SAE Aerospace
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AEROSPACE STANDARD

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Superseding AS4459

(R)

Fittings, Tube, Fluid System (3000/4000 psig Rated Pressure), Externally Swaged, Specification for

1. SCOPE:

1.1 Scope:

This SAE Aerospace Standard (AS) establishes the requirements for externally swaged tube fittings for use in hydraulic and other aerospace fluid systems in temperature range of -65 to 275 °F.

1.2 Classification:

Fittings shall be of the following types and system pressure classes as specified:

Classes:

Class 3000: Maximum supply pressure is 3450 psig.
Class 4000: Maximum supply pressure is 4600 psig.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 4083	Tube, Aluminum Alloy, Seamless, Round, Drawn 6061, Aircraft Hydraulic Quality
AMS 4117	Aluminum Alloy 6061, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn, or Cold Finished
AMS 4127	Aluminum Alloy, Forgings, Heat Treated
AMS 4921	Titanium Bars, Forgings, and Rings, Annealed, 70,000 psi Yield Strength
AMS 4945	Titanium Alloy Tubing, Seamless Hydraulic 3Al-2.5V, Texture Controlled, 105,000 psi (724 MPa) Yield Strength
AMS 5557	Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing (321) 18.5Cr - 10.5Ni - 0.40Ti, Solution Heat Treated
AMS 5561	Steel Tubing, Welded and Drawn Corrosion Resistant, 9Mn - 20Cr - 6.5Ni - 0.27N High Pressure Hydraulic
AMS 5569	Tubing, Steel, Corrosion Resisting (304) Aerospace Vehicle Hydraulic System, 1/8 Hard Condition
AMS 5653	Steel Bars, Forgings, Tubing, and Rings, Corrosion and Heat Resistant 17Cr - 12Ni - 2.5Mo (SAE 30316L)
AMS 5656	Steel Bars, Forgings, and Rings, Corrosion Resistant 9.0Mn - 20Cr - 6.5Ni - 0.27N
AMS-QQ-P-35	Passivation Treatments for Corrosion-Resistant Steel
AS478	Identification Marking Methods
ARP603	Impulse Testing of Hydraulic Tubing Joints and Fittings
ARP1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AS1376	Wrench Pads for Fluid Fittings Machined from Alternate Shapes of Material
ARP4784	Performance and Evaluation Criteria, Surface Defects, Requirements
AS5495	Fitting End Design, Externally Swaged, Permanent
AS7003	National Aerospace and Defense Contractors Accreditation Program (NADCAP)
AS7112	National Aerospace and Defense Contractors Accreditation Program Requirements for Fluid System Components
AS18280	Fittings, Flareless Tube, Fluid Connection

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

FED-STD-595	Colors
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance (Inactive for New Design as of 29 March 1996)
MIL-H-81200	Heat Treatment of Titanium and Titanium Alloys
MIL-PRF-6083	Hydraulic Fluid, Petroleum Base, for Preservation and Testing
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base
MIL-PRF-87257	Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance

2.3 ASME Publications:

Available from ASME, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900.

ASME B46.1	Surface Texture (Surface Roughness, Waviness, and Lay)
ANSI/ASME Z1.4	Sampling Procedures & Tables for Inspection by Attributes

2.4 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 8	Tension Testing for Metallic Materials
ASTM E 1417	Standard Practice for Liquid Penetrant Inspection

2.5 PRI Publications:

Available from PRI, 161 Thornhill Road, Warrendale, PA 15086-7527.

PD2001	Qualified Product Management Council Procedures for Qualified Products Group
PD2101	Aerospace Quality Assurance, Product Standard, Qualification Procedures, Fluid Systems

3. TECHNICAL REQUIREMENTS:

3.1 Qualification:

Fittings supplied in accordance with this document shall be representative of products which have been subjected to and which have successfully passed the qualification tests specified in this standard.

3.1.1 Manufacturer Qualification: A manufacturer producing a product in conformance to this procurement specification shall be accredited in accordance with the requirements of PD2101, AS7003, and AS7112, and shall be listed in a Performance Review Institute (PRI) qualified Manufacturers List (QML).

3.1.2 Product Qualification: All products shall conform to the requirements of this procurement specification and shall be approved in accordance with the requirements of PD2001 and PD2101 for listing in a Performance Review Institute (PRI) Qualified Parts List (QPL).

3.2 Materials:

Fittings shall be manufactured from materials listed in Table 1 as specified on the applicable AS standard.

3.2.1 Aluminum Alloy: Fittings shall be manufactured from material per Table 1 except that the tensile yield strength shall be in the range of 28,000 to 33,000 psi (intermediate temper, sometimes referred to as -T7). Overaging to this strength level may be accomplished as a separate process or in a combination with the PTFE (polytetrafluoroethylene) curing operation. Material code letter is "D".

3.2.2 Commercially Pure (CP) Titanium: Titanium fittings shall be manufactured from material per Table 1 except that tensile yield strength shall be within the range of 70,000 to 95,000 psi. In addition, material of fittings shall be vacuum annealed to remove excess hydrogen. Hydrogen content in finished parts shall not exceed 10 ppm in either forged or bar stock fittings. Oxygen equivalency shall not exceed 0.47 as defined in Equation 1. Fitting surfaces shall be clean and free from contaminants. Vacuum annealing shall met all applicable requirements of MIL-H-81200. Material code letter is "E".

$$O_{eq} = O + 2N + Fe/4 + 2C/3 \qquad \text{(Eq. 1)}$$

3.2.3 Corrosion Resistant Steel 21-6-9: Fittings shall be manufactured from material per Table 1 except that it shall be fully annealed and the tensile yield strength shall not exceed 65,000 psi. The material code letter is "-".

3.2.4 Corrosion Resistant Steel 316L: Fittings shall be manufactured from the material per Table 1 except tensile yield strength shall not exceed 45,000 psi. The material code letter is "K".

TABLE 1 - Materials

Fitting Type	Material	Form	Specification
Straight (Couplings)	Aluminum Alloy	Bars	AMS 4117 (6061) (see 3.2.1)
Straight (Couplings)	Com. Pure Titanium	Bars	AMS 4921 (see 3.2.2)
Straight (Couplings)	CRES (21-6-9)	Bars	AMS 5656 (see 3.2.3)
Straight (Couplings)	CRES (316L)	Bars	AMS 5653 (see 3.2.4)
Shapes	Aluminum Alloy	Forgings	AMS 4127 (6061) (see 3.2.1)
Shapes	Com. Pure Titanium	Forgings	AMS 4921 (see 3.2.2)
Shapes	CRES (21-6-9)	Forgings	AMS 5656 (see 3.2.3)
Shapes	CRES (316L)	Forgings	AMS 5653 (see 3.2.4)

3.2.5 Tube Requirements: Tubing utilized in the qualification program shall conform to the specifications listed in Table 7.

3.3 Design and Dimensions:

Design and dimensions shall be such that fittings will meet all requirements of this specification and the associated aerospace standard part drawings.

3.4 Fabrication:

3.4.1 Fluid Passages:

3.4.1.1 Drill Offset: In the run, tees where the fluid passage is bored from each end, the offset between the bores at the meeting point shall not exceed 0.015 in. A sphere with a 0.020 smaller diameter shall be capable of traversing the bore intersection. The cross sectional area of the bore junction of angle fittings shall not be less than the cross-sectional area of the smaller passage. The mismatch in straight couplings shall be controlled such that a maximum OD tube (nominal + 0.003) will pass through the entire fitting.

3.4.2 Finish:

3.4.2.1 Aluminum Alloy and CP Titanium Fittings: Aluminum alloy fittings shall be chemical film coated per MIL-C-5541 on all surfaces prior to application of elastomeric seals or PTFE coating.

Fittings shall be inspected to ensure that the chemical film coating is properly applied so that PTFE adhesion occurs. Aluminum and titanium fittings shall be coated with PTFE to a baked film thickness of 0.0005 to 0.0015 in. All external metal surfaces shall be coated and the fitting bore or swaged ends shall be coated to the depth specified in the applicable aerospace standard.

3.4.2.2 Corrosion Resistant Steel 21-6-9: 21-6-9 corrosion resistant steel fittings shall be PTFE coated to a baked film thickness of 0.0005 to 0.0015 in. The fitting bore of the swaged end only shall be coated to the depth specified in the applicable aerospace standard. 21-6-9 corrosion resistant steel fittings shall be passivated in accordance with AMS-QQ-P-35.

3.4.2.3 Corrosion Resistant Steel 316L: 316L corrosion resistant steel fittings shall be PTFE coated to a baked film thickness of 0.0005 to 0.0015 in. The fitting outside diameter and the fitting bore of the swaged end shall be coated to the depth specified in the applicable aerospace standard. 316L corrosion resistant steel fittings shall be passivated in accordance with AMS-QQ-P-35.

3.4.2.4 Coating Color: PTFE coatings shall be pigmented as follows:

a. Aluminum Alloy: Light green (to approximate color number 14272 of FED-STD-595)
b. Titanium: Black
c. CRES 21-6-9: Green as for aluminum alloy
d. CRES 316L: Gray (to the approximate color number 16440 of FED-STD-595)

3.5 Identification of Product:

All parts shall be identified in accordance with the instructions specified in 3.5.1, 3.5.2, 3.5.3, and 3.5.4.

3.5.1 AS Standard Symbol and Manufacturer's Trademark: Unless otherwise specified, all fittings shall be marked with the letters "AS" and the manufacturer's identification or trademark. Fitting forging blanks shall be marked with the forging's manufacturer's trademark, code number, or letter to identify forging source. Forgings shall also be marked with raw material lot control number and job number.

3.5.2 Marking for Part Number and Size: A numerical equivalent to the dash number indicating size shall be used. All fittings shall be marked with the part number. See part standards for coding.

3.5.3 Material Identification: Corrosion resistant steel fittings shall be marked with the letter "-" (dash) if manufactured from 21-6-9, the letter "K" if manufactured from class 316L, or the letter "D" shall be used if manufactured from 6061 aluminum alloy. The letter "E" shall be used if produced from commercially pure titanium.

3.5.4 Size, Method, and Location of Marking: Marking shall be accomplished per those permanent methods listed in AS478 which do not cause surface oxidation or other detrimental effects.

3.6 Performance:

Fittings when attached to tubing using equipment and procedures authorized by the procuring activity shall conform to the requirements specified in 3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.6.6, 3.6.7, and 3.6.8, when tested in accordance with the procedures specified in 4.2.

3.6.1 Environmental Conditions: Permanent fittings shall be capable of performance in accordance with this specification when subjected to the natural and induced environments specified herein.

3.6.1.1 Temperature:

a. Ambient Air: -65 to 275 °F
b. Fluid: -65 to 275 °F

3.6.1.2 Leakage: Leakage is defined as any visually detectable escape of fluid from any point of the fitting assembly or the tube fitting interface. The fitting and joint assembly shall not exhibit the escape of any fluid. Any escape of the fluid shall constitute a failure of the test.

3.6.2 Burst Pressure: Burst pressure shall be as specified in Table 2. The fittings shall withstand burst pressure without leakage, slippage, or other failure when tested in accordance with 4.2.2.3.2.

3.6.3 Impulse: Fittings of all materials shall be capable of 200,000 impulse cycles without leakage or other failure when tested in accordance with 4.2.2.3.3.

3.6.4 Flexural Strength: Fittings shall withstand 10,000,000 cycles of flexure at the stress levels specified in Table 3 when tested in accordance with 4.2.2.3.4 without leakage or other failure.

TABLE 2 - Pressures

TABLE 2A

Tube Size	Fitting Material Aluminum Alloy Rated	Fitting Material Aluminum Alloy Proof	Fitting Material Aluminum Alloy Burst
0.188	1500	3000	6000
0.250	1500	3000	6000
0.312	1500	3000	6000
0.375	1500	3000	6000
0.500	1500	3000	6000
0.625	1000	2000	4000
0.750	900	1800	3600
0.750	1000	2000	4000
1.000	600	1200	2400
1.000	1000	2000	4000
1.250	600	1200	2400
1.500	600	1200	2400

TABLE 2B

Tube Size	Fitting Material CRES, Titanium Rated	Fitting Material CRES, Titanium Proof	Fitting Material CRES, Titanium Burst
0.188	3000	6000	12,000
0.250	3000	6000	12,000
0.312	3000	6000	12,000
0.375	3000	6000	12,000
0.500	3000	6000	12,000
0.625	3000	6000	12,000
0.750	3000	6000	12,000
1.000	3000	6000	12,000
1.250	3000	6000	12,000
1.500	2000	4000	8000

TABLE 2C

Tube Size	Fitting CRES, Titanium Rated	Fitting CRES, Titanium Proof	Fitting CRES, Titanium Burst
0.250	4000	8000	16,000
0.312	4000	8000	16,000
0.375	4000	8000	16,000
0.500	4000	8000	16,000
0.625	4000	8000	16,000
0.750	4000	8000	16,000
0.875	4000	8000	16,000
1.000	4000	8000	16,000
1.250	4000	8000	16,000

TABLE 3 - Bending Stresses

Tube Size	Minimum Endurance Limit /1/ /2/ Tube Bending Stress (psi) Aluminum Alloy /3/	Minimum Endurance Limit /1/ /2/ Tube Bending S/N Curve	Minimum Endurance Limit /1/ /2/ Tube Bending Stress (psi) CRES /3/	Minimum Endurance Limit /1/ /2/ Tube Bending S/N Curve	Minimum Endurance Limit /1/ /2/ Tube Bending Stress (psi) Titanium /3/	Minimum Endurance Limit /1/ /2/ Tube Bending S/N Curve
0.188	6000	6.6	24,000	1.8	20,000	2.4
0.250	6000	6.6	24,000	1.8	20,000	2.4
0.312	6000	6.6	24,000	1.8	20,000	2.4
0.375	6000	6.6	22,000	2.1	19,000	2.6
0.500	5500	6.9	20,000	2.4	18,000	2.8
0.625	5500	6.9	18,000	2.8	17,000	3.0
0.750	5000	7.2	16,000	3.1	16,000	3.1
0.875	-	-	-	-	15,000	3.4
1.000	4000	8.0	15,000	3.4	15,000	3.4
1.250	4000	8.0	15,000	3.4	14,000	3.7
1.500	4000	8.0	15,000	3.4	13,000	3.9

NOTES:
/1/ See Table 7 for tube materials and wall thicknesses.
/2/ Intersection of the indicated S/N characteristic curve versus stress at the endurance limit (i.e., 1×10^7).
/3/ Refer to Figure 1 for characteristic curves. For example, and S/N characteristic of 2.4 falls 4/10's the way between the number 2 number 3 curve.

3.6.5 Gaseous Leakage: Test assemblies shall be capable of containment of nitrogen gas without evidence of gas bubbles appearing at the tube/fitting interface when tested in accordance with 4.2.2.3.5. No bubbles may appear after 1 min at pressure.

3.6.6 System Pressure: All test assemblies, with the exception of joint strength test assemblies, shall undergo a system pressure test consisting of gaseous leakage test as described in 4.2.2.3.5 and a hydraulic test as described in 4.2.2.3.6.

3.6.7 Joint Strength: Test assemblies shall withstand without separation, a tensile load as specified in Table 4 when tested in accordance with 4.2.2.3.7.

3.6.8 Proof Pressure: Test assemblies shall withstand pressure equal to two times the rated pressure for 5 min without leakage or evidence of permanent deformation when tested in accordance with 4.2.2.3.1.

TABLE 4 - Minimum Joint Strength

Tube Size	Material/Joint Strength (lb) Aluminum Alloy	Material/Joint Strength (lb) CRES and Titanium Class 3000	Material/Joint Strength (lb) CRES and Titanium Class 4000
0.188	167	333	-
0.250	295	589	785
0.312	459	917	1223
0.375	663	1325	1767
0.500	1178	2356	3142
0.625	1227 /2/	3682	4909
0.750	1767 /2/ 1590 /4/	5301	7069
0.875	-	-	9621
1.000	3142 /2/ 1885 /3/	9424	12,566
1.250	2945 /3/	14,726	- N/A
1.500	- /1/	- /1/	- N/A

NOTES:
/1/ Not required for size 24
/2/ 1000 psig rated pressure
/3/ 600 psig rated pressure
/4/ 900 psig rated pressure

3.7 Workmanship:

Machined surfaces of fittings shall be free from burrs, longitudinal or spiral tool marks. A burr is defined as any localized sharp deviation from the true contour of the part, as implied by the production drawing, the extreme excursion of which falls outside the tolerance envelope defined on the drawing, and/or any thin deviation of lesser magnitude which can be dislodged during normal assembly or operation. Unless a finer finish is specified on the applicable drawings, all machined surfaces shall not exceed 125 µin Ra as defined in ASME B46.1. Unmachined surfaces, such as forging surfaces and bar stock flats, shall be free from blisters, fin folds, seams, laps, cracks, or segregations as defined in ARP4784, and except for forting parting lines, shall not exceed 250 µin Ra. The surface texture of forging parting plane shall be 500 µRa per ASME B46.1. Surface defects may be explored by suitable etching, and if they can be removed so that they do not appear on re-etching, they shall not be cause for rejection.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

4.1.1 Manufacturer Inspection: Unless otherwise specified in the contract, the fitting manufacturer is responsible for the performance of all inspection requirements specified herein. Except as otherwise specified in the contract order, the fitting manufacturer may use its own or any other facilities suitable for the performance of the inspection requirements specified herein unless disapproved by the procuring activity. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1.1 Lot: A lot shall consist of all parts identified by one unique part number fabricated from one mill heat of material; or, if in an assembly, each component part shall be from one mill heat of material, produced by the same machining operation at approximately the same time in one continuous production run. Splits of one production run into two parallel runs that may be machined at different times constitutes splitting the lot into two distinct lots. Lot traceability shall be maintained for each component, with the exception of retaining wires, for parts which consist of assemblies.

The following process examples shall be performed at essentially the same time under the same conditions: (1) heat treating, (2) plating, (3) painting, and (4) baking. Processes not meeting this requirement shall require the assigning of distinguishing lot numbers.

4.1.1.2 Record Maintenance: The supplier shall maintain a record of inspections applied to each lot.

4.1.1.3 Material Certification: Records of chemical composition analysis, magnetic particle inspection, and mechanical property tests showing conformance to the applicable material specifications shall be made available to the procuring activity for each lot of fittings.

4.1.2 Purchaser Inspection: Purchaser's receiving inspection shall control incoming shipments to the requirements of the applicable standard or source control drawing and this specification.

4.2 Classification of Inspections and Tests:

4.2.1 Qualification Inspection: Qualification inspection shall consist of the following requirements and tests, as applicable, and as specified in Sections 3 and 4. Sampling quantities and sequence of tests shall be in accordance with Tables 5 and 6, respectively.

4.2.2 Purchaser Inspection: Quality conformance inspection shall be performed to the sampling plan, inspection and reporting method described on the standard or source control drawing.

4.2.2.1 Examination of Product: Fittings shall be examined to determine conformance with this specification and the applicable standard with respect to material, dimension, wall thickness, surface defects, finish, marking, and workmanship.

TABLE 5 - Qualification Test Specimens

Specimen Size	Exam. of Product 4.2.1.1	Pneumatic Test 4.2.1.3.5	System Pressure 4.2.1.3.6	Proof Test 4.2.1.3.1	Impulse Test 4.2.1.3.3	Flexure Test 4.2.1.3.4	Tensile Test 4.2.1.3.7	Burst Test 4.2.1.3.2
03	17	14	14	14	6	8	3	2
04	17	14	14	14	6	8	3	2
05	17	14	14	14	6	8	3	2
06	17	14	14	14	6	8	3	2
08	17	14	14	14	6	8	3	2
10	17	14	14	14	6	8	3	2
12	17	14	14	14	6	8	3	2
14	17	14	14	14	6	8	3	2
16	17	14	14	14	6	8	3	2
20	17	14	14	14	6	8	3	2
24	17	14	14	14	6	8	3	2
Total	187	154	154	154	66	88	33	22

TABLE 6 - Qualification Test Sequence
Test Type/Test Paragraph 4.2.1.x.x

E/P 1	G/T 3.6	S/T 3.5	Proof 3.1	F/S 3.4	IMP 3.3	Burst 3.2	Tensile 3.7
1	2	3	4	5	-	6	-
1	2	3	4	-	5	6	-
1	-	-	-	-	-	-	2

Abbreviations:

E/P	Examination of Product
F/S	Flexural Strength
G/T	Gaseous Leakage Test
IMP	Impulse Test
S/T	System Pressure Test

4.2.2.2 General Testing Practices:

4.2.2.2.1 Tube Preparation: Tubes shall be cut square within 0.5° and all burrs removed from inside and outside of the tube ends. The break or chamfer on either the outside diameter or inside diameter shall not exceed 25% of the tube wall thickness.

4.2.2.2.2 Tube Material: Compatibility and Rated Pressure: Fittings shall be tested with tubing as specified in Table 7 for the appropriate rated pressure. Compatibility of fitting materials and tubing combinations are listed in Table 8.

TABLE 7 - Tube Material and Nominal Wall Thickness

Tube OD Material	System Pressure (psig)	0.188	0.250	0.312	0.375	0.500	0.625	0.750	0.875	1.000	1.250	1.500
21-6-9	3000	0.016	0.016	0.020	0.020	0.026	0.033	0.039	-	0.052	0.070	-
21-6-9	2000	-	-	-	-	-	-	-	-	-	-	0.054
304-1/8HD	3000	0.016	0.020	0.020	0.028	0.035	0.042	0.058	-	0.065	-	-
304-1/8HD	1500	-	-	-	-	-	-	-	-	-	0.049	0.065
321-1/8HD	3000	-	0.028	0.028	0.035	0.049	0.058	0.065	-	0.083	-	-
3Al-2.5V	4000	-	0.020	0.024	0.028	0.035	0.044	0.052	0.061	0.070	0.088	-
3Al-2.5V	3000	0.016	0.016	0.020	0.019	0.026	0.032	0.039	-	0.051	0.063	-
3Al-2.5V	2000	-	-	-	-	-	-	-	-	-	-	0.054
6061-T6	1500	-	0.035	0.035	0.035	0.035	-	-	-	-	-	-
6061-T6	1000	0.020	0.020	0.028	0.028	0.035	0.035	0.035	-	0.049	-	-
6061-T6	900	-	-	-	-	-	-	0.035	-	-	0.049	0.049
6061-T6	600	-	-	-	-	-	-	-	-	0.035	0.035	0.035

Applicable Material Specification

21-6-9 CRES	AMS 5561
304-1/8HD	AMS 5566
321-1/8HD	AMS 5569
3Al-2.5V CWSR	AMS 4945
6061-T6	AMS 4083

TABLE 8 - Fitting Material and Tubing Material Compatibility

Fitting Material	Tubing Material
21-6-9 CRES per AMS 5656	21-6-9 CRES per AMS 5561 304-1/8HD CRES per AMS 5566 3Al-2.5V Titanium per AMS 4945 6061-T6 Aluminum per AMS 4083
316L CRES per AMS 5653	304-1/8HD CRES per AMS 5566 321-1/8HD CRES per AMS 5569
Commercially Pure Titanium per AMS 4921	3Al-2.5V Titanium per AMS 4945
6061-T6 Aluminum per AMS 4117	6061-T6 Aluminum per AMS 4083

4.2.2.2.3 Proof Pressure: Proof pressure shall be twice the rated pressure.

4.2.2.2.4 Burst Pressure: Burst pressure shall be four times the rated pressure.

4.2.2.2.5 Test Fluids: Unless otherwise specified, fluid conforming to MIL-PRF-87257 or MIL-PRF-6083 shall be the test fluid. Water may also be used as a test fluid unless prohibited by the procuring activity.

4.2.2.3 Performance Tests:

4.2.2.3.1 Hydraulic Proof Test: Test assemblies shall be mounted to a pressure source and pressurized to two times the rated pressure and held for 5 min. Rate of pressure rise shall be 20,000 psi/min ± 5000 psi/min.

4.2.2.3.2 Burst Pressure Test: Test assemblies shall be pressurized to the proof pressure and held at that pressure for 5 min. The pressure shall then be increased at a rate of 20,000 psi/min ± 5000 psi/min until destruction occurs. No burst, slippage, leakage, or other failure shall occur at a pressure below the burst pressure as specified in Table 2.

4.2.2.3.3 Impulse Test: three test assemblies of both straight and shaped configurations of each tube/fitting combination to be qualified shall be tested. Each assembly shall be gaseous leakage tested per 4.2.2.3.5, hydraulic proof tested per 4.2.2.3.1, and system pressure tested per 4.2.2.3.6 prior to impulse testing. Impulse testing shall be in accordance with ARP603. The maximum temperature shall be 275 °F ± 5 °F. The minimum temperature shall be -65 °F ± 5 °F. The impulse cycle rate shall be 70 cpm ± 5 cpm. The rate of pressure rise shall be 125,000 to 300,000 psi/s. Hydraulic fluid shall be used as the testing media. Specimens shall complete 200,000 impulse cycles after which they shall be tested in accordance with 4.2.2.3.1 and 4.2.2.3.6.

4.2.2.3.4 Flexural Strength: Prior to flexural strength test, all test specimens shall be system pressure tested per 4.2.2.3.6. The flexural test shall be performed in accordance with ARP1185. Bending stresses may be applied by planar or rotary beam method. The stress imposed will be the dynamic bending stress. The bending stress shall be measured by two strain gages mounted 90° apart on the tube 0.188 in ± 0.031 in from the tube fitting interface. Testing shall be conducted with the specimen pressurize to the rated pressure. Cycling rate of flexure shall be 30 to 60 cps.

Data point generate by testing shall be plotted on an S/N curve (stress/number of cycles). Refer to Figure 1. One, but not more than two specimens in each size shall complete 10,000,000 cycles without leakage or other failure. Specimens shall perform on or above an S/N characteristic curve specified in Table 3. Specimens surviving 10,000,000 cycles shall then be system pressure tested per 4.2.2.3.6.

4.2.2.3.4.1 Rotary Beam Method: Figure 2 illustrates one method wherein the flexural loading is obtained by imposing a concentrated rotating load on the free end of the tube assembly. The specimen length "L" shall be as recommended in Table 9.

TABLE 9 - Recommended Tube Length for Flexure Specimen

Tube Diameter (in)	Test Length "L" (in)	Tube Length "T" (in)
0.188	5.00	6.35
0.250	6.00	7.35
0.312	7.00	8.48
0.375	7.50	9.05
0.500	9.00	11.14
0.625	10.00	12.25
0.750	11.50	13.72
0.875	12.00	14.96
1.000	12.50	14.98
1.250	14.00	16.62
1.500	15.00	17.71

4.2.2.3.4.2 Planar Flexure Method: Another method of obtaining flexural stresses may be accomplished by mounting a cantilever tube assembly identical to the rotary specimen with the test fitting end fixed and the free end attached to a reciprocating slide. Bending stress shall be measured using a strain gage.

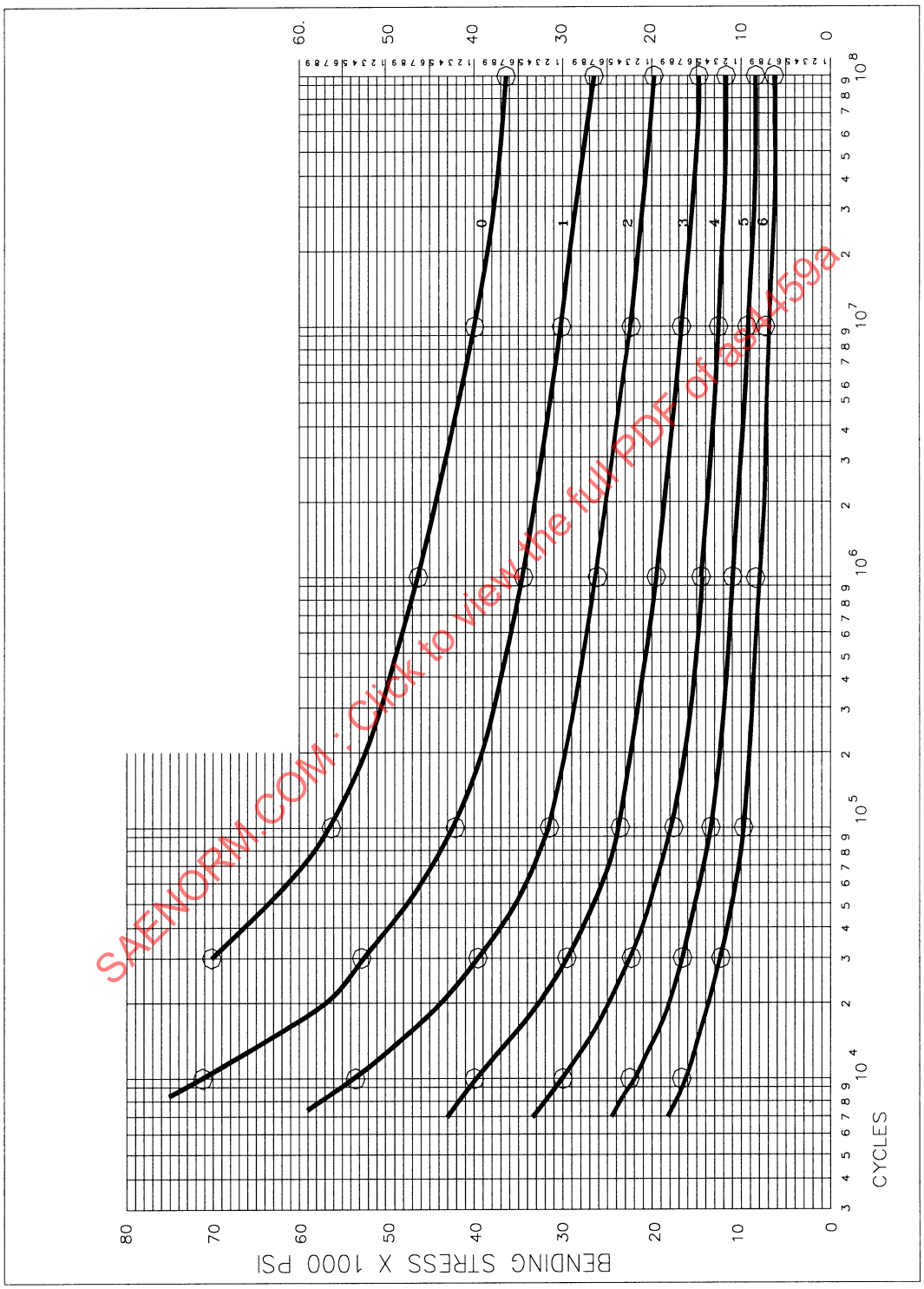

FIGURE 1 - Flexure Fatigue Test S/N Curve

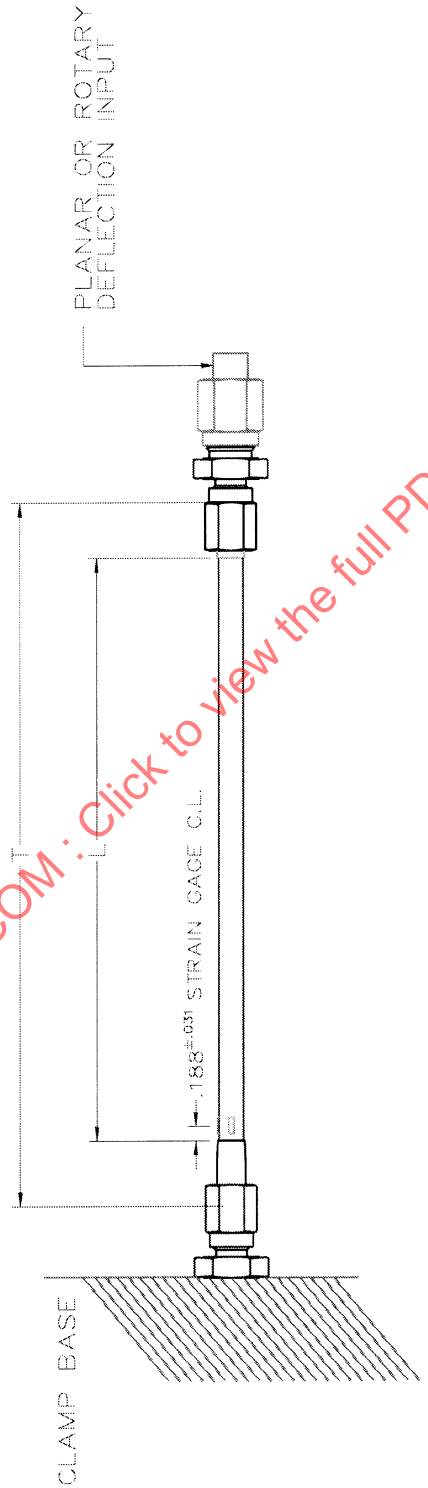

FIGURE 2 - Rotary or Planar Flex Test Specimen

4.2.2.3.5 Gaseous Leakage Test: Test specimens shall be solvent cleaned and air dried prior to test and shall not have been exposed to oil prior to this test. The specimens shall be connected to a gaseous nitrogen pressure source and immersed in a safety tank filled with water. The specimens shall then be pressurized to the system rated pressure or 1800 to 2000 psig, whichever is lower, at room temperature. The test is then repeated at 50 to 100 psig. This test duration for each segment shall be 5 min.

4.2.2.3.6 System Pressure Test: Before this test is conducted, test specimens shall be clean, dry, and free from hydraulic fluid. Specimens shall be then pneumatically tested per 4.2.2.3.5. This process shall be repeated between the low and high pressure phases of this test.

Assemblies shall be pressurized with hydraulic fluid as specified in 4.2.2.3.1 from 50 to 100 psig for 24 h. The assemblies shall then be pressurized to the rated pressure of the assembly for an additional 24 h. Assemblies shall be checked at the beginning, during, and after the test for leakage.

4.2.2.3.7 Joint Strength Test: Test assemblies shall be mounted in a tensile test machine and be tested in accordance with ASTM E 8 at a head travel rate of 0.15 in/min ± 0.05 in/min. Strength requirements shall be per 3.6.7.

4.3 Quality Conformance Inspection:

For each lot of fittings, the supplier shall perform either 100% inspection, acceptance sampling, or Statistical Process Control (SPC) for each characteristic of the fitting. The supplier shall provide the purchaser with a Quality Conformance Plan.

4.3.1 Quality Conformance Plan: For each fitting, the supplier shall provide the purchaser with a Quality Conformance Plan. The plan shall provide the method of quality assurance (i.e., Lot Sampling, SPC) used for each characteristic.

4.3.2 Sampling: Sampling for material, dimensions, finish, and workmanship shall be random in accordance with ANSI/ASME Z1.4 Single Sampling Plan, general inspection level II, and acceptance number of zero. Unless otherwise specified under 4.4.2, the accepted quality level (AQL) shall be 4%.

4.3.3 Parting Planes in Aluminum Forgings: Parting planes in aluminum forgings shall be penetrant inspected per ASTM E 1417, before the application of anodize or any other surface treatment which may seal up indications. Visually inspect parting planes after anodize. Sampling for penetrant and visual inspection shall be per ANSI/ASQC Z1.4, Single Sampling Plan, Inspection Level II with an acceptance number of zero, or a purchaser approved statistical method for product acceptance which provides equivalent protection.