Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE RECOMMENDED PRACTICE

ARP 899A

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TUBE FITTINGS, FLUID SYSTEMS, PERMANENT TYPE, GENERAL REQUIREMENTS FOR

1. SCOPE

1.1 This ARP establishes the basic test and design requirements for permanently attached tube fittings for use in aerospace fluid systems. Definitions of fitting and related terms are included in 6.3.

1.2 Purpose: This document recommends the tooling envelope, design criteria, and test requirements for tube fittings attached to tubing by methods which are usually considered to be permanent (brazing, welding, swaging, shrink fit, etc.).

1.3 Classification: Fittings covered by this specification shall be of the following types and classes:

Type	Temperature Range
I	-65° F to +160° F (-55° C +70° C)
II	-65° F to +275° F (-55° C +135° C)
III	-65° F to +450° F (-55° C +230° C)
IV	-65° F to +600° F (-55° C +315° C)

Class	
1500 psi (10 MPa)	Where the cutout pressure at the main pressure controlling device is 1500 psig ± 15%
3000 psi (20 MPa)	Where the cutout pressure at the main pressure controlling device is 3000 psig ± 15%
4000 psi (30 MPa)	Where the cutout pressure at the main pressure controlling device is 4000 psig ± 15%

2. APPLICABLE DOCUMENTS

2.1 The following specifications pertain to this ARP:

2.1.1 Specifications:

Military

MIL-S-5002	Surface Treatments & Metallic Coating for Metal Surfaces of Weapons Systems
MIL-H-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance
MIL-B-7883	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys
MIL-R-11468	Radiographic Inspection; Soundness Requirements for Arc and Gas Welds in Steel

2.1.1 Specifications: (Cont'd.)

Standards

Federal

No. 151	Federal Test Method Standard

Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-453	Inspection, Radiographic
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of

2.1.2 Other Publications:

Society of Automotive Engineers (SAE)

ARP 603	Impulse Testing of Hydraulic Hose Assemblies, Tubing, Coils, Fittings and Similar Fluid System Components
ARP 1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
ARP 1258	Qualification of Hydraulic Tube Joints to Specified Flexure Fatigue Requirements
ARP 1275	Torque Transmittal Testing of Threaded Tube Fittings
AMS 2552	Cleaning, Packaging, and Assembly of Critical System Components Clean Room Procedure, 500 micron max. Particle Size
AMS 2553	Cleaning, Packaging, and Assembly of Critical System Components Clean Area Procedure, 2500 micron max. Particle Size

American National Standards Institute, Inc.

ANSI B46.1	Surface Texture

American Welding Society

American Welding Society Brazing Manual (Library of Congress catalog card number 63-11712)

AWS A5.8-69 Brazing Filler Materials

American Society for Testing and Materials

ASTM A393-63	Conducting Acidified Copper Sulfate Test for Intergranular Attack in Austenitic Stainless Steel

3. REQUIREMENTS

3.1 Qualification Tests: Fittings furnished under this document shall be considered qualified if they are identical to those that have been tested and have passed the qualification tests defined herein. They shall be considered suitable for use in aerospace fluid systems under conditions specified herein. Fittings permanently distorted or damaged during testing shall not be delivered as serviceable components.

3.2 Materials:

3.2.1 Fittings: Fittings shall be manufactured from materials as specified or approved for the individual design, and suitable for and compatible with the specified system tubing, fluid temperature, fluid and pressure. The materials shall be uniform in quality and free from defects.

3.2.2 Tubing: The tubing used for the fabrication of the test assemblies shall be uniform in quality and free from defects, and of a material and heat treatment or work-hardened condition as specified or approved by the procuring activity. The tubing wall thickness and tolerances shall permit the test assemblies to meet the requirements of this specification. Tubing material, finish and dimensional tolerances shall be as specified or approved by the procuring activity.

3.2.3 Tube Attachment: The method used to attach the tubing to the permanent fittings (i.e., welding, brazing, swaging, shrink fit, etc.) shall be of a quality compatible with the design and performance requirements of this specification. The fitting assembly shall be inspectable by means such as direct measurement, x-ray, or other suitable non-destructive evaluation means.

3.2.4 Filler Material: Filler material, where used, shall be compatible with the performance requirements of this specification, the specified tubing, the fluid temperature, fluid and pressure (see 6.3.4).

3.2.5 Flux: Where fluxes are employed, the design of the fitting shall be such as to minimize the amount of flux which contacts the system fluid. The supplier shall be prepared to demonstrate that the use of flux does not contribute to the promotion of corrosion and does not raise the level of contamination beyond that specified by the procuring activity (see 3.6.11 and 3.7). The flux shall be compatible with the system fluid.

3.3 Design and Dimension: Fittings shall be so designed that tooling and processing to accomplish their installation will require a minimum amount of space. Dimensional envelope ranges of presently available tools are shown in Fig. 1 and 2 (brazing), Fig. 3 and 4 (welding), Fig. 5 (swaging), and Fig. 6 (shrink fit).

3.3.1 Drill Offset: On fittings where the fluid passage is drilled from each end, the offset between the drilled holes at the meeting point of the drills shall not exceed .005 inch (0.127 mm). Angular misalignment between drilled holes shall not exceed 2 degrees (0.0349 rad.).

3.3.2 Reduction in Fluid Passage Cross Section: It shall be possible to pass through the passage a ball whose diameter is 0.010 inch (0.254 mm) less than the minimum diameter specified for the passage. On angle joints or reducers, the cross sectional area at the junction of the fluid passages shall in no case be smaller than the cross sectional area at the smallest passage.

3.3.3 Weight: Fitting weight shall be held to a minimum. Actual nominal weights shall be shown on the manufacturer's drawings.

3.3.4 Installation Tooling: Tool envelopes, including joint alignment and joint process tooling required to install fittings on tubing in vehicle or system, and to effect repair of the system or replacement of the fittings within the system, shall be kept to a minimum.

3.3.5 Heat Generation: Fittings assembled by a thermal process, if intended for installation assembly as opposed to bench assembly, shall be designed to permit installation in vehicle systems without heat damage to adjacent structure or components.

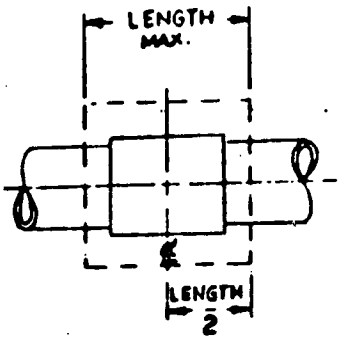
3.3.6 Tube End Preparation: Fittings shall be designed so as to require a minimum of tube end preparation when using standard or close tolerance aircraft quality tubing stock. A slight increase or decrease of tube end diameter by mechanical processing is permissible, provided tubing strength and integrity are not impaired, and the requirements of 3.3.1 and 3.3.2 are met.

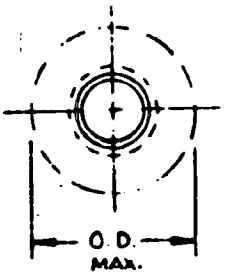
3.3.7 Wetted Area (Brazed Connections): Brazed connections shall meet the joint requirements of MIL-B-7883 unless specifically designed otherwise. Examination criteria shall be per 4.7.12.

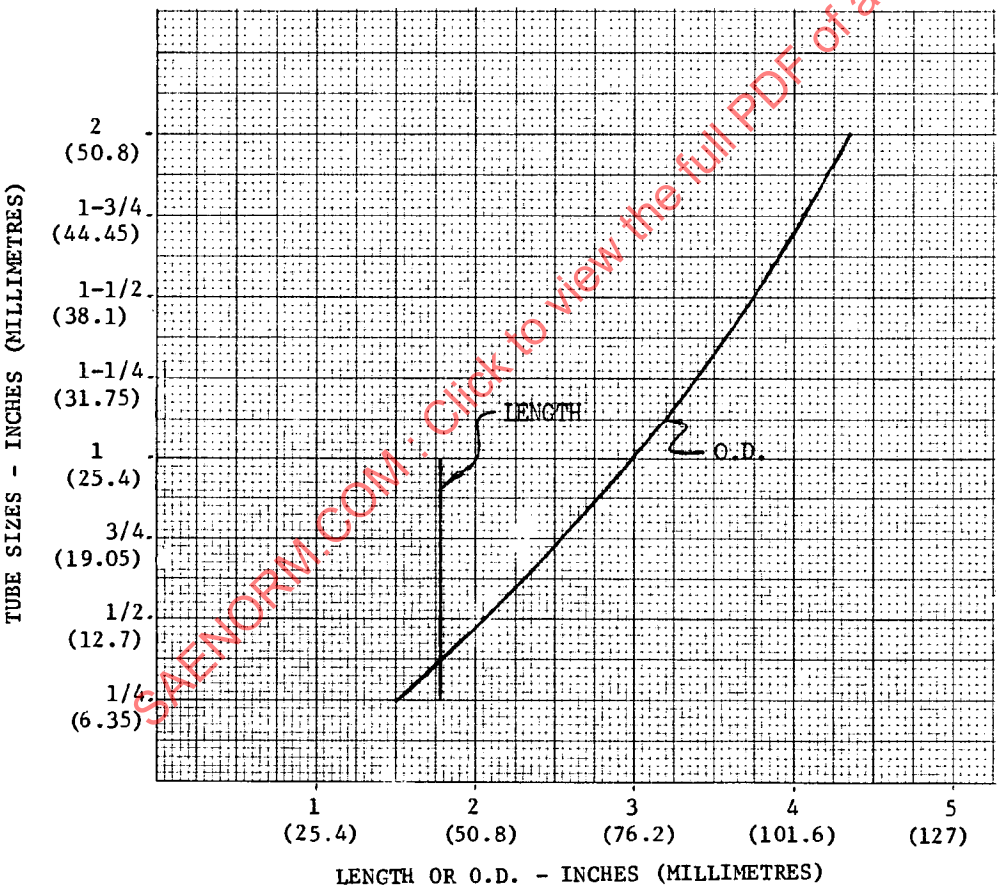
3.3.8 Weld Integrity (Welded Connections): Welds shall meet the quality level requirements of MIL-R-11468, Standard I, when inspected per 4.7.12 and MIL-STD-453.

3.3.9 Material Certification: Records of chemical composition analysis and mechanical property tests showing conformance to applicable specifications shall be made available to the procuring activity for each lot of fittings (see 6.3.5).

TUBE TO TUBE CONNECTIONS



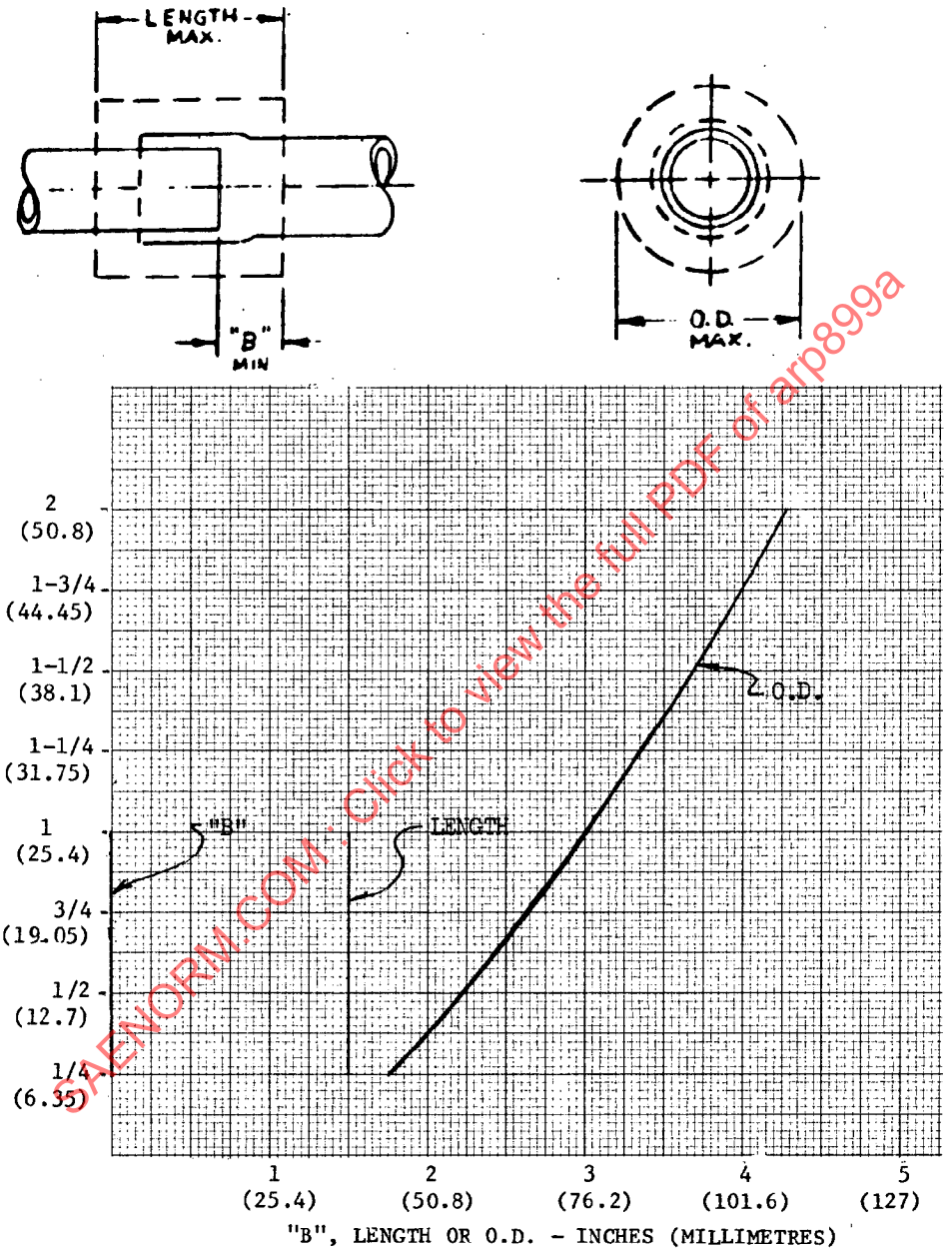




TYPICAL BRAZE TOOL

FIGURE 1. TOOL ENVELOPE SIZES

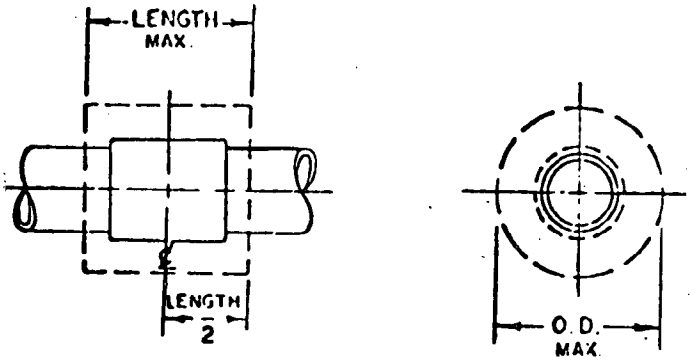
TUBE TO FITTING CONNECTIONS

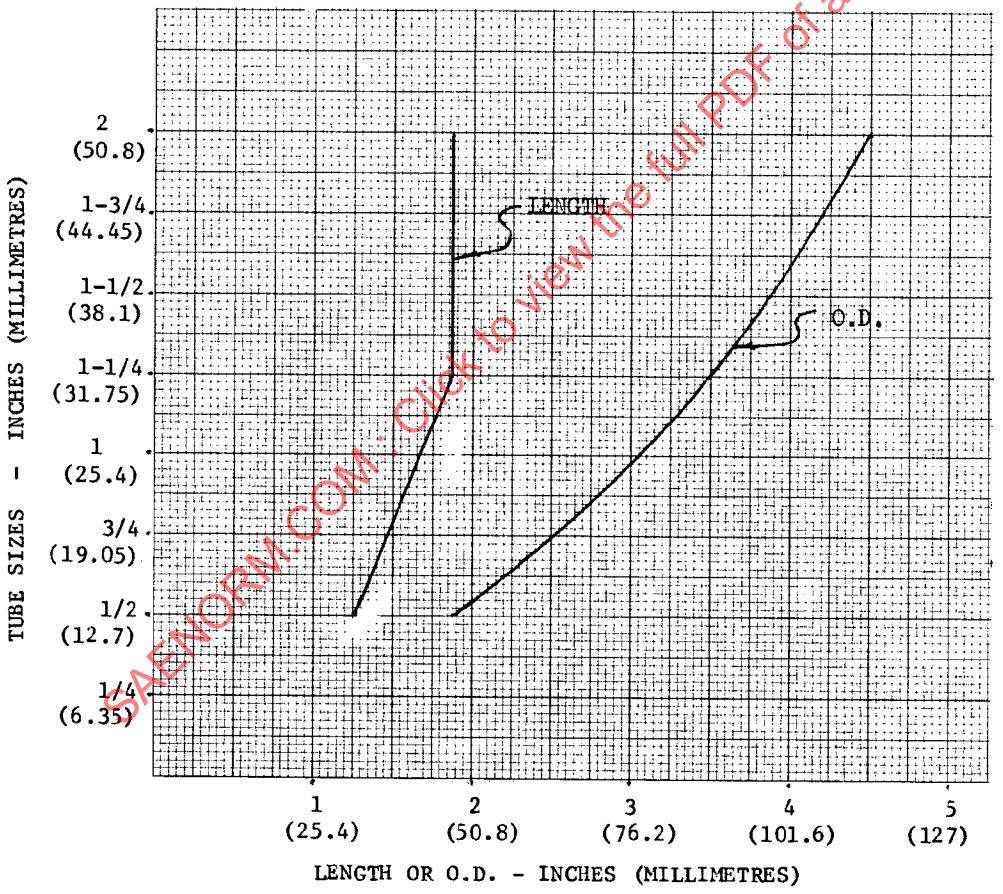


TYPICAL BRAZE TOOL

FIGURE 2. TOOL ENVELOPE SIZES

TUBE TO TUBE CONNECTIONS

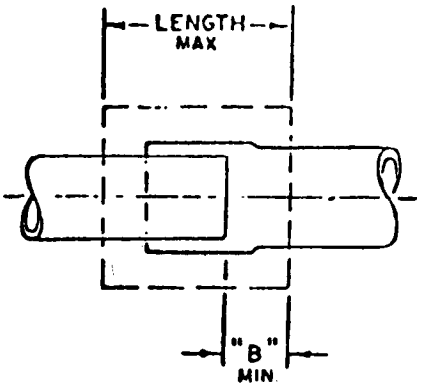


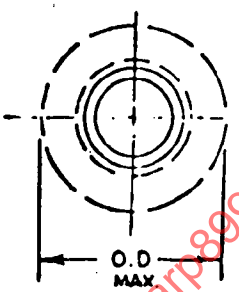


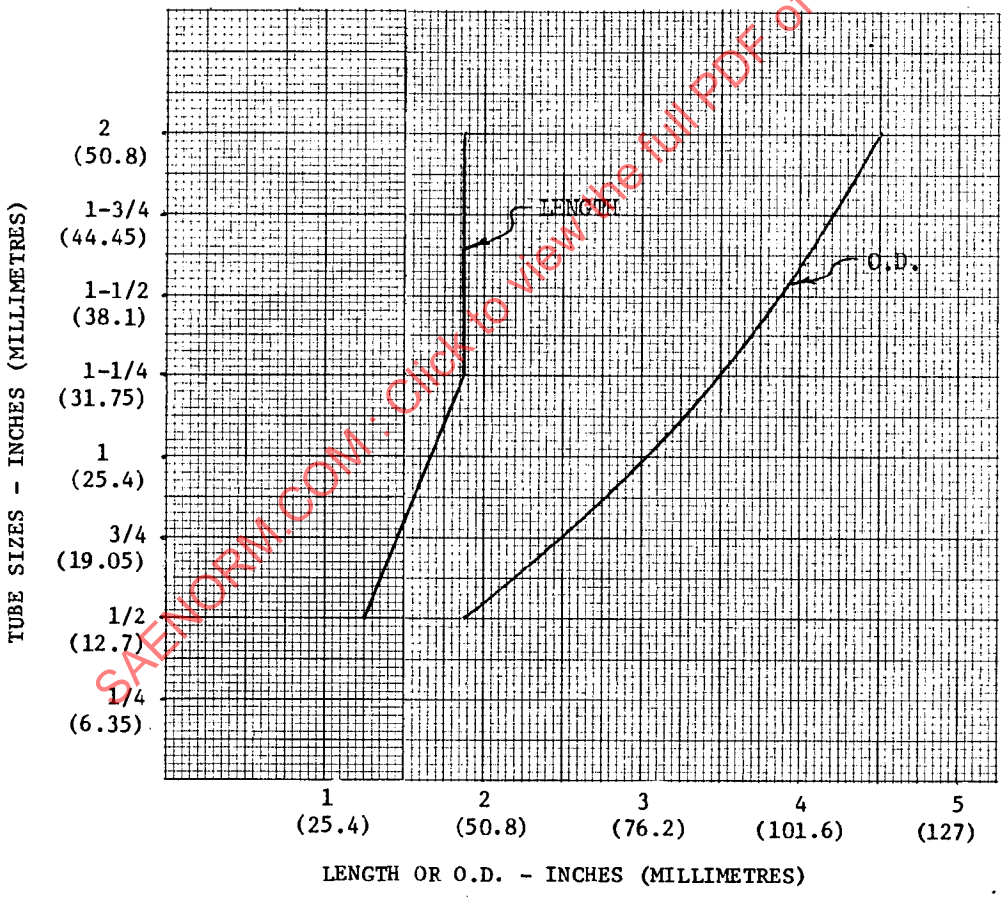
TYPICAL WELD TOOL

FIGURE 3. TOOL ENVELOPE SIZES

TUBE TO FITTING CONNECTIONS

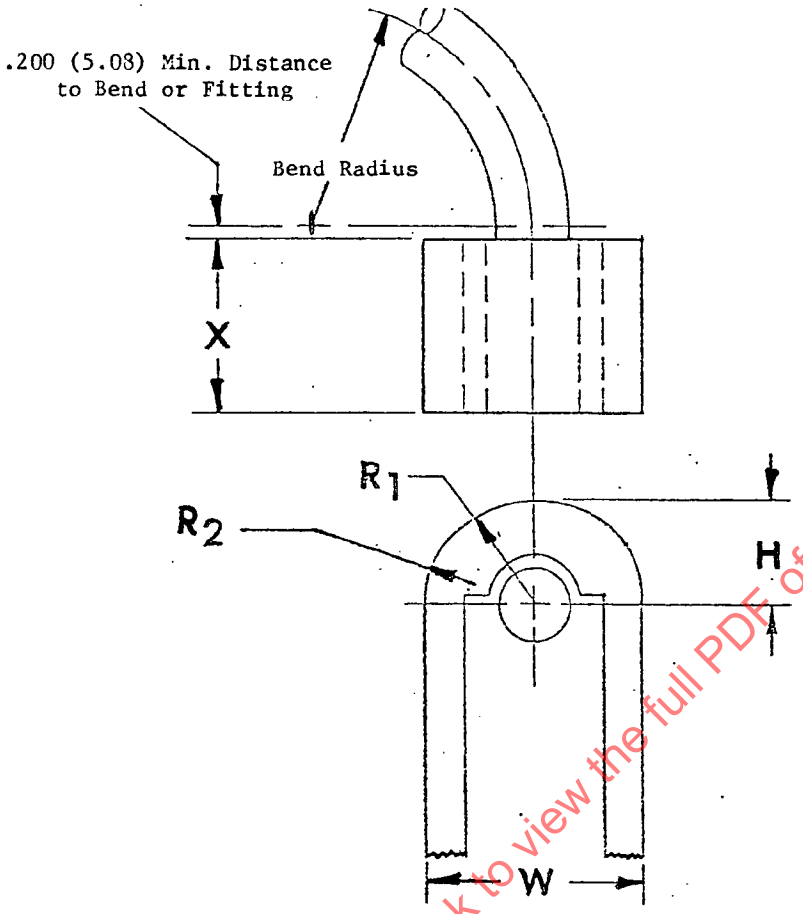






TYPICAL WELD TOOL

FIGURE 4. TOOL ENVELOPE SIZES



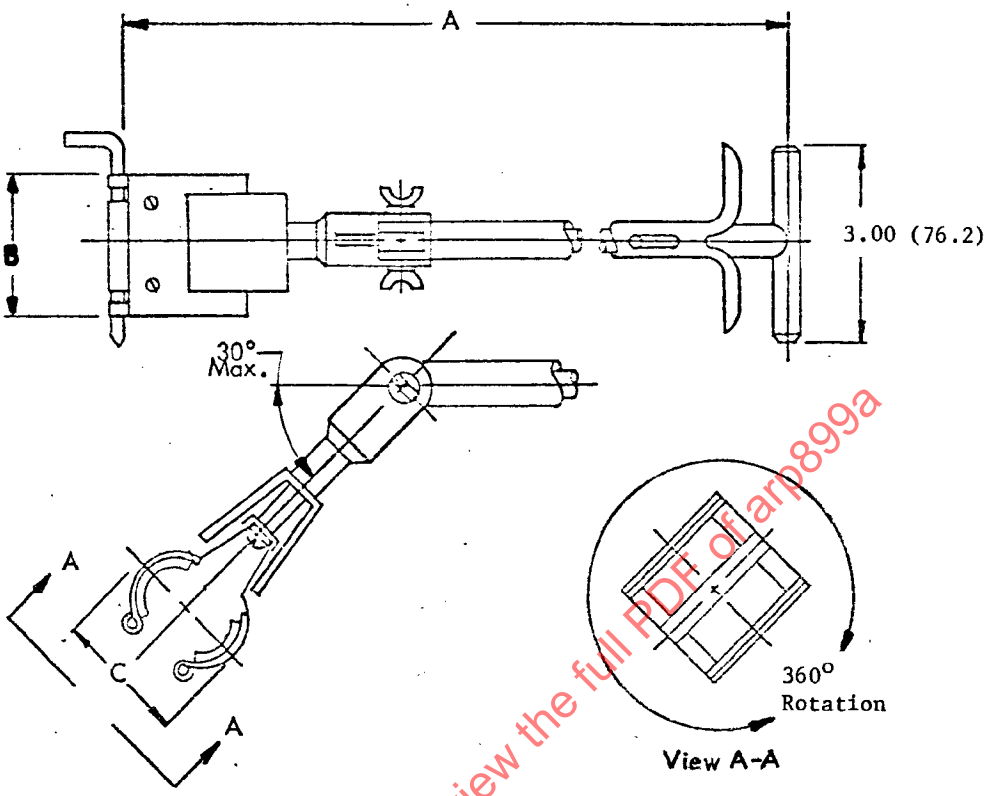
TUBE SIZE	W	H	X	R_1	R_2
3/8 (9.53)	1-3/8 (34.93)	11/16 (17.47)	1-1/8 (28.58)	11/16 (17.47)	11/16 (17.47)
1/2 (12.7)	2 (50.8)	29/32 (23.03)	1-5/8 (41.28)	1-1/16 (26.99)	3/4 (19.05)
5/8 (15.88)	2-1/8 (53.98)	29/32 (23.03)	1-5/8 (41.28)	1-1/4 (31.75)	3/4 (19.05)
3/4 (19.05)	2-5/16 (58.73)	15/16 (23.82)	1-5/8 (41.28)	1-7/16 (36.52)	3/4 (19.05)
7/8 (22.23)	2-9/16 (65.07)	1-5/32 (29.37)	2 (50.8)	1-9/16 (39.69)	1 (25.4)
1 (25.4)	3 (76.2)	1-3/8 (34.93)	2 (50.8)	2-1/16 (52.39)	1-1/4 (31.75)
1-1/4 (31.75)	3-5/8 (92.08)	1-11/16 (42.87)	2 (50.8)	2-11/16 (68.27)	1-11/32 (34.13)
1-1/2 (38.1)	3-5/8 (92.08)	1-11/16 (42.87)	2 (50.8)	2-7/16 (61.92)	1-11/32 (34.13)

NOTE: Dimensions shown in inches (millimetres).

FIGURE 5. TOOL ENVELOPE SIZES

Tube to Tube and Tube to Fitting Connections

TYPICAL SWAGE TOOL



TUBE SIZE	A	B	C
1/4 (6.35)	11.50 (292.1)	.90 (22.86)	.85 (21.59)
3/8 (9.53)	11.75 (298.45)	1.06 (26.92)	1.02 (25.9)
1/2 (12.7)	11.88 (301.75)	1.30 (33.02)	1.18 (29.97)
5/8 (15.88)	12.25 (311.15)	1.61 (40.89)	1.35 (34.29)
3/4 (19.05)	12.50 (317.5)	1.92 (48.77)	1.50 (38.1)
1 (25.4)	12.75 (323.85)	2.55 (64.77)	2.00 (50.8)

NOTE: Dimensions shown in inches (millimetres).

FIGURE 6. TOOL ENVELOPE SIZES

Tube to Tube and Tube to Fitting Connections

TYPICAL SHRINK FIT TOOL

3.4 Surface Treatment: Unless otherwise specified, surface treatment of corrosion-resistant steel fittings shall be in accordance with specification MIL-S-5002. After attachment, the fitting tube junctions (6.3.6) shall retain their corrosion resistance when subjected to the tests in 4.7.9.

3.5 Identification of Product: All fittings shall be identified in accordance with the following instructions. Marking shall be impressed, embossed, electroetched, or plated without damage to the fitting. All marking shall remain legible after the fitting is permanently joined to the tubing. Fittings too small, or without suitable noncritical surfaces, shall be identified by markings on the package or a tag within the package.

3.5.1 Symbol and Trademark: Unless otherwise specified, all fittings shall be marked with the manufacturer's identification or trademark.

3.5.2 Part Number: Unless otherwise specified, fittings shall be marked with the manufacturer's basic part number.

3.6 Performance: The fittings, when permanently attached to the appropriate tubing and tested in accordance with the applicable procedures described in paragraph 4, shall be capable of the following performance:

3.6.1 Proof Pressure: The test assembly shall withstand proof pressure equal to twice the nominal operating pressure of the system (1.3) for 5 minutes when tested in accordance with 4.7.3. Failure criterion shall be evidence of leakage or permanent deformation.

3.6.2 Burst Pressure: The test assembly shall not rupture and shall show no evidence of leakage at any pressure up to four times the nominal operating pressure of the system when tested in accordance with 4.7.4. Failure criterion shall be leakage or burst at a value less than four times the nominal operating pressure. Tubing expansion is permissible.

3.6.3 Thermal Shock: The test assembly shall not leak or burst during temperature cycling from the minimum system temperature to the maximum system temperature when tested in accordance with 4.7.5. Failure criterion shall be evidence of leakage at any point throughout the test.

3.6.4 Impulse: The test assembly shall withstand 200,000 impulse pressure cycles without leakage or other failure when tested in accordance with 4.7.6. Failure criterion shall be leakage from the fitting tube junction during any phase of the test.

3.6.5 Flexure: Test assemblies of each size and combination of materials shall have failure data points falling on or above the curve shown in ARP 1258 when tested in accordance with 4.7.7. Failure criterion shall be failure data points falling below the curve shown in ARP 1258.

3.6.6 Gaseous Leak: The test assembly shall be capable of zero nitrogen gas leakage when tested in accordance with 4.7.8. Failure criterion shall be any visible leakage or air bubbles. Zero leakage shall be defined as zero bubbles per minute after one minute at pressure.

3.6.7 Stress Corrosion: The test assembly shall withstand 50 hours of salt spray exposure or 100 hours of alternate immersion testing with no cracking, pitting or indications of inter or transgranular stress corrosion paths when tested in accordance with 4.7.9 or 4.7.9.1. Failure criterion shall be: a) indications of cracking or pitting of the exposed surfaces of the fitting and tubing within one diameter of the fitting end when visually examining with 10 power magnification, b) leakage or burst at a value less than four times the nominal operating pressure when subjected to the burst pressure test, or c) indications of inter or transgranular stress corrosion paths during metallurgical examination of longitudinal and transverse sections of the fitting tube junction.

3.6.8 Tensile Strength: The test assemblies shall withstand a tensile load while pressurized at nominal system operating pressure equal to or greater than the load generated in the fitting by four times the nominal operating pressure when tested in accordance with 4.7.10. Failure criterion shall be leakage or rupture at the fitting-tube junction at an axial load less than that generated in the fitting by four times the nominal system operating pressure.

3.6.9 Torsion: When applicable, the test assembly shall withstand the torsional test requirements of 4.7.11. Failure criterion shall be leakage at the fitting tube junction and/or failure to meet criteria of ARP 1275.

3.6.10 Intergranular Corrosion: Brazed and welded test assemblies shall not be susceptible to intergranular corrosion when tested in accordance with 4.7.13.

3.6.11 Contamination: The test assemblies shall meet the contamination test requirements of 4.7.14.

3.7 Cleanliness: Cleanliness of the fitting is essential to ensure proper performance. Care shall be used in the manufacture, handling, assembly, testing and packaging of the fitting to ensure cleanliness. The final cleanliness level of the fittings shall be per AMS 2552 or AMS 2553, or other cleaning specification approved by the procuring activity. Assembly, acceptance testing, flushing, sealing and packaging shall be done in an area sufficiently clean to ensure that the capability of the fitting shall not be impaired.

3.8 Workmanship: Fittings shall comply with the workmanship and marking requirements of this document when examined in accordance with 4.7.2. Machined surfaces of fittings shall be free from burrs, slivers and particles that can dislodge and become entrapped within the fitting before or during usage. Machined surface finish shall not exceed 125 RHR (3.175 μ m). Unmachined surfaces, such as forging surfaces and bar stock flats, shall be of uniform quality and condition, free from blisters, fins, folds, seams, laps, cracks, segregations, spongy areas, or other defects which would adversely affect their serviceability, and except for forging parting lines, shall not exceed 250 RHR (6.35 μm) as defined by ANSI B46.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection: Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the manufacturer may utilize his own facility or any commercial laboratory acceptable to the procuring activity. The procuring activity reserves the right to perform any inspection set forth in the specification whenever such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Material Certification: Records of the chemical analysis and mechanical property tests showing conformance to the applicable specification shall be made available to the procuring activity upon request. Material, heat treat and inspection records shall be retained for a period of five years.

4.3 Classification of Tests:

(a) Qualification Tests (4.4) (6.3.7)
(b) Quality Conformance Tests (4.5) (6.3.8)
(c) First Article Inspection Tests (4.5) (6.3.9)

4.4 Qualification Tests:

4.4.1 Sampling Instructions: Test samples shall consist of the test assemblies specified in Table I for each size and type of tubing and fitting material, including filler material if applicable, for which approval is desired.

4.4.2 Tests: The qualification tests shall consist of the following requirements and tests, as applicable, and as specified in sections 3 and 4. Additional testing of those fitting styles (such as tees, reducers, etc.) not included in the test samples shall be conducted as specified or approved by the procuring activity.

(a)	Examination of Product	(3.8, 4.7.2)
(b)	Proof Pressure	(3.6.1, 4.7.3)
(c)	Burst Pressure	(3.6.2, 4.7.4)
(d)	Thermal Shock Test	(3.6.3, 4.7.5)

4.4.2 (Continued)

(e)	Impulse	(3.6.4, 4.7.6)
(f)	Flexure	(3.6.5, 4.7.7)
(g)	Gaseous Leak	(3.6.6, 4.7.8)
(h)	Stress Corrosion	(3.6.7, 4.7.9.1)
(j)	Tensile	(3.6.8, 4.7.10)
(k)	Torsion	(3.6.9, 4.7.11)
(l)	Intergranular Corrosion	(3.6.10, 4.7.13)
(m)	Contamination	(3.6.11, 4.7.14)

TABLE 1

TEST SAMPLES

Assembly Numbers	1-4	5-6	7-8	9-11	12-19	20-21	22-23
Fitting Style	Union	Union	Union	Union	Union	Tee	Union
L (see Figure 7)	6" (152.4 mm)	6"	6"	6"	(2) Per Table I ARP 1185		6"
Test Sequence	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2
	4.7.3	4.7.8	4.7.8	4.7.3	4.7.3	4.7.3	4.7.3
		4.7.3	4.7.3	4.7.9	4.7.7	4.7.7	4.7.11
	4.7.6	4.7.10	4.7.5				
	4.7.4						
	4.7.13						

It is permissible to run each test on separate samples in the quantities indicated when specified or approved by the procuring activity.

It is also permissible to combine certain tests in order to minimize sample quantities when approved by the procuring activity.

NOTES:

1. Test specimen per Figure 7.

(2) Flexure test specimen configuration per ARP 1185 and ARP 1258.

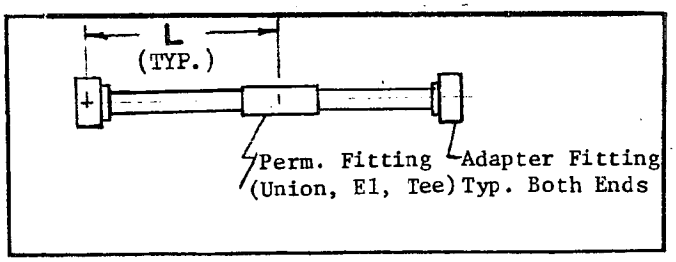


FIGURE 7. TEST SPECIMEN

4.5 Quality Conformance And First Article Inspection Tests: Quality conformance and First Article Inspection tests shall be specified at the option of the procuring agency.

4.6 Test Conditions:

4.6.1 Test Fluids: The test fluids used shall be suitable for and comparable with the fluid system temperature range and materials used.

4.6.2 Temperature: Except where otherwise specified, the tests shall be conducted at room temperature of approximately 60° F (15.6° C) to 100° F (37.8° C) and the fluid temperature of 60° F (15.6° C) to 170° F (76.7° C). Minimum and maximum temperature when testing shall be per 1.3 with a tolerance of ± 5 percent.

4.7 Performance Tests:

4.7.1 Preparation of Test Specimens: Specimens shall be prepared in accordance with manufacturer's recommended procedures and processes.

4.7.2 Examination of Product: All fitting assemblies shall be inspected for compliance with the workmanship, material, heat treat and marking requirements specified herein and shall meet the dimensions and tolerances on the applicable inspection drawings.

4.7.3 Proof Pressure Test: The test assemblies shall be connected to a source of pressure with one end free to move and proof pressure tested at a value equal to 2 times the nominal system operating pressure for a minimum period of 5 minutes. Rate of pressure rise shall be 20,000 psi ± 5,000 (138 MPa ± 34.5) per minute.

4.7.4 Burst Pressure Test: The test assemblies shall be connected to a source of pressure with one end free to move. Pressure shall then be increased at a rate of 20,000 psi ± 5,000 (138 MPa ± 34.5) per minute until the assembly bursts or leaks or reaches the specified burst pressure. Two assemblies shall be tested at room temperature and two assemblies at the maximum rated temperature. It is not essential that the assemblies actually be burst but they must be capable of withstanding 4 times nominal system operating pressure at the specified temperature extremes. (See Figure 8 for typical test setup.)

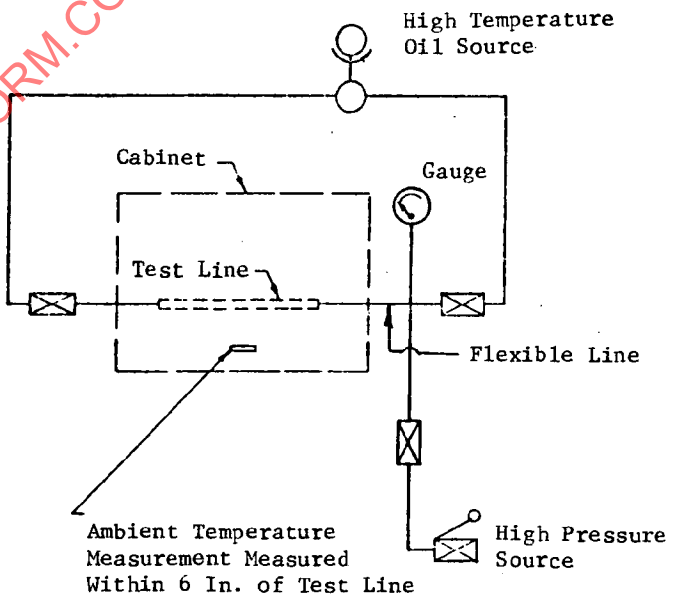


FIGURE 8. TYPICAL SETUP FOR HIGH TEMPERATURE PRESSURE TESTING

4.7.5 Thermal Shock Test:

4.7.5.1 Test Assembly Mounting: The test assemblies shall be mounted in an environmental chamber, connected to a pressure source and completely filled with the specified test fluid.

4.7.5.2 High to Low Temperature: Pressurize the test assemblies to the maximum system operating pressure and raise the ambient temperature to the maximum temperature requirement for the specified system and hold at this temperature for a minimum of 2 hours. At the end of this period, while still at temperature, release the hot test fluid and replace with test fluid at the minimum temperature requirement of the specified system then within 20 seconds raise the fluid pressure to 2-1/2 times the maximum system operating pressure. Maintain this pressure for one minute and then reduce to 5 psi (.03 MPa) for an additional one (1) minute period. During the two one-minute pressurization periods, the assemblies shall be checked for leakage or indication of malfunction. Restabilize test system at room temperature.

4.7.5.3 Low To High Temperature: Pressurize the test assemblies to the maximum system operating pressure and lower the ambient chamber temperature to the minimum temperature requirement of the specified system and hold at this temperature for a minimum of 2 hours. At the end of this period while still at low temperature, release the cold fluid and replace with test fluid at the maximum temperature requirement of the specified system and within 20 seconds raise the fluid pressure to 2-1/2 times the maximum system operating pressure. Maintain this pressure for one minute while checking the test assemblies for leakage or indication of malfunction.

4.7.5.4 Retest: Repeat entire test a total of 3 times. See Fig. 9 for typical test setup.

4.7.6 Impulse Test: The test assemblies shall be tested in accordance with ARP 603 with the deviations listed below and in the sequence shown in Table 2. Prior to impulse testing the assemblies shall be proof pressure tested in accordance with 4.7.3.

4.7.6.1 Test Temperature: The test temperature during impulse testing shall be per Table 2. After the temperature is stabilized, a minimum soak time of 1 hour is required before beginning the test. The temperature shall be measured within 1/2 inch (13 mm) of the fitting-tube joint with the tolerance limitations defined in 4.6.2 and shall be maintained during testing.

4.7.6.2 Peak Pressure: 143 - 157% of maximum system operating pressure.

4.7.6.3 Cycling Rate: 70 ± 5 cycles per minute (1.17 ± .08Hz).

4.7.6.4 Rate of Rise: 175,000 to 300,000 psi/second (1200 to 2100 MPa/sec).

TABLE 2 - SEQUENCE OF CYCLING

NUMBER OF CYCLES	TEMPERATURE (°F)
100,000 MINIMUM	MAXIMUM OPERATING
48,000 MINIMUM	ROOM
2,000 MINIMUM	MINIMUM OPERATING
10,000 MINIMUM	MAXIMUM OPERATING

NOTE: Total number of cycles shall be 200,000.

Balance of cycles (40,000) not shown in table may be added to any sequence or divided among the sequences of cycling.