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AEROSPACE STANDARD

SAE AS1576 | REV. B

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FITTINGS, WELDED, HYDRAULIC, TITANIUM AND CORROSION RESISTANT STEEL, 3000 PSI HYDRAULIC

1. SCOPE:

This document defines the requirements for weld fittings and machine weldments using an orbiting welding head suitable for use on cold worked 3Al-2.5V titanium and 21Cr-6Ni-9Mn CRES tubing.

2. REFERENCES:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other documents shall be the issue in effect on the date of the purchase order.

2.1 Military:

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MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-129	Marking for Shipment and Storage
MIL-F-18280	Fittings, Flareless Tube, Fluid Connections
MIL-H-5440	Hydraulic Systems, Aircraft, Type I and II Design, Installation and Data Requirements for
MIL-H-6875	Heat Treatment of Steels, Process for
MIL-STD-6866	Inspection, Liquid Penetrant
MS21921	Nut, Sleeve Coupling, Flareless
MS33514	Fitting End Standard Dimensions for Flareless Tube Connection

2.2 Industry:

AMS 4928	Titanium Alloy Bars, Forgings and Rings, 6Al-4V, Annealed, 120,000 psi (825 MPa) Yield Strength
AMS 4944	Titanium Alloy Tubing, Seamless, Hydraulic 3.0Al-2.5V Cold Worked, Stress Relieved

2.2 (Continued):

AMS 5561	Steel Tubing, Welded and Drawn, Corrosion and Heat Resistant, 9.0Mn-20Cr-6.5Ni-0.28N, High-Pressure Hydraulic
AMS 5656	Steel Bars, Forgings, and Rings, Corrosion Resistant, 9.0Mn-20Cr-6.5Ni-0.27N
AMS 5659	Steel Bars, Forgings, Rings, and Extrusions, Corrosion Resistant, 15Cr-4.5Ni-0.03 (Cb + Ta) 3.5Cu, Consumable Electrode Melted, Solution Heat Treated
ARP 603	Impulse Testing of Hydraulic Hose Assemblies, Tubing and Fittings
ARP 1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
ARP 1258	Qualification of Hydraulic Tube Joints to Specified Flexure Fatigue Requirements
AS1577	Tube End, Welding, Hydraulic
AS1578	Bellmouth Tube End, Welding
AS1579	Fitting End, Welded Girth Joint, Dimensions, 3000 psi Hydraulic
AS1580	Ring, Tube Weld, 3000 psi Hydraulic, Titanium
AS1581	Sleeve, Flareless Tube End, Welded, Hydraulic, 3000 psi
AS1582	Union, Flareless Tube End, Welded, 3000 psi Hydraulic
AS1583	Tee, Tube Weld, 3000 psi Hydraulic
AS1584	Elbow, 90° Tube Weld, 3000 psi Hydraulic
AS1585	Reducer, Tube Weld, Hydraulic
AS1893	Ring, Tube Weld, 3000 psi Hydraulic, CRES.
AWS A3.0	Welding Terms and Definitions (American Welding Society)
ANSI B46.1	Surface Texture, Surface Roughness, Waviness, and Lay
NAS 1760	Fitting End, Fluid, Acom, Standard Dimensions for

3. REQUIREMENTS:

3.1 Qualification:

Fittings furnished under this document shall be products which have been subjected to and successfully passed the test requirements of this specification.

3.2 Materials:

3.2.1 Fitting Materials: Fittings and other parts shall be made of materials listed in Table 1.

3.2.2 Fitting Forgings:

3.2.2.1 Surface Defects: Forged fittings shall be free from cracks, laps, seams and other defects.

NOTE: Surface defects may be removed as long as wall thickness requirements are met and as long as defects do not reappear after etching and in penetrant inspection.

3.2.2.2 Titanium Forgings: Titanium forgings shall exhibit an equiaxed microstructure. Oxide or other gas contaminated surface scale shall be removed by pickling.

TABLE 1 - Materials

TYPE OF PART	MATERIAL	MATERIAL CODE	SPECIFICATION
Straight and Shape Fittings	Corrosion Resistant Steel	V	AMS 5659[1] (15-5 PH, H-1075)
Weld Ring	Corrosion Resistant Steel	-	AMS5656 (21Cr-6Ni-9Mn)
Straight and Shape Fittings and Weld Ring	Titanium	T	AMS 4928 (Ti-6Al-4V)

[1]Solution heat treated, aged to H-1075 per MIL-H-6875 after machining

3.3 Design and Construction:

Fittings and other parts shall be per the following standards, as applicable:

a. AS1577
b. AS1578
c. AS1579
d. AS1580
e. AS1581
f. AS1582
g. AS1583
h. AS1584
i. AS1585
j. AS1893

Tubings shall be to the requirements per AMS 4944 and AMS 5561, as applicable. Shape fittings such as elbows, tees, or crosses shall be machined from forgings or bar stock. Straight fittings shall be machined from bar stock.

3.3.1 Passages:

3.3.1.1 Drill Offset: On straight 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 0.015 in.

3.3.1.2 Cross Section: On shape fittings, the cross sectional area at the junction of the fluid passages shall not be smaller than the cross sectional area of the smaller passage.

3.4 Identification of Product:

All fittings shall be identified as follows. Marking shall be impressed, embossed, or electroetched in a location and in a manner not detrimental to the fitting. Where practical, marking shall remain visible after the fitting is installed.

3.4.1 Marking of Fittings: All fittings shall be marked with part number, material code letter, and the manufacturer's name or trademark. All fittings shall be marked with the basic part number less the size code for sizes -8 and larger, and letters "AS" for -6 size and smaller. Material code letter and the manufacturer's name or trademark shall be etched or impression stamped on all fitting parts unless otherwise noted.

3.4.2 Marking of Forged Shapes: All forged shapes, such as tees and elbows, shall also be marked with the forging manufacturer's trademark, code number, or code letter.

3.4.3 Marking of T-rings: The AS1580 and AS1893 T-rings shall be marked by giving the part number, code letter if any and manufacturer's name, code, or trademark on the package.

3.5 Performance:

Fitting samples per Table 2 welded to tubing shall be capable of meeting the requirements of 3.5.1, 3.5.2, 3.5.3, 3.5.4, and 3.5.5 when tested per the test procedures specified in Section 4.

3.5.1 Leakage: The welded fitting shall show no evidence of bubbles when immersed in water and pressurized to proof pressure of Table I of MIL-H-5540 for 5 min.

3.5.2 (R) Proof Pressure Test: The test assembly shall withstand proof pressure per MIL-H-5440 without leakage, evidence of permament deformation at separable connectors, or other malfunction that would affect assembly or disassembly.

3.5.3 Impulse Test: The test assemblies shall withstand 200 000 impulse pressure cycles without leakage as specified in 3.5.1 or other failure.

3.5.4 Burst: The test assemblies shall not rupture or leak in excess of that specified in 3.5.1 at pressures up to and including the values specified in MIL-H-5440.

3.5.5 Flexure: The test assemblies shall not rupture or leak in excess of that specified in 3.5.1 when flexure-fatigue tested to the requirements of ARP1258 or MIL-F-18280.

3.6 (R) Workmanship:

All machined surfaces shall be smooth to 125 µin Ra maximum per ANSI B46.1. Unmachined areas, such as forged surfaces, shall be free of laps, seams, or other defects. Parting lines in forging shall blend smoothly with the forged body and shall have a finish not exceeding 250 µin Ra as defined in ANSI B46.1.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection and Test:
(R)

Unless otherwise specified, the supplier is responsible for the performance of all inspection and test requirements specified herein. The suppliers may utilize their own facilities or other facilities which have been approved by the user. The user has the right to perform any of the inspections or tests set forth in this document, as deemed necessary to assure that the parts conform with the specified requirements.

4.2 Material Certification:
(R)

Tests for chemical composition and heat treat condition shall be performed to show conformance with the applicable requirements. Tensile and hardness test shall be performed to verify compliance with the mechanical properties of 3.2. Gas content of titanium shall be controlled per AMS 4928, except that forgings shall comply with requirements under 3.2.2. Records of these tests shall be made available to the user upon request.

4.3 Inspection Lot:

A lot shall consist of all parts of a given part number made from the same batch of material and processed at the same time. The supplier shall maintain a record of inspections applied to each lot.

4.4 Inspection Records:

The supplier shall keep a complete record of all material certifications, examinations, inspections, and tests performed to verify conformance to the requirements of this document. Such records shall be available upon request.

4.5 Classification of Inspections:

The testing and inspection shall be classified as follows:

a. Qualification inspection
b. Quality conformance inspection

4.6 Qualification Inspection:

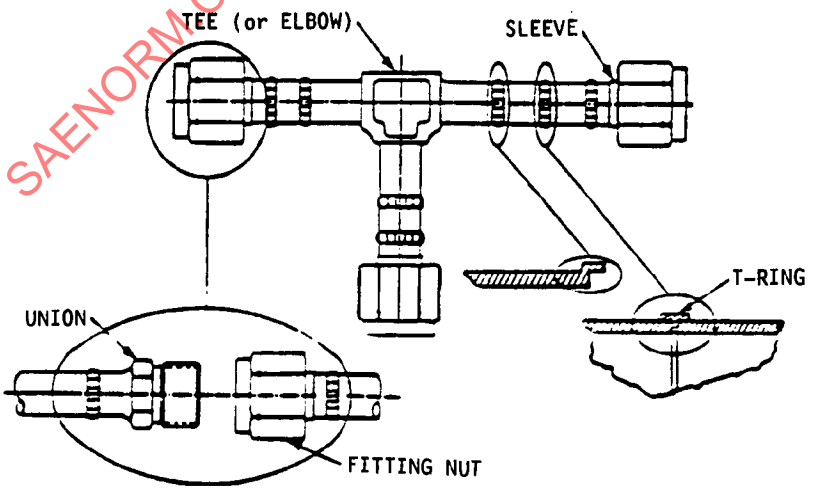
4.6.1 Sampling Instructions: Qualification inspection shall be conducted for each fitting or part standard as listed in Table 2 and for the sizes and materials used.

(R) TABLE 2 - Qualification Test Samples

PART	STANDARD	QUANTITY	TEST	PARAGRAPH
Tube End	AS1577	3	Impulse	3.5.3, 4.6.3.3
	AS1578	3	Burst	3.5.4, 4.6.3.4
		6	Flexure	3.5.5, 4.6.3.5
		3	Impulse	3.5.2, 4.6.3.3
T-Ring (Tube-Tube)	AS1580	3	Burst	3.5.3, 4.6.3.4
	AS1893	6	Flexure	3.5.4, 4.6.3.5
		3	Impulse	3.5.2, 4.6.3.3
Tee	AS1583	3	Burst	3.5.3, 4.6.3.4
		2	Flexure	3.5.4, 4.6.3.5
Union,	AS1582	3	Impulse	3.5.2, 4.6.3.3
Sleeve,	AS1581	3	Burst	3.5.3, 4.6.3.4
Nut	MS21921 (T)	6	Flexure	3.5.4, 4.6.3.5

NOTE: All specimens shall be proof tested per 3.5.2 prior to impulse, burst, and flexure testing.

4.6.1.1 (R) Test Specimen Preparation: Specimens for proof, burst, and impulse tests shall be assembled as illustrated in Figure 1. Flexure test specimens shall be in accordance with ARP1185.



NOTE: The minimum distance between welds is 3 in.

(R) FIGURE 1 - Examples for Proof, Burst, and Impulse Test Specimen (Optional, Combined or Single)

4.6.1.2 Tube Preparation: Tube ends to be welded shall be in accordance with AS1577 or AS1578, as applicable. Corrosion resistant steel specimens shall be alkaline cleaned or vapor degreased and then thoroughly drained and blown out to remove any remaining cleaning fluid. Titanium tubing shall be alkaline cleaned and then drained and blown out like the CRES tubing. No chlorinated solvents shall be used with titanium. Immediately prior to welding, the tube area that will be exposed to heat shall be solvent cleaned with MEK or acetone, unless specified otherwise.

4.6.2 Weldments:

4.6.2.1 Weld Beads: Welds for test specimens shall be smooth and uniform in appearance, with 100% penetration and fusion of the mating tube and fitting end. Undercut, thinning, concavity, or overlap at the edge of the weld bead shall be unacceptable. Underfill shall be unacceptable, except that for titanium a local blended underfill of 10% of the thinner wall thickness is allowed as long as it does not exceed 50% of the weld circumference. Cracks, weld craters, or open holes in the weld are unacceptable, except that a local blended depression in the weld tail-out area in the middle of weld reinforcement width with a maximum of 0.005 in depth x 0.015 in diameter is not regarded as detrimental.

NOTE: Definitions of welding terms, such as undercut, and overlap, are given in American Welding Society Standard AWS A3.0.

4.6.2.2 Weld Porosity: Subsurface porosity and inclusions shall not exceed the following items:

a. Porosity and inclusions with sharp terminations are unacceptable.

b. Porosity and inclusions shall not be closer together than three times the size of the smallest adjacent pore or inclusion in its largest dimension.

c. Interconnected porosity, or two or more pores or inclusions which are closer together than the largest dimension of the smaller adjacent pore or inclusion, shall be considered as a single pore or inclusion.

d. Porosity and inclusions shall not exceed one-half of the wall thickness in their largest dimension or 0.020 in, whichever is less.

e. Porosity and inclusions shall not exceed an accumulated length of 1-1/3 of the wall thickness in any lineal 1/2 in of weld.

4.6.2.3 Weld Discoloration: For titanium weldments, the following applies regarding discoloration:

a. Bright silver to straw to pale violet is acceptable. Light blue is acceptable only on the base metal, provided it does not contact the weld metal. All discoloration shall be removed when additional welding is to be performed.

4.6.2.3 (Continued):

b. Discoloration removal, when required, shall be done with a suitable abrasive fabric such as Scotch-Brite Type A or S, fine to ultrafine.

4.6.3 Qualification Tests:

4.6.3.1 Examination of Product: Prior to testing, the fitting parts and tubing shall be submitted to quality conformance inspection. All welded assemblies shall be visually and penetrant inspected and X-rayed in two planes, at a 90° angle, for compliance with the requirements under 4.6.2.

4.6.3.2 Proof Pressure: Test assemblies shall be connected to a pneumatic source of pressure immersed in water and pressure tested to the proof test value per MIL-H-5440 for a period of 5 min. The test shall be conducted at room temperature. The test assembly shall meet the requirement of 3.5.1.

CAUTION: A suitable tank or screen shall be provided to protect the operator in case of failure of the assembly.

4.6.3.3 Impulse Test: Test assemblies as illustrated in Figure 1 and Table 2 shall be tested to the requirements specified in ARP603 for:

a. Operating Pressure: 3000 psi
b. Peak Pressure: 4500 psi
c. Temperature: Room temperature
d. Specimen: Figure 1 or equivalent
e. Speed: 70 cpm
f. Rate of Rise: 175 000 - 300 000 psi/s

4.6.3.4 Burst Test: Test assemblies as described in Figure 1 and Table 2 shall be connected to a liquid source of pressure. The pressure shall be increased at a rate of 20 000 psi ± 5000 psi/min until leakage occurs or the burst pressure is reached. This test shall be conducted at room temperature.

CAUTION: A suitable tank or screen shall be provided to protect the operator in case of failure of the assembly.

4.6.3.5 Flexure Test: Samples shall be fabricated and the test shall be conducted per ARP1185 or MIL-F-18280 as applicable.

4.7 Quality Conformance Inspection:

Each lot of fittings shall be subjected to the inspections as listed.

4.7.1 Sampling: Sampling for material, dimensions, finish, and workmanship shall be random in accordance with MIL-STD-105. Unless otherwise specified under 4.8, the accepted quality level (AQL) shall be 4%.

4.7.2 Penetrant Inspection: Fitting forgings shall be 100% penetrant inspected per MIL-I-6866 until 30 consecutive pieces of each part number have been found defect free. Thereafter, a sampling plan in accordance with

4.7.2 (Continued):

MIL-STD-105, General Inspection Level II shall be applied. Indications of any surface defect within the sample size shall cause rejection of the entire lot. Inspection shall be done after machining, with the option that it may be done before threads and sealing surfaces are machined. Defects may be removed if drawing tolerances are not exceeded and the part passes penetrant inspection after in-process correction.

4.7.3 Microexamination - Titanium Forgings: Sample fittings or forgings from each forging lot shall be microscopically examined for compliance with 3.2.2.2, in particular for microstructure and oxide scale.

4.8 Classification of Defects:

4.8.1 Classes: Definitions of classes are in accordance with MIL-STD-109. Classes, AQLs, and defect characteristics as defined in MIL-STD-109 are clarified as follows:

TABLE 3 - Defect Classification

CLASS	AQL	CHARACTERISTIC
Major	1.5%	Likely to cause malfunction, or reducing usability of the part
Minor A	4%	May have a slight effect on usability
Minor B	6.5%	Essentially no effect on usability

4.8.2 Detail Requirements: See Tables 4 through 10.

TABLE 4 - AS1579 Fitting End, Welded Girth Joint, Dimensions, 3000 psi Hydraulic

CLASS	CHARACTERISTIC
MAJOR	A - Outside Diameter B - Weld End Diameter E - Weld End Depth D - Fitting End Diameter Machine Finish - "B" Diameter, "D" Diameter, Bore Diameter and Tube Butting Surface
MINOR A	C - Overlap Diameter F - Overlap Length Machining Finish

TABLE 5 – AS1580 Ring, Tube Weld, 3000 psi, Hydraulic, Titanium; AS1893 Ring, Tube Weld 3000 psi Hydraulic, CRES

CLASS	CHARACTERISTIC
MAJOR	B – Weld End Diameter E – Weld End Depth R – Shoulder Radius Cleanliness/Finish – "B" Diameter, "C" Diameter and Tube Butting Surface
MINOR A	A – Outside Diameter C – Inside Diameter .015/.020 Shoulder Thickness (AS1580) .005/.010 Shoulder Thickness (AS1593)

TABLE 6 – AS1581 Sleeve, Flareless Tube End, Welded, 3000 psi Hydraulic (Ends per AS1579 and NAS 1760)

CLASS	CHARACTERISTIC
MAJOR	A – Weld Positioning Length B – Gage Diameter F – Gage Depth H – Acorn Length M – Wire Recess Diameter Cleanliness/Finish – Globe Seal, ID, Weld End
MINOR A	A – Center, Acorn Radius C – Acorn Diameter D – Sleeve End Diameter E – Sleeve I.D. Bore L – Shoulder Diameter N – Nut Shoulder P – Sleeve Skirt Diameter T – Radius Cleanliness, Finish
MINOR B	Remainder