SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS2078

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Reaffirmed 2007-08

Test Methods, Hose Assemblies, Polytetrafluoroethylene (PTFE)

RATIONALE

This document has been reaffirmed to comply with the SAE 5-Year Review policy.

This standard is equivalent to MA2078 (ISO 8829) except that Imperial Units are used.

FOREWORD

This standard has been prepared to standardize on the test methods for qualification of polytetrafluoroethylene (PTFE) hose and hose assemblies used in aircraft fluid systems. Compliance with these test methods is necessary for hose and hose assemblies which are used in systems where a malfunction could affect the safety of flight.

1. SCOPE AND FIELD OF APPLICATION:

   This SAE Standard describes the test methods for flexible PTFE hose and hose assemblies used in aircraft fluid systems in the pressure and temperature ranges defined in specific procurement specifications. It applies to the hose and the hose coupling. The tests and assembly requirements for the connecting end fitting are covered in the procurement specification.

   This document applies each time that it is referred to in a procurement specification or other definition document.

   Fluids and materials used for the tests are listed in Section 2.

2. REFERENCES:

2.1 Specifications:

2.1.1 Federal:

P-D-680	Dry Cleaning Solvent
TT-I-735	Isopropyl Alcohol
TT-S-735	Standard Test Fluids, Hydrocarbon

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2.1.2 Military:

MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-T-5624	Turbine Fuel, Aviation, Grade JP4, JP5, JP5/JP8 ST
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-C-81302	Cleaning Compound, Solvent, Trichlorotrifluoroethane
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic, Hydrocarbon Base, Aircraft

Copies may be obtained from the Standardization Document Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.2 Standards:

ARP603	Impulse Testing of Hydraulic Hose, Tubing and Fitting Assemblies
ARP1153	Method for Determining Relative Specific Gravity, PTFE Tubing
AS1055	Fire Resistance, Fire Test and Performance Requirements for Flexible Hose and Rigid Tube Assemblies

Copies may be obtained from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.3 Other Publications:

ASTM D 380	Testing Rubber Hose
ASTM D 792	Specific Gravity and Density of Plastics by Displacement
ASTM D 1457	PTFE Molding and Extrusion Materials

Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

2.4 Definitions:

ROOM TEMPERATURE: Temperature in the test laboratory between 60 and 90°F.

SLEEVE: Flame and heat retardant elements, normally tubular, slipped over the hose assembly and fastened at the hose fitting.

FIRE CUFF: Flame and fire retardant element, normally (silicone) rubber, molded over the hose and hose fittings.

3. TESTS ON PTFE INNER TUBES:

3.1 Density and Relative Density:

This test is intended to control the crystallinity of PTFE inner tubes. The relative density of PTFE tubing shall be measured in accordance with ARP1153. The density of the PTFE tubing shall be measured in accordance with ASTM D 792.

3.2 Tensile Test and Elongation:

This test is intended to determine the mechanical properties of the PTFE tubing.

3.2.1 Test Conditions: Test specimens shall be conditioned for at least 2 h at room temperature before testing (see 2.4).

3.2.2 Testing Machine: Tension tests shall be conducted on a power-driven machine which maintains a uniform rate of grip separation at 2 in/min and which has a suitable dynamometer and a device for measuring the applied force within ±2%. If the capacity range cannot be changed during a test as in the case of pendulum dynamometers, the applied force at break shall be measured within ±2%, and the smallest tensile force measured shall be accurate to within ±10%. If the dynamometer is of the compensating type for measuring tensile stress directly, means shall be provided to adjust for the cross-sectional area of the specimen. The response of the recorder shall be sufficiently rapid that the applied force is measured accurately during the extension of the specimen to rupture. If the test machine is not equipped with a recorder, a device shall be provided that indicates after rupture the maximum force applied during extension. Test machines shall be capable of measuring elongation in increments of 10%.

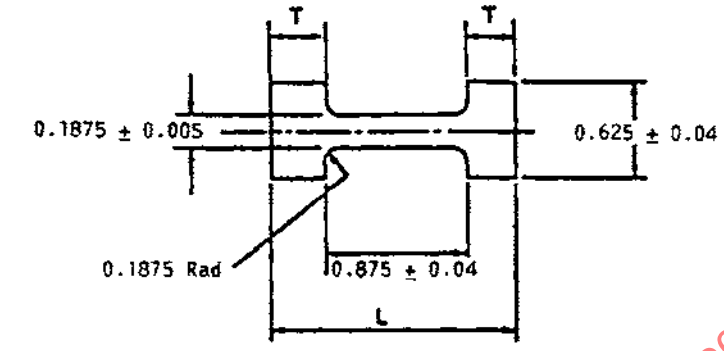
3.2.3 Micrometers: The micrometer used for measuring flat specimen thickness shall be capable of exerting a pressure of 3.6 psi ± 0.7 on the specimens and of measuring the thickness to within ±0.001 in.

NOTE: Dial micrometers exerting a force of 80 g force on a circular foot 0.25 inch in diameter, or 20 g force on a circular foot 0.125 inch in diameter conform to this pressure requirement. A micrometer should not be used to measure the thickness of specimens narrower in width than the diameter of the foot unless the contact pressure is properly adjusted.

3.2.4 Calibration of Testing Machine: The testing machine shall be calibrated. If the dynamometer is of the strain-gage type, calibrate the test machine at one or more forces at regular intervals.

3.2.5 Tensile Test Specimens: Tensile test specimens shall be in accordance with Figure 1.

NOTE: Careful maintenance of die cutting edges is of extreme importance and can be obtained by light daily honing and touching up the cutting edges with jewelers' hard honing stones. The condition of the die may be judged by investigating the rupture point on any series of broken specimens. When broken specimens are removed from the clamps of the testing machine, it is advantageous to pile these specimens and note if there is any tendency to break at or near the same portion of each specimen. Rupture points consistently occurring at the same place may be an indication that the die is dull, nicked, or bent at that particular position.



Dimensions in inch
Thickness = Measured Thickness of Specimen
Minimum Tab Length T = 0.3125
Minimum Length L = 1.50

FIGURE 1 - Tensile Test Specimen

3.2.6 Determination of Tensile Strength and Elongation: Place the specimens in the jaws of the testing machine, using care to adjust the specimen symmetrically in order that the tension will be distributed uniformly over the cross section. Start the machine and note continuously the distance between the jaws, taking care to avoid parallax. At rupture, measure and record the elongation to the nearest 10% on the scale.

3.2.7 Calculation:

a. Calculate the tensile strength as follows:

$$\text{Tensile strength (psi)} = F/A \qquad \text{(Eq. 1)}$$

where:

F = observed force, in pounds, required to rupture the specimens
A = cross-sectional area in in^2, of the unstretched specimen

b. Calculate the elongation as follows:

$$\text{Elongation, \%} = (L - L_o)/L_o \times 100 \qquad \text{(Eq. 2)}$$

where:

L = observed distance between the jaws at rupture of the specimen
L_o = original distance between the jaws

3.3 Tube Roll and Proof Test:

This test is intended to verify that there are no flaws in the sintered tube.

3.3.1 Tube Rolling: Each tube shall be passed, in a single pass, through six sets of metal rollers so that it is subjected to the following sequence of diametral flexings; rollers shall be arranged to prevent inadvertent rotation of the tube. It is assumed that the tube is in a horizontal position and that pressure of the first set of rolls is exerted vertically; angles given for the final three sets of rolls may be taken as either clockwise or counterclockwise from the vertical diameter of the tube. Roller angles are specified in Table 1. A tolerance of ±2° is allowed on each roller angle. The roller gap dimensions are specified in Table 2.

Roller gaps shall not be larger than specified in Table 2 for each size.

TABLE 1 - Roller Functions and Angles

Phase	Type of Action	Roller Angle, Degree
A	Flattening	0
B	Flattening	90
C	Rounding	0
D	Flattening	45
E	Flattening	135
F	Rounding	45

TABLE 2 - Gap Dimensions for Rolling[1]

Size	Flattening Gap Maximum (inch) 1500 psi Hose	Flattening Gap Maximum (inch) 3000 and Higher psi Hose	Rounding Gap Maximum (inch) 1500 psi Hose	Rounding Gap Maximum (inch) 3000 and Higher psi Hose
03	0.203	.203	0.218	.250
04	0.218	.281	0.218	.250
05	0.218	--	0.250	--
06	0.218	.281	0.312	.328
08	0.234	.328	0.375	.469
10	0.250	.328	0.500	.578
12	0.250	.328	0.500	.688
14	--	.328	--	.765
16	0.250	.328	0.750	.828
20	0.312	.438	0.875	1.000
24	0.375	--	1.250	--

[1]8000 psi odd size high pressure hose assembly callout will utilize lower even hose size except for -03 size. (Example: -07 assy = -06 hose.)

3.3.2 Proof Test: Following the roll test, the tube shall be held for not less than 2 min at pressures as shown in Table 3 using water or air as the test medium.

TABLE 3 - Proof Pressures of Hose Inner Tube[1]

Size	Proof Pressure – Minimum (psi) 1500 psi Hose	Proof Pressure – Minimum (psi) 3000 and Higher psi Hose
03	390	480
04	360	380
05	290	--
06	230	280
08	180	220
10	170	170
12	140	130
14	--	110
16	90	95
20	65	95
24	45	--

[1]8000 psi odd size high pressure hose assembly callout will utilize lower even hose size except for -03 size. (Example: -07 assy = -06 hose.)

3.4 Electrical Conductivity Test:

3.4.1 The test specimen shall be a 14 in length of PTFE hose tube without braid. The inner surface of the tube shall be washed first with solvent per P-D-680 and then with isopropyl alcohol per TT-I-735 to remove surface contamination. The tube inside shall then be thoroughly dried at room temperature.

3.4.2 The test specimen shall then be arranged vertically as shown on Figure 2. The relative humidity shall be kept below 70%. Apply 1000 V DC between the upper saltwater electrode and the lower (adapter) electrode. The saltwater solution shall be 450 g of Na Cl in 1 ℓ chemically pure water.

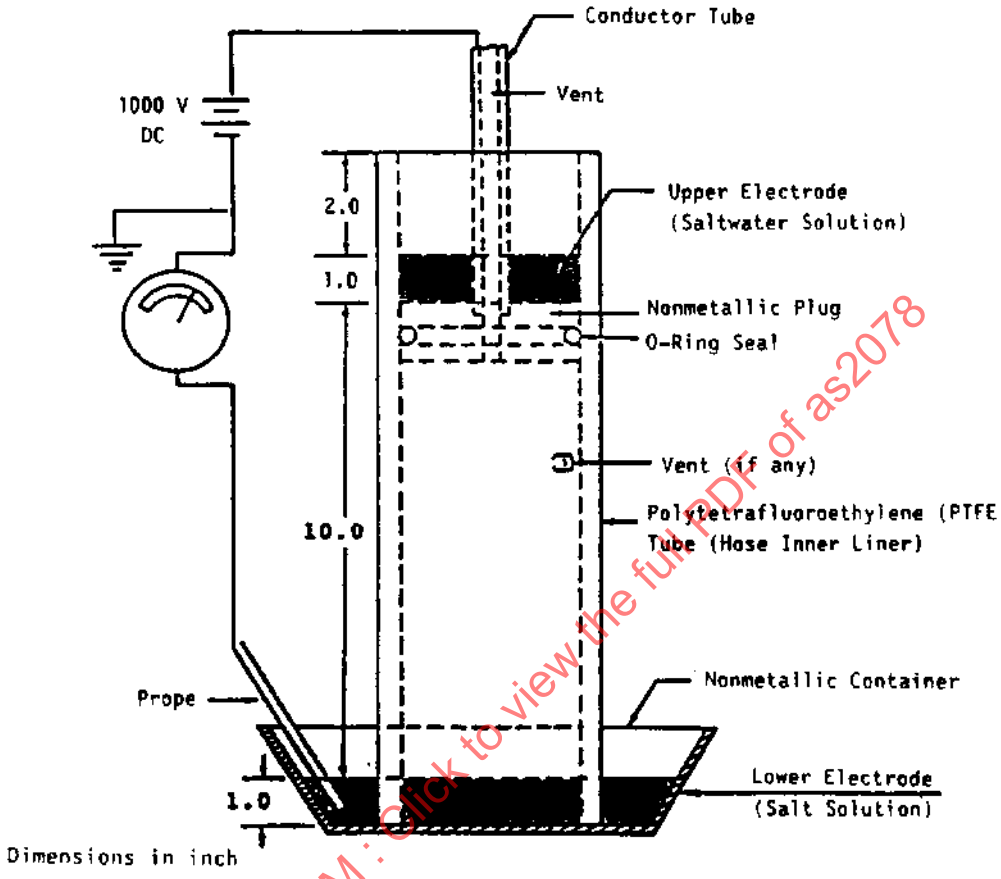


FIGURE 2 - Diagram for the Electrical Conductivity Test of Lining

3.4.3 The current shall be measured with an instrument with a sensitivity of at least 1 μA (1 x 10^{-6}).

4. HOSE AND HOSE ASSEMBLY TESTS:

4.1 Stress Degradation Test:

This test is intended to verify that the hose inner tube has been sintered and quenched to the proper crystallinity to eliminate stress cracking or creep with subsequent leakage.

4.1.1 Hose (3000 psi and Higher): The hose assemblies shall be subjected to the following test sequence:

a. The hose assemblies shall be filled with a high temperature test fluid per MIL-L-7808 or MIL-H-83282 and placed in an oven that shall be maintained at 400 °F ± 10. The nominal operating pressure specified by the procurement specification shall be applied to the hose assemblies.

NOTE: Precautions shall be taken to assure that the hose assemblies do not come in contact with parts of the oven that are at a higher temperature.

b. After a minimum of 20 h at 400 °F, the pressure shall be gradually released and the assemblies removed from the oven, drained, and cooled to room temperature. The assemblies shall then be flushed with a quantity of new test fluid equivalent in volume to at least twice the test sample volume and drained.

c. The hose assemblies shall then be filled with hydraulic test fluid per MIL-H-5606. The nominal operating pressure specified by the procurement specification shall be applied and held for a minimum of 2 h at room temperature.

d. The procedure specified in steps a, b, and c shall be repeated for a total of three cycles.

e. Within 4 h after the final 2 h pressurization period, the hose assemblies shall be drained and flushed with trichlorotrifluoroethane per MIL-C-81302 and placed in an oven for 1 h. The temperature of the oven shall be maintained at 160 °F ± 10.

f. Within 8 h after completion of the drying process the hose assemblies shall be removed from the oven, cooled to room temperature, and then subjected to an air underwater test. To conduct this test, the hose assemblies shall be installed in an apparatus constructed similar to that shown in Figure 3.

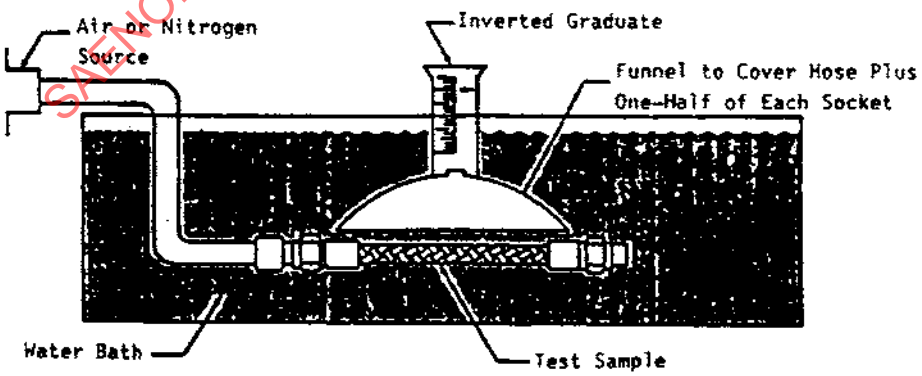


FIGURE 3 - Test Setup for Pneumatic Effusion Tests

4.1.1 (Continued):

g. The test setup with the installed hose assembly shall be immersed in water. Nominal operating pressure shall be applied for 15 min to allow any entrapped air in the hose to escape.

h. The pressure shall be held for an additional 5 min period, during which time the effused gas shall be collected from the test sample, including the juncture of the hose and the fitting, but not including the fitting nut. After the 5 min period of pressurization, the average rate of effusion through the hose and two fittings shall be computed into cubic centimeter per minute per inch of hose length.

4.1.2 Hose (1500 psi): The hose assemblies shall be tested in the same manner as specified in 4.1.1 except that the test temperature shall be 450 °F ± 10 instead of 400 °F.

4.2 Pneumatic Effusion Test:

This test is intended to show that the hose inner tube does not have excessive porosity. The hose assemblies shall be subjected to a nominal operating pressure for 1 h using dry air or N_2 at room temperature. The gas escaping from the hose assembly during the second half hour shall be collected and measured using the water displacement method and an air collecting device similar to that depicted in Figure 3.

NOTE: The fluid in the test device shall be water that has been treated for pH control and wetting of the hose by adding 1.5% by volume of water softener or wetting agent.

4.3 Electrical Conductivity Test:

This test is intended to show that the tube is sufficiently conductive to prevent buildup of excessive electrostatic charges, which could cause arcing and pin holes. The conductivity test shall be conducted as follows:

a. The test specimen shall be a length of hose (with braid and one end fitting) as shown in Figure 4. The inner surface of the tube shall be washed first with solvent per P-D-680, then with isopropyl alcohol per TT-I-735 to remove surface contamination, and then thoroughly dried at room temperature. The wire braid shall flare out as shown in Figure 4 to prevent contact with the end of the PTFE tube. One steel adapter of appropriate size shall be assembled to the hose end fitting as shown on Figure 4.

b. The test specimen shall then be arranged vertically. The relative humidity shall be kept below 70%. Apply 1000 V DC between the upper saltwater electrode and the lower (adapter) electrode. The saltwater solution shall be 450 g Na Cl in 1 ℓ chemically pure water.

c. The current shall be measured with an instrument with a sensitivity of at least 1 μA (1×10^{-6} A).

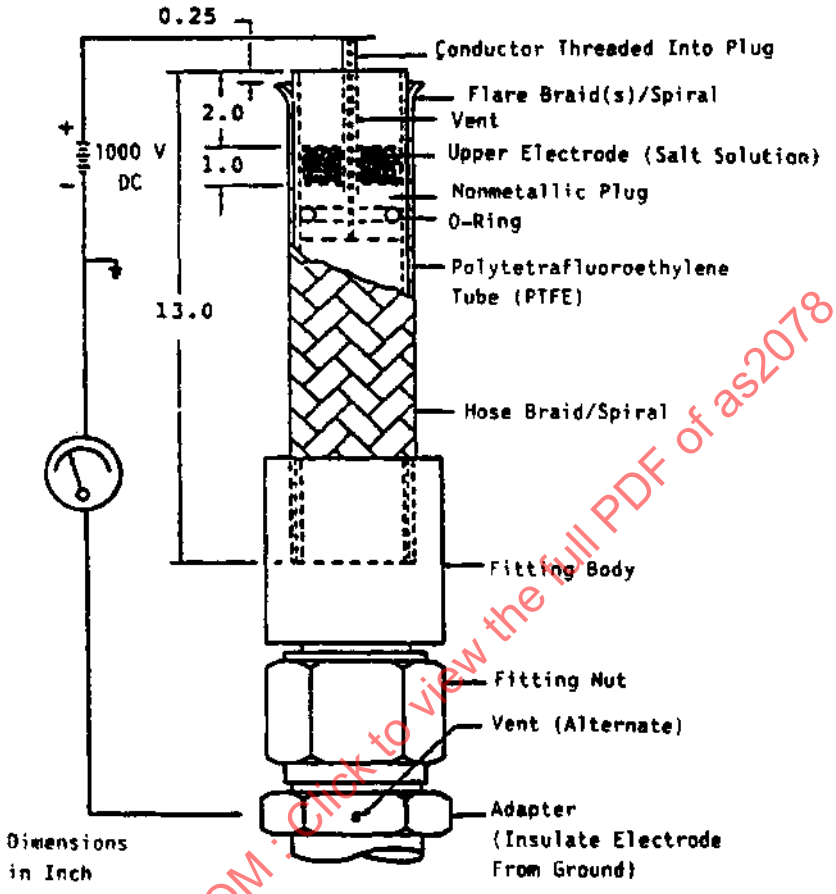


FIGURE 4 - Conductivity Test Setup, Braided Hose

4.4 Visual and Dimensional Inspection:

Hose assemblies shall be inspected using the normal tools and procedures.

4.5 Elongation and Contraction:

This test is intended to verify that the proper reinforcing braid angle was used to minimize axial motion due to pressurization. With the hose held in a straight position, unpressurized, a 10 in gage length shall be marked off on the hose and the hose then subjected to the nominal operating pressure shown in the procurement specification. After a minimum of 5 min, while still pressurized, the gage length shall be measured and the change in length calculated.

4.6 Volumetric Expansion:

This test is intended to determine the increase in volume that occurs when a hose assembly is pressurized.

4.6.1 Test Setup: The test setup shall be designed in such a way that air pockets cannot form. There shall be only one low point between the reservoir and the pump (see Figure 5). The internal passages shall not have constrictions or surface roughness that could allow air pockets. The hose end fittings and system tubes shall be sufficiently strong and rigid to allow only negligible expansion under test pressure. The test fluid shall be distilled water. The pump pressure shall be increased at a rate of 250 to 580 psi/s.

4.6.2 Variation in Volume: The test procedure shall be as follows and as illustrated in Figure 5.

a. The hose assembly to be tested shall be installed at D.
b. The valve C shall be set to the position indicated in the diagram.
c. The valve E shall be opened.
d. The valve F shall be closed.
e. The pump shall be operated until the water is visible in the tube G.
f. The valve E shall be closed.
g. The hose assembly shall be subjected to the appropriate proof pressure for 3 min and the system checked for leakage.
h. The valve E shall be opened.
i. The water level shall be brought to zero in tube G using the pump and valve F.
j. The valve F and then valve E shall be closed.
k. The pressure in the system shall be raised to the appropriate operating pressure and held there for 3 to 6 min.
l. The valve C shall be closed.
m. The valve E shall be opened.
n. The increase in the volume of the hose assembly is indicated by the difference in level in the graduated tube. Subtract from this the expansion of the rest of the system which has been measured beforehand.

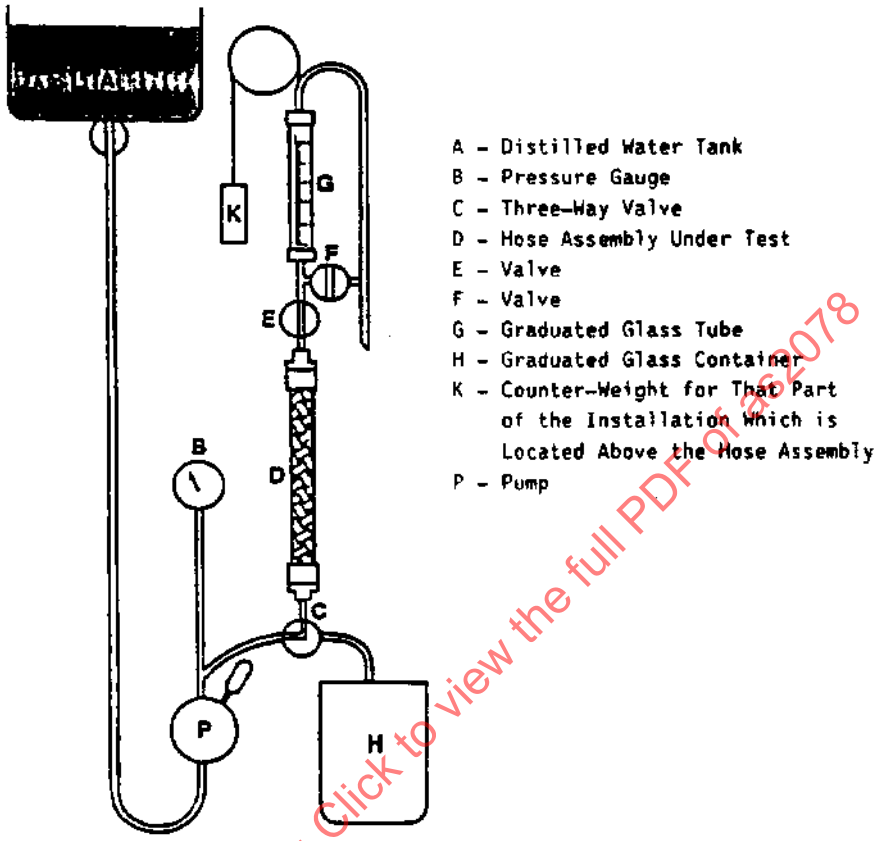


FIGURE 5 - Volumetric Expansion Test Setup

4.7 Leakage Test:

This test is intended to demonstrate that the hose will not rupture at 70% of the minimum required burst pressure. The hose assemblies shall be pressurized with water or system fluid to 70% of the minimum room temperature burst pressure shown in the procurement specification and held for 5 min minimum. The pressure shall then be reduced to 0 psi, after which it shall again be raised to 70% of the minimum room temperature burst pressure for a final 5 min check.

4.8 Proof Pressure Test:

This test is intended to verify the structural integrity of a hose assembly prior to its use. All hose assemblies shall be tested to the proof pressure specified in the procurement specification for not less than 30 s and not more than 5 min. The test fluid may be either water or system fluid. The proof pressure test of hose assemblies having firesleeves shall use water as the test medium. The proof pressure shall be held for a minimum of 2 min, during which time any firesleeves installed on the specimens shall be pulled back from the end fittings, and prior to the installation of fitting cuffs or sleeves.

4.8 (Continued):

NOTE: The proof test shall be repeated if temperature is applied during the installation of cuffs or sleeves.

4.9 Burst:

This test is intended to establish failure mode under overpressure at room temperature and at high temperature. The testing shall be conducted as described below. The hose assemblies shall be tested in the straight condition, the end opposite to the pressure source being left free. The assemblies shall be observed throughout the test. The type of failure, and the pressure at which it occurred, shall be recorded.

4.9.1 Room Temperature Burst Pressure Test: The hose assemblies shall be subjected to pressure and the pressure increased until burst of the assembly occurs. The test fluid shall be hydraulic fluid or water. Pressure shall be applied with a rate of pressure rise of 20 000 psi/min ± 5000.

NOTE: The room temperature burst pressure shall be in accordance with the procurement document.

4.9.2 High Temperature Burst Pressure Test: The hose assemblies shall be filled with a suitable test fluid. The 1500 psi hose assemblies shall be soaked for 1 h with ambient and fluid temperature at 450 °F ± 10, all others at 400 °F ± 10. After 1 h, the pressure shall be raised to the rated operating pressure and held there for 5 min. The pressure shall then be increased at the rate of 20 000 psi/min ± 5000 until rupture or leakage occurs.

NOTE: The high temperature burst pressure shall be in accordance with the procurement specification.

4.10 Impulse:

This test is intended to verify the service life of a hose assembly when exposed to hydraulic pressure cycling and surging. The procedure shall be as follows:

a. Prior to the impulse test, the hose assemblies shall be aged and/or exposed to a salt solution soak test if so specified in the procurement specification.

b. The hose assemblies shall be connected to rigid supports in the test rig and bent through 180° to the appropriate minimum bend radius specified in the procurement specification.

c. Using system fluid or a high temperature test fluid per MIL-L-7808, MIL-H-83282, or equivalent, hose assemblies for 1500 psi system pressures and above shall be subjected to impulse testing in accordance with ARP603. During the test, the fluid and ambient temperatures shall vary from room temperature to 400 °F. The test shall be run in such a manner that the hose assemblies shall be temperature-cycled a minimum of two times with a minimum of 80% of the cycles at 400 °F.