/50 and 75/25 mixtures of the fluid with each of the qualified products, and on a mixture of equal proportion with all the qualified products. Requirements are as follows:

SEQUENCE	FOAM VOLUME AT END OF 5 MINUTE BLOWING PERIOD (mL)	COLLAPSE TIME (SECONDS)
75 F	400 MAX	250 MAX
200 F	425 MAX	200 MAX
75 F (AFTER 200 F RUN)	425 MAX	220 MAX

5.3.5 CORROSION, HYDROLYTIC AND OXIDATION STABILITY

Fluid characteristics and metal weight shall not exceed the following values when the fluid is tested in accordance with Section 8.5.

a. Weight changes of metal test specimens:

METAL	REQUIREMENT (mg/cm^2)
Steel, 4130, MIL-S-18729	±0.1 MAX
Steel, 4130, Cadmium Plated QQ-P-416, Type I, Class 2	±0.4 MAX
Aluminum, 7075-T6, QQ-A-250/4B	±0.1 MAX
Magnesium, QQ-M-44	±0.2 MAX
Copper, QQ-C-576	±0.4 MAX
Steel, 4130, Silver Plated **FL 1**	±0.2 MAX

FL 1 Plate 0.0005 inch thick minimum in accordance with QQ-S-365. Solid silver may be used in place of the plated specimen.

b. Fluid characteristic changes:

CHARACTERISTIC	REQUIREMENT
Acid, mg KOH/g	±0.3 MAX
Viscosity in centistokes	
at 100 F	±3.0 MAX
at 210 F	±1.0 MAX

5.3.6 THERMAL STABILITY

Fluid characteristics and metal weight changes shall not exceed the following values when tested in accordance with Section 8.6:

a. Weight changes of metal test specimens:

METAL	REQUIREMENT (mg/cm^2)
Steel, 4130, MIL-S-18729	±0.3 MAX
Steel, 4130, Cadmium Plated QQ-P-416, Type I, Class 2	±0.3 MAX
Aluminum, 7075-T6, QQ-A-250/4B	±0.2 MAX
Magnesium, QQ-M-44	±5.0 MAX
Copper, QQ-C-576	±0.5 MAX

b. Fluid characteristic changes

CHARACTERISTIC	REQUIREMENT
Acid, mg KOH/g	±0.1 MAX
Viscosity in centistokes	
at 100 F	±1.0 MAX
at 210 F	±0.3 MAX

5.3.7 FLAMMABILITY

The fluid shall meet the following flammability requirements when tested in accordance with Section 8.7.

TEST	REQUIREMENT
Flammability, Wick Test	25 CYCLES MINIMUM
Flammability, High Temperature Ignition Test	$K_h \geq 10$
Flammability, Manifold Test	$K_m \geq 10$

5.3.8 FOUR-BALL WEAR TEST

After testing in accordance with ASTM D 2266 (600 rpm at 4, 10 and 40 kg loads), the following limiting values shall apply for each fluid type:

LOAD (kg)	REQUIREMENT - SCAR DIAMETER (mm)
4	0.45 MAX
10	0.50 MAX
40	0.55 TO 0.75

5.3.9 MATERIAL COMPATIBILITY

5.3.9.1 Paint Compatibility Test

Final hardness shall be not less than 2B when the fluid is tested in accordance with Section 8.10.

5.3.9.2 Elastomeric Compatibility Test

All elastomeric tests of D6-3614 are to be conducted with the fluid and shall meet the requirements of the applicable section of D6-3614.

5.3.10 SYSTEM CYCLING TESTS

Upon satisfactorily meeting the requirements of Section 5.1 through 5.3.9, system tests utilizing aircraft components as described below will be conducted on the fluid.

5.3.10.1 Pumping Test

a. After the fluid is subjected to the pumping test (Section 8.8), the following fluid characteristic limits shall not be exceeded:

Characteristic	REQUIREMENT
Acid No. change, mg KOH/g	± 0.10 MAX
Viscosity at 100 F, cs	6.00 MIN
Viscosity at 210 F, cs	2.00 MIN

b. In addition, the fluid shall exhibit no adverse effect on the system or system materials. Each system filter elements will meet the following pressure drop test requirement: Using a supply pressure of 3000 psi and a flow rate of 6 gallons per minute (gal/min), the pressure drop across the filter elements shall not exceed 24 psi.

5.3.10.2 Erosion Tests

The valve internal leakage during testing (Section 8.9) shall meet the following requirements:

a. Erosion Resistance Test (Section 8.9.1

200 cm^3/min maximum after 300 hours of testing with methyl chloroform added and with no greater than a 0.5 cm^3/min/h rate of change in leakage in the final 50 hours.

(Grade A test to be conducted at 225 ± 10 F, Grade B test to be conducted at 100 ± 10 F)

b. Erosion Control Test (Section 8.9.2)

600 cm^3/min maximum after 300 hours of testing with no greater than a 0.5 cm^3/min/h rate of change in leakage in the final 50 hours.

(Grade A test to be conducted at 225 ± 10 F, Grade B test to be conducted at 100 ± 10 F)

6 QUALIFICATION

6.1 REQUESTS FOR QUALIFICATION

All requests for qualification shall be directed to a Materiel department of The Boeing Company. Materiel will forward the request to the appropriate Engineering department for evaluation. After receiving written authorization from Materiel, the manufacturer shall submit the data and samples required for qualification purposes.

6.2 SAMPLES AND TEST REPORTS

a. Prior to submitting a material for qualification to this specification, the supplier shall provide its material safety data sheet, and if requested its chemical formulation. Agreements for nondisclosure and control of proprietary information shall be considered and executed as appropriate. The information provided shall be submitted to the appropriate Boeing, Safety, Health, and Environmental Affairs organizations to evaluate it, determine whether it is adequate or whether additional information is necessary, and identify and document appropriate precautions for the material's use.

   (1) Submit an initial sample of 10 gallons of fluid together with test data indicating compliance with the requirements of Section 5.2 (Tables I and II). Duplicate testing for each requirement is a minimum.

   (2) After successful passage of initial testing in accordance with Section 5.2, additional fluid will be required for Boeing tests in accordance with Section 5 which will require a 65 gallon sample. This testing will be performed at The Boeing Company's option. System cycling tests shall be accomplished.

   (3) The sample containers shall be made of materials similar to those used for shipment of the product and shall not react chemically with the product.

b. All suppliers shall have test facilities required to test in accordance with this specification or use certified commercial test laboratories with capability to test in accordance with this specification. The adequacy of the test facilities may be verified as deemed necessary by a survey of the facilities conducted by representatives of The Boeing Company.

c. The supplier shall submit analytical method(s) for measuring the quantity of anti-erosion additive present in new fluid. Supplier manufacturing and analytical tolerances shall be provided to The Boeing Company.

6.3 APPROVAL

a. All requests for qualification shall be directed to a Materiel department of The Boeing Company. Materiel will forward the request to the appropriate Engineering department for evaluation. After receiving written authorization from Materiel, the manufacturer shall submit the data and samples required for qualification purposes.

b. No changes in approved product formulation, raw materials, basic methods of manufacture, or plant site shall be made without notification and prior approval in writing. Requalification of the revised material may be required and a revised supplier designation may be requested.

c. Qualified products shall be listed in the QPL.

d. Production materials shall be capable of meeting all qualification requirements.

e. All suppliers shall have test facilities required to test in accordance with this specification or use certified commercial test laboratories with capability to test in accordance with this specification.

f. Prior to submitting a material for qualification to this specification, the supplier shall provide its Materials Safety Data Sheet, and, if requested, its chemical formulation. Agreements for non-disclosure and control of proprietary information shall be considered and executed as appropriate. The information provided shall be submitted to the appropriate Boeing Safety, Health, and Environmental Affairs Organizations to evaluate it, determine whether it is adequate or whether additional information is necessary, and identify and document appropriate precautions for the material's use.

6.4 FORMULATION CHANGES

No change in approved product formulation, raw materials, basic methods of manufacture, or geographic location shall be made subsequent to qualification without notification and prior written approval by the Division of The Boeing Company granting the original approval. Requalification of the revised product may be required, and a revised supplier designation may be requested. Any or all of the qualification tests may be repeated at any time by the purchaser, and the material shall pass the qualification requirements.

7 QUALITY CONTROL

7.1 SUPPLIER QUALITY CONTROL

Production shipments of qualified products from the supplier shall be accompanied by actual data from the tests listed in Tables II and III, and shall indicate revision letter in effect. Deviation limits from the qualified products as shown in Table III shall be met. In no case shall the allowable deviation be construed as a relaxation of the requirements of Table I. The supplier shall keep on file the anti-erosion additive content which shall be available immediately upon request to authorized individuals. The quality control system shall provide for in-process records and inspections to assure proof of product repeatability. These records shall be made available to authorized Boeing personnel.

7.1 SUPPLIER QUALITY CONTROL (Continued)

TABLE III DEVIATION LIMITS

TEST	MAXIMUM ALLOWABLE DEVIATION OF ANY INDIVIDUAL VALUE FROM THAT OF QUALIFIED PRODUCT	TEST METHOD
Viscosity at 100 F, cs	± 0.5 CS **FL 3**	ASTM D 445
Viscosity at 210 F, cs	± 0.2 CS **FL 3**	ASTM D 445
Pour Point, F	**FL 1**	ASTM D 97
Specific Gravity at 77 F / 77 F (25 C / 25 C)	± 0.006 **FL 3**	ASTM D 941
Acid No., mg KOH/g	**FL 1**	ASTM D 974
Moisture Content, percent by weight	**FL 1**	ASTM D 1744
Autoignition Temp., F	**FL 1**	ASTM D 2155-66
Particle Count, Particles/100 mL	**FL 1**	ARP 598 **FL 2**

FL 1 No deviation limits. Requirements of Table I, Section 5.2 shall be met.

FL 2 Particulate contamination may also be measured by automatic particle counters in lieu of the optical procedure detailed in ARP 598.

FL 3 Nominal content shall be determined at the time of qualification and shall be listed on the QPL.

7.2 PURCHASER QUALITY CONTROL

Purchaser Quality Assurance shall review all supplier test data submitted with shipment and perform any additional inspection of testing necessary to ensure that the production material meets all requirements specified herein.

8 MATERIAL TEST METHODS

8.1 HIGH TEMPERATURE EFFECTS ON METALS

8.1.1 TEST MATERIALS AND APPARATUS

a. Titanium (6Al-4V in accordance with MIL-T-9046, Type III, Comp. C) and stainless steel (304 in accordance with MIL-T-6845) specimens 3/4 inch by 3/4 inch by any available thickness up to 0.1 inch.

b. Test fluid.

c. Heat transfer apparatus consisting of 301 stainless steel cups with inner diameter of 1-1/8 inch, suitable temperature probes, hot plate, and heater control. Cups shall incorporate bottom drains.

8.1.2 TEST PROCEDURE

a. Measure ppm of hydrogen present in the titanium alloy by vacuum gas analysis FL 1 in a control panel obtained from the metal sheet from which test specimens were cut.

b. Prior to running test, clean and dry all test specimens with acetone and weigh to the nearest 0.1 mg.

c. Drip test fluid onto test panels at a rate of approximately 1/4 cm^3 per hour. Test fluid shall be at room temperature. Heat specimens in the heat transfer cups on a temperature controlled hot plate. Conduct tests for a period of 4 days (96 hours minus cleaning time). Test titanium specimens at 350 ± 20 F and stainless specimens at 425 ± 20 F.

d. Every 24 hours inspect test specimens and if a surface film or coating occurs, remove film in the following sequence, or equivalent, until clean:

(1) Clean mechanically while hot with paper towels and a wooden tongue depressor.

(2) Repeat the above during and after soaking in acetone.

(3) Apply Turco 5351 brushable stripper at room temperature for 10 or 20 minutes and repeat the mechanical cleaning.

(4) Boil in a solution of Kelite 235 (16 to 32 ounces per gallon) or equivalent alkaline rust remover and repeat mechanical varnish removal.

NOTE: Do not use acid strippers. Acids will alter the weights and hydrogen determinations to follow.

FL 1 The LECO Hot Extraction Hydrogen Determinator, Model 534-600 or equivalent is recommended. Follow manufacturer instructions for operation.

e. Following the 4 day test, clean each test specimen, weigh to the nearest 0.1 mg, and determine weight loss (average of two readings).

f. Determine ppm hydrogen by vacuum gas analysis on the titanium specimens and report increase in hydrogen content (average of two readings) compared to control panel.

8.2 SONIC SHEAR STABILITY

a. Apparatus to be used: Westinghouse Sonic Cleaning Apparatus Model 3515 (60 watts and 70 to 80 kHz/second) or equivalent.

b. Expose 120 mL of test fluid in a 4-ounce polyethylene bottle to shearing in the apparatus for 12 hours at room temperature.

c. Measure the viscosity at 100 F in accordance with ASTM D 445.

d. Report results as percent loss in viscosity at 100 F.

8.3 BULK MODULUS TEST

8.3.1 TEST SETUP (FIGURE 1)

a. A coil of 1/2 by 0.049-inch 304 stainless steel tubing is used as the fluid receiver. This coil is installed in an oven which is used as a heat source.

b. The test fluid is pumped into the receiver with an air driven Sprague pump (Model S216-C60) and the pressure is read on a Heise gage (graduated in 10 psi increments). The fluid temperature is monitored with thermocouples inserted into the top and bottom of the coil.

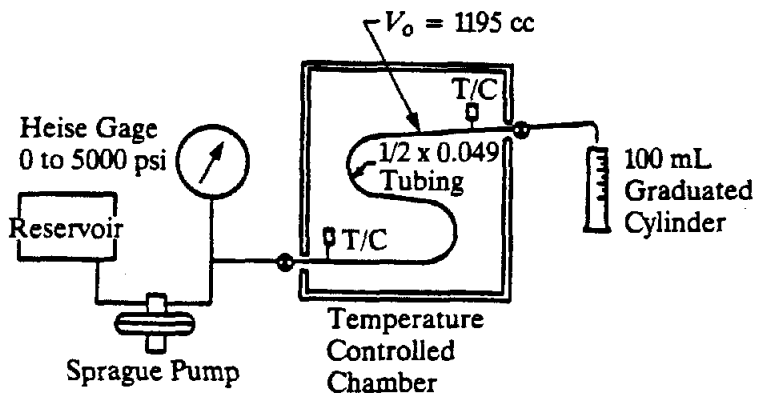


Figure 1 BULK MODULUS DETERMINATION TEST SETUP

8.3.2 TEST PROCEDURE

a. After determining the volume of the fluid receiver by filling it with water and then draining into a beaker, determine the coefficient of expansion of the test fluid. This is done by heating 60 cm^3 of the test fluid in a 100 mL graduated cylinder and recording the increase in temperature required to increase the volume 1 cm^3.

b. After the receiver has been filled and bled of air, adjust the system to 3000 ± 25 psi and 100 ± 5 F. Then close the inlet valve and open the outlet valve.

c. The compressed fluid expands to atmospheric pressure, and the volume of fluid associated with raising the pressure in the receiver to the desired level is recorded. Record this value along with the temperature of the effluent at the time of reading.

8.3.3 METHOD OF COMPUTATION

a. The secant bulk modulus is the total change in fluid pressure divided by the total change in fluid volume per unit volume under pressure.

$$B = \frac{(P - P_o)\ V_o}{(V_o - V)}$$

B – secant bulk modulus, psi
P – pressure, psig
P_o – initial pressure, psig (usually 0 psig)
V_o – volume at P_o (receiver volume)
V – volume at P (V_o minus effluent volume)

b. Correct the volume of the receiver for changes due to pressure and temperature. Correct the effluent volume for the difference between its temperature at the time of reading and its temperature when it is in the receiver.

8.4 FLUID COMPATIBILITY

Make mixtures of 25/75, 50/50 and 75/25 percent, by volume of the fluid, with each previously qualified product and also prepare a mixture of equal proportions of the fluid and all qualified products. Place mixtures in beakers, stir vigorously and note appearance. Let specimens stand 48 hours, and note appearance. Observe turbidity, foam, layering, or other indications of incompatibility.

After the above test, heat all the mixtures to 250 ± 10 F for 168 hours. Cool to room temperature. Observe turbidity, foam, layering, or other indications of incompatibility.

8.5 CORROSION, HYDROLYTIC AND OXIDATION STABILITY TEST

a. Obtain specimens of the following materials (approximately 1 inch by 1 inch by 1/16 inch).

Steel, 4130, MIL-S-18729

Steel, 4130, Cadmium plated, QQ-P-416, Type I, Class 2

Aluminum, 7075-T6, QQ-A-250/4B

Copper, QQ-C-576

Silver, in accordance with Section 5.3.5.

b. Drill a hole approximately 1/16 inch in diameter at each corner of the metal specimens.

c. Polish each specimen, except plated steel, with 600 grit paper to remove all surface oxidation, and rinse in acetone to remove contamination. Do not polish plated specimens, but rinse in acetone to remove contamination.

d. Weigh all strips and determine the surface area of each in square centimeters.

e. Arrange the specimens as shown in Figure 2 such that they form a metal parallelogram with the magnesium specimen touching aluminum, steel, and cadmium plated steel, but not copper. This is done by tying the strips together with a fluid resistant cord (nylon) previously washed with acetone and dried. The silver specimen shall not contact the other metal pieces. It shall, instead, be tied separately to the teflon stand described in Section 8.5f.

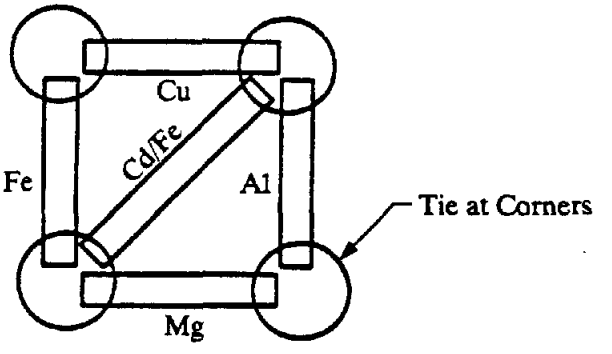


Figure 2 TEST CONFIGURATION

8.5 CORROSION, HYDROLYTIC AND OXIDATION STABILITY TEST (Continued)

f. Place the resulting metal parallelogram into a 250 mL wide-mouth bottle as follows:

Mount the metal parallelogram on a suitable teflon stand in such a way that the setup is rigid inside the bottle.

The metal parallelogram should be positioned as near the center as possible.

g. Prepare approximately 500 mL of test fluid by adjusting the water content of the fluid to 0.8 ± 0.05 percent by weight. Use distilled water for water adjustment.

h. Determine the following on the prepared test fluid:

Viscosity at 100 F and 210 F in accordance with ASTM D 445.

Acid number in accordance with ASTM D 974.

Moisture content in accordance with ASTM D 1744.

i. Place 125 mL of the fluid in the 250-mL widemouth bottle and seal with a cap which has been fitted with an ethylene propylene rubber liner (BMS1-50 or equivalent).

j. Mount the bottle in a tumbling mechanism inside an air convection oven at 180 ± 10 F such that the bottle will be rotated at approximately 5 r/min. Leave the bottle at this condition for 168 hours.

k. At the end of 168 hours, remove the bottle.

l. Remove the test specimens and treat each strip individually as follows:

Wash in acetone and dry. Remove any corrosion products remaining adherent to the metals by rubbing firmly with a piece of cheesecloth wetted with acetone. Dry again.

Weigh each strip and calculate the weight change in milligrams and milligrams/square centimeter.

m. Shake the test fluid thoroughly to suspend any particles present, and immediately remove sample(s) for determination of acid number, in accordance with ASTM D 974. After acid number has been confirmed, filter the test fluid through a fine metal screen or Millipore NR or equivalent phosphate ester resistant filter and determine viscosity on the filtrate at 100 F and 210 F, in accordance with ASTM D 445.

8.6 THERMAL STABILITY

Use the same test method as Section 8.5, except omit addition of water to the fluid, Section 8.5g., and test temperature shall be 250 ± 10 F instead of 180 ± 10 F, Section 8.5j.

8.7 FLAMMABILITY

8.7.1 FLAMMABILITY, WICK TEST (PIPE CLEANER TEST)

Arrange a means for cycling an ordinary pipe cleaner in a horizontal plane through or into the flame from a laboratory burner at a fixed rate of speed, preferably 30 to 40 cycles per minute. Soak the pipe cleaner with the test fluid and allow the excess to drain off. Adjust the burner with sufficient air to provide a nonluminous flame, but not enough to form a sharp liner cone. For best results, a flame height of approximately 4 inches is recommended. Cycle the pipe cleaner through or into the hottest part of the flame and count the number of cycles until a self-sustaining flame is achieved.

8.7.2 FLAMMABILITY, HIGH TEMPERATURE IGNITION TEST

8.7.2.1 Test Procedure

a. Assemble equipment for applying 1000 ± 50 psi to the test fluid. A suggested arrangement, shown in Figure 3, consists of a nitrogen bottle, a large hydraulic cylinder, and necessary lines, valves, and gages. Use a steel disc 0.063 inch thick with an orifice approximately 0.0145 inch in diameter to spray the fluid.

b. Charge the hydraulic cylinder with the test fluid. Apply nitrogen pressure so that the gage on the fluid side reads 1000 ± 50 psi. Open the valve at the orifice and attempt to ignite the spray at a point 1.5 to 12 inches from the orifice with an oxy-acetylene torch, using a No. 1 Purox tip, while maintaining the pressure at 1000 ± 50 psi. Record the result as follows: "Will not ignite", "flashes with difficulty", or "flashes readily". Also, indicate whether any flashing is self-extinguishing or results in a sustained fire.

8.7.2.2 Data Evaluation

Determine K_h as follows:

a.	Will not ignite	+ 20 points
b.	Flashes with difficulty	
	self-extinguishing	+ 15 points
	sustained fire	+ 5 points
c.	Flashes readily	
	self-extinguishing	+ 10 points
	sustained fire	0 points
d.	K_h = a *or* b *or* c	

8.7.2.2 Date Evaluation (Continued)

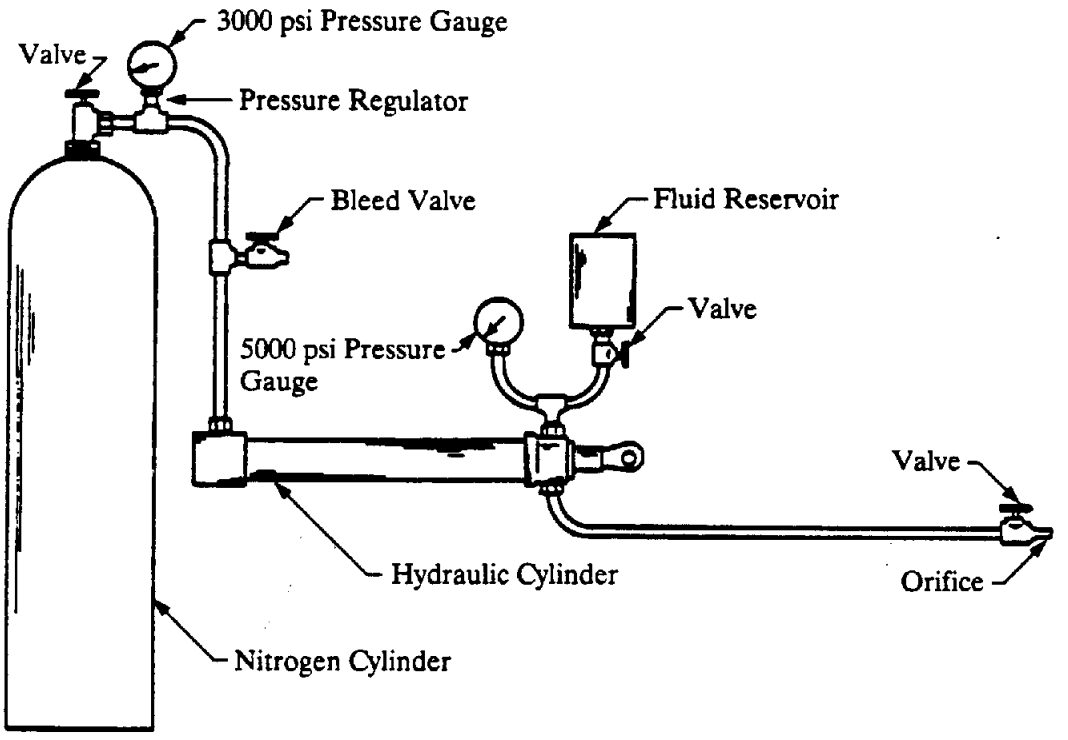
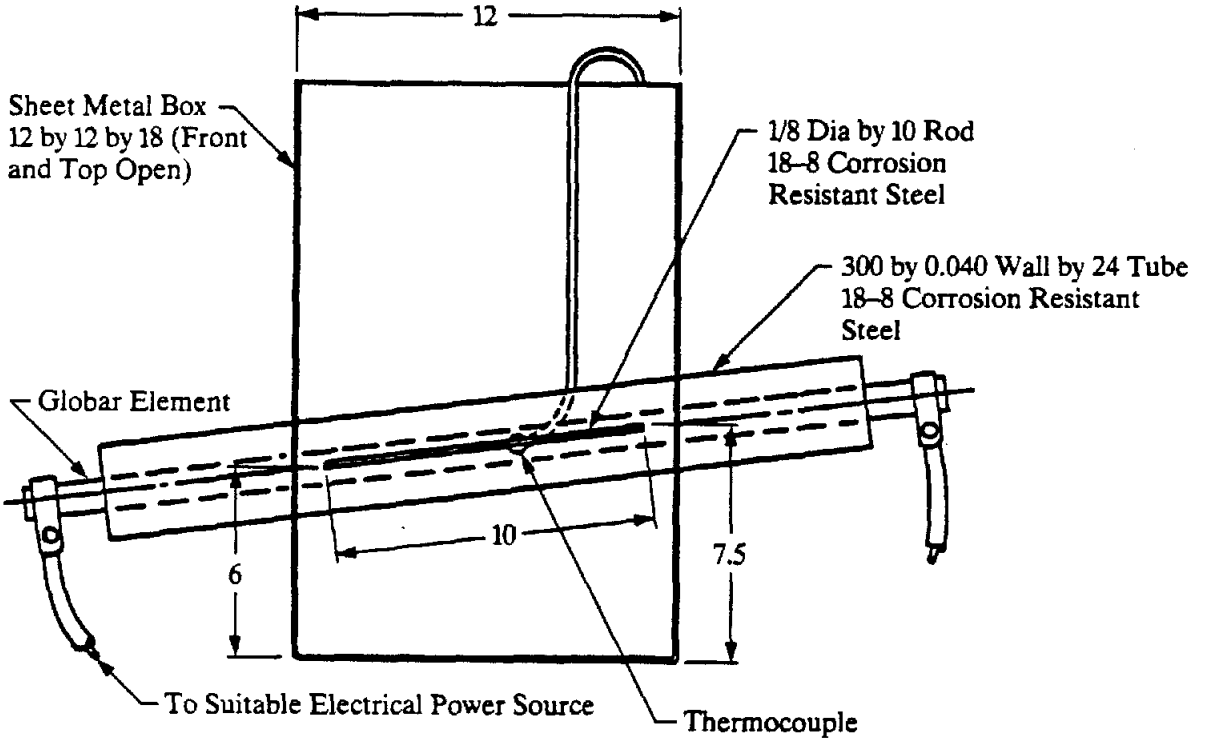


Figure 3 HIGH TEMPERATURE IGNITION TEST

8.7.2.2 Date Evaluation (Continued)



Dimensions are in inches. Values are nominal.

Figure 4 HOT MANIFOLD TEST

8.7.3 FLAMMABILITY, MANIFOLD TEST

8.7.3.1 Test Procedure

a. Fabricate a simulated exhaust stack section and mount in a shield as shown in Figure 4. Opposite the steel rod, spotweld a thermocouple and insulate the leads to ensure proper temperature readings. Insert a Globar element or equivalent (similar to Type AT, 31 inches by 12 inches by 1 inch, 0.633 ohms, manufactured by the Carborundum Company, Niagara Falls, New York) into the tube and make the necessary electrical connections. Adjust voltage so that the temperature of the tube is 1300 ± 25 F. Clean the tube before each series of tests with steel wool or by sandblasting.

b. Slowly pour 10 mL of test fluid on the simulated exhaust stack in not less than 40 seconds. Record the results as follows: "fluid burns on the tube", "fluid does not burn on the tube" and "burns", "flashes", or "does not burn" in the bottom of the shield.

8.7.3.2 Data Evaluation

Determine K_m as follows:

a.	Burns on tube	0 points
	Does not burn on tube	+ 5 points
b.	Burns on bottom of shield	0 points
	Flashes on bottom of shield	+ 5 points
	Does not burn on bottom of shield	+ 10 points
c.	$K_m = a + b$	

8.8 PUMPING TEST

a. The test system to be used is schematically shown in Figure 5. The hardware setup is available as BC368367. The system has a minimum capacity of 8 gallons with 20 percent of this fluid contained in the test section. The test section is to be controlled at a bulk fluid temperature of 250 ±10 F. Pump outlet flow is to be maintained such that the flow rate in gpm equals the volume of the fluid in the system. Pump outlet pressure is to be maintained at 2850 ± 50 psig.

b. Prior to beginning the test, the system is to be drained, the load valve and test section cylinders disassembled and cleaned, and new filters installed. The system is to be thoroughly flushed with new test fluid and then drained as completely as possible. The system will then be refilled with new test fluid, and that fluid is to be circulated for 15 minutes to bleed off entrained air or gas. An initial fluid sample will be taken as a base for property comparisons.

c. Fluid is to be circulated for a test duration of 500 hours. Test system operation will be set up for completely automatic cycling to allow continuous operation with minimum personnel attention. Safety provisions will be connected to shut down the test if the fluid level in the reservoir becomes too low, if higher than predetermined fluid temperatures are reached, or if system low pressure occurs. Filter differential pressure indicators will be provided and calibrated for 40 psid indication at maximum travel.

d. Short term elevated temperature: After completing 500 hours, the control temperature is to be raised 25 F (to 275 F). Testing is to be restarted and 5 hours completed at the raised temperature to demonstrate acceptability for short durations at elevated temperatures.

e. Fluid samples will be taken at approximately 100 hours, 200 hours and 350 hours during bulk fluid temperature testing. Samples will also be taken at the conclusion of the 500 hours and at the conclusion of short term elevated temperature testing. No makeup fluid will be added to the system during the test. The samples removed will be tested for:

   Acid number in accordance with ASTM D 974

   Viscosity at 100 F and 210 F in accordance with ASTM D 445.

f. After completing the pumping test, or at any time a component is removed during the test in progress, a disassembly to inspect for evidence of erosion, unusual deposits, or unacceptable wear will be performed

8.8 PUMPING TEST (Continued)

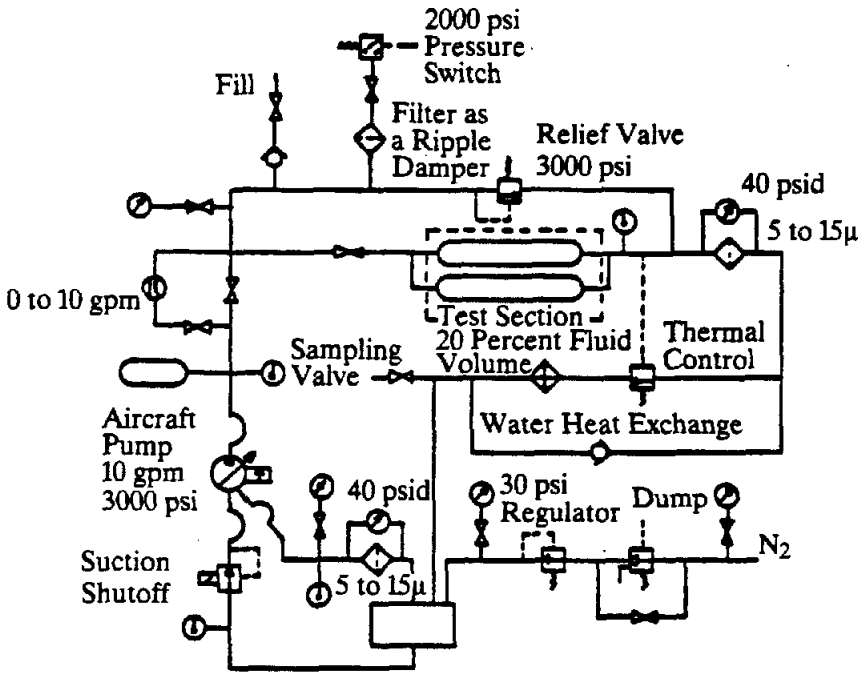


Figure 5 PUMPING TEST SYSTEM BC368367

8.9 EROSION TESTS

8.9.1 TYPE IV EROSION RESISTANCE TEST

8.9.1.1 Grade A Fluid (Test Temperature 225 ± 10 F)

a. The test system to be used is schematically shown in Figure 6. The test hardware is available as either BC368441 or BC368442. The test system requires a minimum quantity of 2.5 gallons of fluid under test. A maximum of 5.0 gallons may be used. Fluid bulk temperature is to be maintained at 225 ± 10 F. Nominal system pressure shall be 3000 psig with a minimum of 2850 psig allowable if the bypass valve is used in a open position as a means of regulating system temperature.

b. Prior to beginning the test, the system is to be drained of any previously tested fluid and flushed with the fluid to be tested. Flushing is to be accomplished using 2 to 3 gallons of new fluid circulated through a combination of both the erode and desilt loops for a total of 0.5 hours. A second flush will be accomplished in the same manner, if considered necessary, to thoroughly clean the system. Flushing fluid is to be drained and not to be reused.

8.9.1.1 Grade A Fluid (Test Temperature 225 ± 10 F) (Continued)

c. A measured volume of new test fluid of near maximum capacity for the system is to be installed, and air bleeding procedures conducted. The system is to be operated a minimum of 2 hours at 225 ± 10 F through a combination of both the erode and desilt loops. The test valve, Figure 7, is then to be calibrated for flow gain at 225 ± 10 F and set to operate within the knee of the flow gain curve, as illustrated on Figure 8. The calibration is to be accomplished by repeating testing for flow gain until five consecutive curves are obtained. Total accumulated time of operation during run-in and calibration is to be a minimum of 4 hours.

d. Operate the system through automatic sequencing for 500 hours beginning with the accomplishment of the test valve calibration. The automatic sequence is a 5 minute cycle, the last 6 seconds of this cycle being the desilt cycle. For 2 of the 6 seconds the valve slide shall be shuttled to a fully open position. Throughout the 500 hours of testing the two sleeve lock screws (see Figure 7) shall be retorqued to 45 ± 5 in-lb on a periodic cycle (no less frequent than 96 hour intervals). A record of system pressure, temperature and leakage flow will be obtained at least each 10 hours.

e. After the first 200 hours of testing add methyl chloroform (1,1,1-trichloroethane) to yield 1000 ppm +200/-000 by weight of chlorine, in the fluid to be qualified, by injection through the hypodermic valve installed in the system for this purpose. Circulate fluid for at least 15 minutes with system bypass partially open to insure uniform distribution of the methyl chloroform and to restore the system bulk fluid temperature to 225 ±10 F.

f. Test fluid samples will be taken at the hypodermic valve within 0.5 hours of the beginning of test, after the addition of chlorine at 200 hours, and at the completion of 500 hours. The samples will be checked for total chlorine against the amount added in step 8.9.1.1e. and retained for chemical analysis. The increase in leakage flow through the valve will be compared to allowable.

8.9.1.2 Grade B Fluid (Test Temperature 100 ± 10 F)

a. The test system to be used is schematically shown in Figure 6. The test hardware is available as either BC368441 or BC368442. The test system requires a minimum quantity of 2.5 gallons of fluid under test. A maximum of 5.0 gallons may be used. Fluid bulk temperature is to be maintained at 100 ± 10 F. Nominal system pressure shall be 3000 psig with a minimum of 2850 psig allowable if the bypass valve is used in an open position as a means of regulating system temperature.

b. Prior to beginning the test, the system is to be drained of any previously tested fluid and flushed with the fluid to be tested. Flushing is to be accomplished using 2 to 3 gallons of new fluid circulated through a combination of both the erode and desilt loops for a total of 0.5 hour. A second flush will be accomplished in the same manner, if considered necessary, to thoroughly clean the system. Flushing fluid is to be drained and not to be reused.

8.9.1.2 Grade B Fluid (Test Temperature 100 ± 10 F) (Continued)

c. A measured volume of new test fluid of near maximum capacity for the system is to be installed, and air bleeding procedures conducted. The system is to be operated a minimum of 2 hours at 100 ± 10 F through a combination of both the erode and desilt loops. The test valve, Figure 7, is then to be calibrated for flow gain at 100 ± 10 F and set to operate within the knee of the flow gain curve, as illustrated on Figure 8. The calibration is to be accomplished by repeating testing for flow gain until five consecutive curves are obtained. Total accumulated time of operation during run-in and calibration is to be a minimum of 4 hours.

d. Add methyl chloroform (1,1,1-trichloroethane) to yield 1000 ppm +200/-000 by weight of chlorine, in the fluid to be qualified, by injection through the hypodermic valve installed in the system for this purpose. Circulate fluid for 15 minutes with system bypass partially open to insure uniform distribution of the methyl chloroform.

e. Operate the system through automatic sequencing for 300 hours, beginning with the addition of the methyl chloroform. The automatic sequence is a 5-minute cycle, the last 6 seconds of this cycle being the desilt cycle. The 6 seconds will include 2 seconds at full open stroke, in each direction of the valve slide. Throughout the 300 hours of testing the two sleeve lock screws (see Figure 7) shall be retorqued to 45 ± 5 in-lb on a periodic cycle (no less frequent than 96 hour intervals). A record of system pressure, temperature, and leakage flow will be obtained each 10 hours.

f. Test fluid samples will be taken at the hypodermic valve within 0.5 hours of the beginning of test and at the conclusion of 300 hours. The samples will be checked for total chlorine against the amount added in step Section 8.9.1.2d. The increase in leakage flow through the valve will be compared to allowable.

8.9.2 TYPE IV EROSION CONTROL TEST

NOTE: Grade A Fluid: (Test Temperature 225 ± 10 F)
Grade B Fluid: (Test Temperature 100 ± 10 F)

a. The test setup used is the same as in Section 8.9.1.

b. Prior to beginning of the test, the system is to be drained of any previously tested fluid, and flushed with SAE AS 1241 test fluid 1 (obtained from Monsanto Chemical Company). Flushing is to be accomplished at less than 110 F and using 2 to 3 gallons of new fluid, circulated through a combination of both the erode and desilt loops for a total of 0.5 hours. Repeat with a second flush using new fluid. Flushing fluid is to be drained and not to be reused.

c. A measured volume of 2.5 gallons of clean SAE AS 1241 test fluid 1 is to be installed, and air bleeding procedures conducted. The system is to be operated at less than 110 F for a minimum of 2 hours through a combination of both the erode and desilt loops. The test valve, Figure 7, is then to be calibrated at 110 ±10 F for flow gain, as in Section 8.9.1. Valves with leakage at the calibrated test position of greater than 750 cm^3/min shall not be used. The total accumulated time of operation during run-in and calibration is to be a minimum of 4 hours.

8.9.2 TYPE IV EROSION CONTROL TEST (Continued)

d. Add methyl chloroform (1,1,1-trichloroethane) to yield 1000 ppm +200/-000 by weight of chlorine, in the fluid to be qualified, by injection through the hypodermic valve installed in the system for this purpose. Circulate fluid through the automatic valve cycle operation (5-minute erode/desilt cycle) for 15 minutes and take samples of fluid for analysis as described in Section 8.9.1 while operating at 110 ± 10 F. The leakage change shall result in an average straight line slope of greater than 100 cm^3/min/h over a 5 hour period with such slope demonstrated within 100 hours of test initiation with methyl chloroform. Valve leakage will not be allowed to exceed 2000 cc/min in obtaining this result.

e. Upon obtaining the above slope, the test will be stopped and the total fluid volume in the system (corrected to room temperature) will be determined based on the reservoir volume level indication. This volume may be slightly lower than the 2.5 gallons at the initiation of the test due to system bleed and minor fluid leaks. Add a quantity of the candidate fluid equal to the total volume that is determined to presently be in the system established above. The mixture will be circulated for 15 minutes with system bypass partially open to assure uniform mixing. Take a fluid sample for analysis as described in Section 8.9.1.

f. Operate the system at grade test temperature by automatic cycling (5-minute erode/desilt cycle) beginning with the addition of the candidate fluid. Conduct a 300 hour test under this operation beginning 1 hour after the addition of the Type IV fluid. Throughout the 300 hours of testing the two sleeve lock screws (see Figure 7) shall be retorqued to 45 ± 5 in-lb on a periodic cycle (no less frequent than 96-hour intervals). A record of system pressure, temperature and valve leakage shall be obtained each 10 hours during the 300 hour test.

g. Test fluid samples will be taken and analyzed as in Section 8.9.1 at the conclusion of testing. Total chlorine will be greater than 500 ppm. The increase in leakage flow will be compared to allowable requirements.

8.9.2 TYPE IV EROSION CONTROL TEST (Continued)

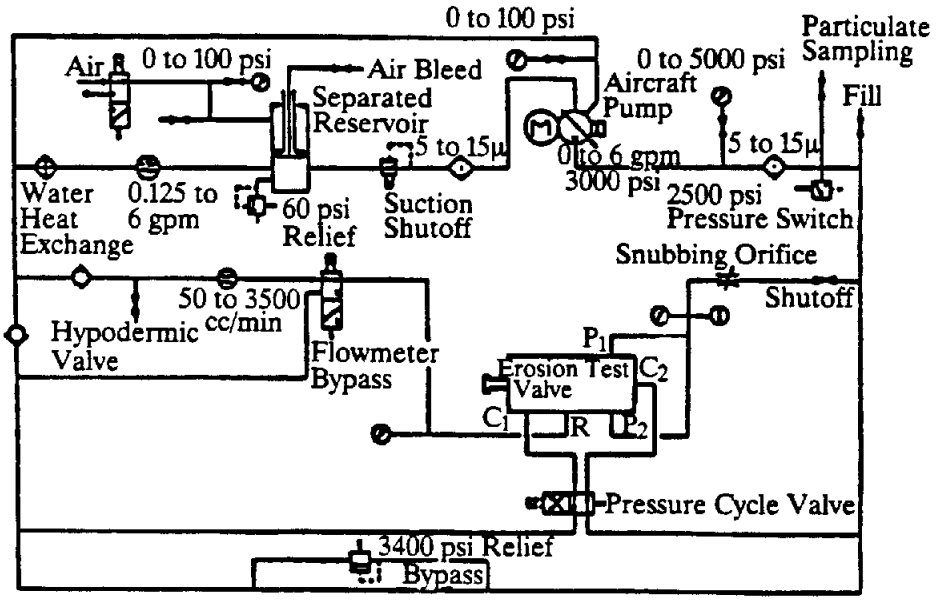


Figure 6 EROSION TEST SYSTEM BC368441 AND BC368442

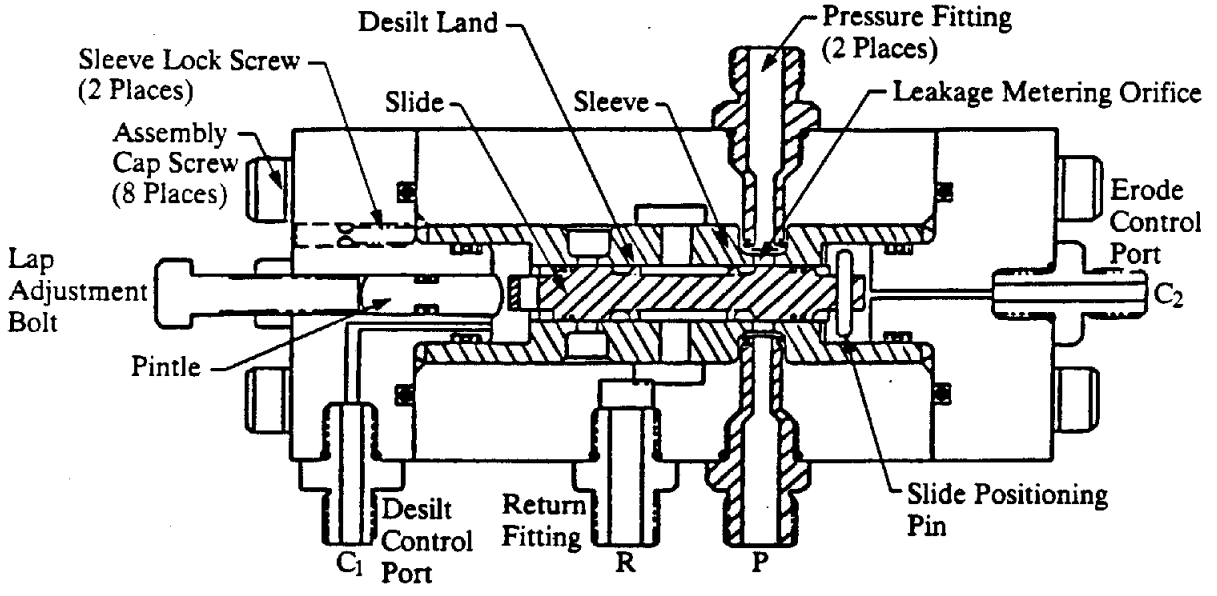


Figure 7 EROSION TEST VALVE 65-87781

8.9.2 TYPE IV EROSION CONTROL TEST (Continued)

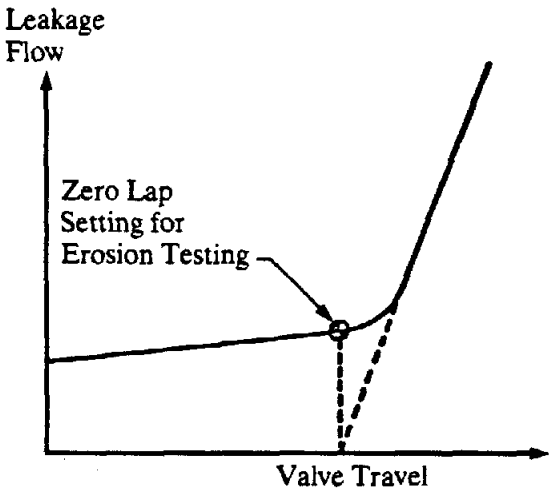


Figure 8 EROSION TEST FLOW GAIN CALIBRATION

8.10 PENCIL HARDNESS

a. Prepare test panels of 2024-T3 alclad treated with Alodine 1000 in accordance with BAC5719. Coat these test panels with BMS10-11, Type I primer in accordance with BAC5736 and topcoat with BMS10-60, Type II in accordance with BAC5845. Dry coating for a minimum of 168 hours.

b. Immerse one or more test panels into each hydraulic fluid at room temperature. Observe daily for evidence of softening or deterioration of the paint. After 30 days, remove test panels and make a pencil hardness test.

c. Wipe hydraulic fluid off test panel with an absorbent towelling, followed by a solvent wash with TT-N-95 naphtha. Wipe test panel dry with gauze.

d. Lay test panel flat and determine pencil hardness adhesion as follows:

(1) Use a set of drawing pencils **FL 1** ranging in hardness from 6B to 5H. Strip the wood away for about 3/8 inch and square the end by holding the tip of the pencil in a vertical position and move the lead back and forth over a piece of 400 grit or finer sandpaper. Square the tip after each trial test.

(2) Start with the softest lead first. Push the lead across the coated surface of the test panel at a 45 degree angle until one is found which will cut or scratch the coating. The number of the lead of this pencil shall be used to express the pencil hardness.

FL 1 The following drafting leads are acceptable:

(1) KOH-I-NOOR 1500

(2) Venus drawing pencils

(3) A. W. Faber-Castell

(4) Eagle Turquoise

(5) Clutch-type holder (i.e., Locktite 9400) and leads to fit.

8.11 ANALYTICAL METHODS

8.11.1 X-RAY FLUORESCENCE DETERMINATIONS

Determine calcium, chlorine, potassium and sulfur by X-ray fluorescence, using the Siemens Sequential X-ray-Spectrometer, Model SRS-1, or any other method capable of verifying the requirement within the following accuracies:

Calcium	± 4 ppm from 0 to 150 ppm
Potassium	± 2 ppm from 0 to 150 ppm
Chlorine	± 20 ppm from 0 to 500 ppm
Sulfur	± 10 ppm from 0 to 1000 ppm
Sulfur	± 50 ppm from 1000 to 3000 ppm

8.11.2 ATOMIC ABSORPTION DETERMINATIONS

Determine sodium by flameless Atomic Absorption Spectroscopy, or any other method capable of an accuracy of ± 3 ppm from 0 to 60 ppm.

9 MATERIAL IDENTIFICATION

The fluid shall be purple in color.

10 PACKAGING AND MARKING

a. Unless otherwise specified, the hydraulic fluid shall be supplied in 55-gallon drums. The drums or containers shall be clean and not lined with material that is soluble in, or might contaminate, the hydraulic fluid.

b. All labeling shall conform to OSHA 1910.1200.

(1) Hydraulic Fluid, Fire-Resistant

(2) BMS3-11, latest revision letter and Type, Class and Grade as applicable

(3) Supplier's name

(4) Batch number

(5) Date of manufacture

(6) Supplier's designation or number

(7) Quantity

(8) Purchase order number

(9) Shipments to The Boeing Company shall be marked with the following words:

CAUTION MAY CAUSE EYE OR SKIN IRRITATION. AVOID EYE OR SKIN CONTACT. IN CASE OF EXPOSURE, FLUSH SKIN WITH WATER. IN CASE OF EYE CONTACT, FLUSH WITH WATER AND OBTAIN MEDICAL AID.

MATERIAL CLASSIFICATION	SUPPLIER PRODUCT DESIGNATION	SUPPLIER	QUALIFYING COMPANY	DATE
Type IV, Class 1, Grade A	Skydrol LD4	Monsanto Chemical Group 800 N. Lindbergh Boulevard St. Louis, MO 63166 Specific Gravity = 1.009 Viscosity at 100 F = 11.15 cs at 210 F = 3.86 cs	BCAG	16-AUG-1977
	Chevron Hyjet IV-A	Chevron International Oil Co., Inc. 555 Market Street San Francisco, CA 94120 Specific Gravity = 0.998 Viscosity at 100 F = 10.13 cs at 210 F = 3.42 cs	BCAG	29-JUL-1987
	Chevron Hyjet IV-A Plus	Chevron International Oil Co., Inc. Specific Gravity = 0.999 Viscosity at 100 F = 10.32 cs at 210 F = 3.80 cs	BCAG	17-DEC-1993
Type IV, Class 2, Grade A	Skydrol 500B-4	Monsanto Chemical Group Specific Gravity = 1.056 Viscosity at 100 F = 11.90 cs at 210 F = 3.88 cs	BCAG	16-AUG-1977