AEROSPACE STANDARD

AS1576™	REV. G

Issued 1980-02
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Revised 2024-02

Superseding AS1576F

Fittings, Welded, Hydraulic, Titanium, Corrosion-Resistant Steel and Nickel, 3000 psi Hydraulic

RATIONALE

Documents used for qualification control updated. Typo for numbering sequence in 5.1 corrected. Remove Pneumatic Leakage Test in the Periodic Control Report, in Appendix B.

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, 21Cr-6Ni-9Mn CRES, and 718 nickel alloy tubing. Fitting standards covered by this specification include non-separable welded elbow, tee, and reducer fittings, and reconnectable 24-degree cone fittings, such as sleeves and unions.

2. REFERENCES

2.1 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2759/3	Heat Treatment Precipitation-Hardening Corrosion-Resistant, Maraging, and Secondary Hardening Steel Parts
AMS4928	Titanium Alloy Bars, Wire, Forgings, Rings, and Drawn Shapes, 6Al - 4V Annealed
AMS4945	Titanium Alloy Tubing, Seamless, Hydraulic 3Al - 2.5V, Controlled Contractile Strain Ratio Cold Worked, Stress Relieved
AMS4946	Titanium Alloy Tubing, Seamless, Hydraulic 3Al - 2.5V, Texture Controlled Cold Worked, Stress Relieved

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AS1576G/

AMS5561	Steel, Corrosion and Heat-Resistant, Welded and Drawn or Seamless and Drawn Tubing, 9.0Mn - 20Cr - 6.5Ni - 0.28N, High-Pressure Hydraulic
AMS5589	Nickel Alloy, Corrosion and Heat-Resistant, Seamless Tubing 52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) 0.90Ti - 0.50Al - 18Fe Consumable Electrode Remelted or Vacuum Induction Melted 1775 °F (968 °C) Solution Heat Treated
AMS5656	Steel, Corrosion-Resistant, Bars, Wire, Forgings, Extrusions, Rings and Forging Stock, 9.0Mn - 20Cr - 6.5Ni - 0.27N, Solution Heat Treated
AMS5659	Steel, Corrosion-Resistant, Bars, Wire, Forgings, Rings, and Extrusions, 15Cr - 4.5Ni - 0.30Cb (Nb) - 3.5Cu Consumable Remelted, Solution Heat Treated, Precipitation Hardenable
AMS5662	Nickel Alloy, Corrosion- and Heat-Resistant, Bars, Forgings, Rings, and Stock for Forgings and Rings, 52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) - 0.90Ti - 0.50Al - 18Fe Consumable Electrode or Vacuum Induction Melted 1775 °F (968 °C) Solution Heat Treated, Precipitation-Hardenable
AMS5663	Nickel Alloy, Corrosion- and Heat-Resistant, Bars, Forgings, Rings, and Stock for Forgings and Rings 52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) - 0.90Ti - 0.50Al - 18Fe Consumable Electrode or Vacuum Induction Melted 1775 °F (968 °C) Solution and Precipitation Heat Treated
AMS-H-6875	Heat Treatment of Steel Raw Materials
AMS-T-6845	Tubing, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System 1/8 Hard Condition
ARP1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
ARP1258	Qualification of Hydraulic Tube Joints to Specified Flexure Fatigue Requirements
ARP4784	Definitions and Limits, Metal Material Defects and Surface and Edge Features, Fluid Couplings, Fittings, and Hose Ends
ARP9013	Statistical Product Acceptance Requirements
AS478	Identification Marking Methods
AS603	Impulse Testing of Hydraulic Hose, Tubing, and Fitting Assemblies
AS1577	Tube End, Weld, Design Standard
AS1579	Fitting End, Integral Weld, Lip, Design Standard
AS1580	Ring, Weld, 3000 psi, Titanium
AS1581	Fitting, Sleeve, Flareless Acorn to Integral Weld Ring, 3000 psi
AS1582	Fitting, Adapter, External Thread Flareless to Integral Weld Ring, 3000 psi
AS1583	Fitting, Tee, Integral Weld Ring, 3000 psi
AS1584	Fitting, Elbow, 90 Degree, Integral Weld Ring, 3000 psi
AS1585	Fitting, Reducer, Integral Weld Ring, 3000 psi
AS1893	Ring, Weld, 3000 psi, CRES
AS2094	Test Methods for Tube-Fitting Assemblies
AS4375	Fitting End, Flareless, Design Standard

AS4377 Fitting End, Bulkhead, Flareless, Design Standard

AS4458 Fitting End, Flareless, Blunt Nose, Design Standard

AS4693 Union, Tube End, External Thread to Weld, Short Flareless

AS4695 Sleeve, Tube End, Acorn to Weld, Short Flareless

AS4696 Fitting, Sleeve, Flareless, Nonreducer and Reducer, Short Acorn to Weld Tube End

AS4703 Fitting End, Acorn, Short Flareless, Design Standard

AS5233 Fitting Assembly, Cap, Flareless

AS5234 Nut, Coupling, Flareless

AS5863 Fitting End, 24° Cone, Flareless, Fluid Connection, Design Standard

AS5864 Fitting End, Bulkhead, 24° Cone, Flareless, Fluid Connection, Design Standard

AS8879 Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter

AS18280 Fittings, 24 Degree Cone Flareless, Fluid Connection, 3000 psi

AS33514 Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal

AS33515 Fitting End, Standard Dimensions for Bulkhead Flareless Tube Connections

2.1.2 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME B46.1 Surface Texture, Surface Roughness, Waviness, and Lay

2.2 ASQ Publications

Available from American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203, Tel: 800-248-1946 (United States or Canada), 001-800-514-1564 (Mexico), or +1-414-272-8575 (all other locations), www.asq.org.

ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

2.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E1417 Practice for Liquid Penetrant Examination

ASTM E1447 Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method

ASTM F945 Standard Test Method for Stress-Corrosion of Titanium Alloys by Aircraft Engine Cleaning Materials

ASTM F2111 Standard Practice for Measuring Intergranular Attack or End Grain Pitting on Metals Caused by Aircraft Chemical Processes

2.3.1 NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS1760 Fitting End, Fluid, Acorn, Standard Dimensions for

2.3.2 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 3161 Aerospace - UNJ Threads - General Requirements and Limit Dimensions

ISO 17025 General Requirements for the Competence of Calibration and Testing Laboratories

2.3.3 AWS Publications

Available from American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672, Tel: 1-800-443-9353 or 305-443-9353, www.aws.org.

AWS A3.0 Welding Terms and Definitions

2.3.4 PRI Publications

Available from Performance Review Institute, 161 Thorn Hill Road, Warrendale, PA 15086-7527, Tel: 724-772-1616, www.pri-network.org.

AC7112 Nadcap Audit Criteria for Fluid Systems Component Manufacturers

AC7112/2 Nadcap Audit Criteria for Fittings and other Machined Components

OP2007 Appendix G3 Aerospace Quality Assurance, Product Standards, Qualification Procedure, Fluid Distribution Systems

PD2000 PRI-QPL Program Requirements

PRI-QPL-AS1576 Fittings, Welded, Hydraulic, Titanium, Corrosion Resistant Steel and Nickel, 3000 psi Hydraulic

2.3.5 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

O-H-795 Hydrofluoric Acid, Technical

O-N-350 Nitric Acid, Technical

2.4 Definitions

WATER-BREAK-FREE SURFACE: A surface which maintains a continuous water film for a period of at least 30 seconds after having been spray or immersion rinsed in clean water at a temperature below 100 °F.

3. REQUIREMENTS

3.1 Product Qualification

Fittings, nuts, and sleeves furnished under this specification shall be representative of products which have been qualified to the requirements of this document. All products shall conform to the requirements of this procurement specification and shall be approved in accordance with the requirements of PD2000 and OP2007 Appendix G3 for listing in the Performance Review Institute (PRI) Qualified Products List (QPL) PRI-QPL-AS1576.

3.2 Manufacturer Qualification

A manufacturer producing a product in conformance to this procurement specification shall be accredited in accordance with the requirements of OP2007 Appendix G3, and AC7112 and shall be listed in a PRI Qualified Manufacturers List (QML).

3.2.1 Accreditation of Special Processes

Fabrication of fitting seal areas to AC7112/2 requires Nadcap accreditation by the manufacturer and their sub-tier. Initial approval of a sub-tier without Nadcap accreditation requires passing requirements of the periodic control test of titanium, 15-5PH, and nickel sample fittings, per 4.7.4, prior to supplying parts for procurement. For final approval of the sub-tier, this test has to be repeated three times following fabrication of 2500, 5000, and 10000 fittings. Following fabrication of 10000 fittings, the sub-tier shall maintain the same test-period criteria as the manufacturer.

NOTE 1: This requirement shall be specified for each different sub-tier that a manufacturer utilizes under their fabrication system. Records shall be maintained showing compliance with these requirements for each sub-tier utilized by the manufacturer.

NOTE 2: Seal area of fittings is defined as the contact area between 24-degree union cone and the rounded sleeve or acorn which establishes a seal when the assembly is tightened. This pertains to fittings having AS33514, AS33515, AS4375, AS4377, AS5863, or AS5864 fitting ends.

3.3 Materials

3.3.1 Fitting Materials

Fittings and other parts shall be made of materials listed in Table 1.

3.3.2 Fitting Forgings

3.3.2.1 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.

3.3.2.2 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	AMS5659 /1/ (15-5PH)
Weld Ring	Corrosion-Resistant Steel	--	AMS5656 (21Cr-6Ni-9Mn)
Straight and Shape Fittings and Weld Ring	Titanium	T	AMS4928 (Ti-6AL-4V)
Straight Fittings	Nickel	Y	AMS5662 /2/ (Alloy 718, Solution Heat Treated)

Notes:
/1/ Heat treat to condition H1075 in accordance with AMS2759/3 or AMS-H-6875, as required by the part standard. Verify heat treat.
/2/ Precipitation heat treated per AMS5663 after machining, unless otherwise specified in the procurement order.

3.4 Design and Construction

Fittings are defined per the applicable part standards.

Tubing shall be to the requirements per AMS4946 and AMS4945 with contractile strain ratio (CSR) in accordance with AMS4946, AMS5561, or AMS5589, as applicable. Tubing ends shall be prepared for welding per AS1577. Shape fittings such as elbows, tees, or crosses shall be machined from forgings or bar stock. Straight fittings shall be machined from bar stock.

3.4.1 Passages

3.4.1.1 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 inch.

3.4.1.2 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.

3.5 Cleaning

Parts that are to be cleaned to standard industry practice for fittings shall have no suffix code letter in the part number and shall be cleaned per 5.1.1. These parts may then have special cleaning as specified by the user prior to welding. Parts that are to be alkaline cleaned as suitable for welding shall have the suffix letter “C” in the part number and shall be cleaned per 5.1.2. Titanium alloy parts that are to be cleaned and nitric-hydrofluoric acid etched as suitable for welding shall have the suffix letter “E” in the part number and shall be cleaned and etched per 5.1.3.

NOTE: Safety - Hazardous Materials: While the materials, methods, applications, and processes described or referenced in this specification may involve use of hazardous materials, this specification does not address the hazards which may be involved in such use. Contact local officials if you have questions regarding use of these materials.

3.6 Identification of Product

All fittings, nuts, and sleeves shall be marked in accordance with the following instructions. The marking shall be applied, per AS478, as specified on the applicable drawing in a location not detrimental to the performance of the fitting and not detrimental to the corrosion protection of the fitting. For weld rings, and for items that cannot be physically marked because of lack of space or because marking would have a deleterious effect, the package shall provide the identification per 5.2.

3.6.1 Manufacturer's Identification

Unless otherwise specified, all fittings and sleeves shall be marked with the manufacturer's name, CAGE code or trademark, and with the letters "AS."

3.6.2 Material Identification

Fittings and sleeves shall be marked with the material code letter as shown in Table 1. Forged shapes, such as elbows or tees, shall also be marked with the forging manufacturer's trademark or a code identification letter or number.

3.6.3 Marking for Part Number and Size

A numerical size code equivalent to the nominal tube size in 0.0625-inch increments is optional. All fittings and sleeves larger than 06 fitting size code shall be marked with the basic part number, exclusive of size. Fitting or sleeve assemblies with assembled nuts shall be marked as above on the fitting body, but assembled nuts that have their own part number identification are acceptable. T-rings shall not be marked, but the package shall be identified per 5.2.

3.7 Performance

Fitting samples welded to tubing as listed in Table 2 shall be capable of meeting the requirements listed in this section. Details for the test procedures are specified in Section 4. Table 2 provides the operating pressure for test assemblies with the indicated tubing. Table 3 and Figure 1 describe test specimens, and Table 4 specifies tightening torque requirements.

Table 2 - Operating pressures

Nominal Tubing OD	Tube Size in 0.0625 Increments	Nominal Wall Thickness Type 3AL-2.5V Titanium Alloy Tubing per AMS4946	Nominal Wall Thickness Type 21-6-9 Corrosion-Resistant Tubing per AMS5561	Nominal Wall Thickness Type 718 Nickel Alloy Tubing per AMS5589	Bending Stress Level in Tube for Flexure Test +0/-10% psi	Operating Pressure Maximum
0.250	04	0.016	0.016	--	20000	3000
0.312	05	0.019	0.019	--	20000	3000
0.375	06	0.019	0.020	--	19000	3000
0.500	08	0.026	0.026	--	18000	3000
0.625	10	0.032	0.033	--	17000	3000
0.750	12	0.039	0.039	--	16000	3000
1.000	16	0.051	0.052	--	15000	3000
1.250	20	0.065-0.070	--	--	9000	3000
1.500	24	0.074	--	--	9000	3000
1.500	24	--	--	0.040	--	600

3.7.1 Pneumatic Pressure

The test assembly when assembled at minimum torque shall withstand pneumatic pressure equal to the operating pressure without visible leakage. There shall be no bubbles after 1 minute and during a 5-minute test duration. See 4.6.3.

3.7.2 Proof Pressure Test

The test assemblies with one half of the fitting nuts assembled at minimum and one half at maximum torque shall withstand pressure equal to 2X operating pressure. There shall be no leakage sufficient to form a drop, evidence of permanent deformation or permanent set, or other malfunction that would affect assembly or disassembly using the specified range of torque values. See 4.6.4.

3.7.3 Impulse Test

Test assemblies when torque tightened to minimum specified installation torque shall pass 200000 impulse pressure cycles to requirements of AS603 without leakage or other failure. The test procedure shall follow AS2094 (see 4.6.5). Specimens shall be proof tested per 3.7.2 prior to impulse testing and following completion of the impulse test.

3.7.4 Burst

The test assemblies with one half of the fitting nuts assembled at minimum and one half at maximum torque shall not rupture or show evidence of leakage at any pressure, up to and including 4X the operating pressure. Tubing expansion is permissible. See 4.6.6. Refer to AS2094.

3.7.5 Flexure

3.7.5.1 Flexure, Alternate Test Methods

3.7.5.1.1 Standard Flexure Test

The test specimens shall meet flexure testing to the stress levels specified in AS18280 for the appropriate tubing material, when tested per 4.6.7. Six assemblies shall withstand 10^7 flexure cycles without leakage.

Modifications of 24-degree cone fittings, tubing materials other than those specified in AS18280, or other welding process are to be qualified by comparing their fatigue life against that of the basic 24-degree cone fitting by testing to 10^7 cycles, to the same fatigue life measured in deflection as the basic fitting. The performance of such other designs, materials, or joining methods shall meet or exceed that of the standard 24-degree cone fitting and cold-worked corrosion-resistant steel tubing, as specified in AS18280.

3.7.5.1.2 S-N Flexure Test

The S-N test method, per ARP1185, using eight specimens, may be used as an alternative to the method of testing six specimens per 3.7.5.1.1. Two specimens shall pass the minimum stress levels specified for tube and fitting materials as specified in AS18280. The remaining six specimens shall be tested at stress levels outlined in ARP1185 to establish an S-N curve. There shall be no leakage from the fitting or fitting to tube junction during testing at any of the stress levels.

3.7.6 Repeated Assembly

The test assembly shall withstand eight repeated assemblies at the specified minimum and maximum torque values when tested at room temperature without:

a. Leakage at any of the pressure tests.

b. Inability to reassemble the fitting to the point of interface by hand.

c. Nut deformation preventing engagement of the hex of the nut with an open-end wrench.

3.8 Workmanship

All machined surfaces shall be smooth to 125 µin Ra per ASME B46.1. Seal areas shall be fabricated by single point machining. Unmachined areas, such as forged surfaces, shall be free of laps, seams, or other defects. The process used to machine weld cups shall not leave embedded particles. Parting lines in forging shall blend smoothly with the forged body and shall have a finish of 250 µin Ra as defined in ASME B46.1. The surface finish on sealing surfaces shall be as specified on the part standard and shall not leak in testing. There shall be no chatter marks on sealing surfaces greater than the limits specified in ARP4784. Inspection shall follow ARP4784 except that 10X magnification shall be used. Grit blasting is not permitted on sealing surfaces unless required as preparation for solid film lubricant.

3.9 Threads

Threads shall be per AS8879 Category I or ISO 3161 except that the root radius is not required on incomplete threads. Threads shall not be grit or bead blasted unless required as preparation for application of solid film lubricant.

External threads on corrosion-resistant steel, titanium, and nickel alloy parts may be produced by a single point method, cut or rolled.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection and Test

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 to ISO 17025. 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

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 3.3. Gas content of titanium shall be controlled per AMS4928, except that forgings shall comply with requirements under 3.3.2. 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

c. Periodic control tests

4.6 Qualification Inspection

4.6.1 Sampling Instructions

Qualification inspection shall be conducted for each fitting or part standard as listed in Table 3 and for the sizes and materials used.

4.6.1.1 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.

4.6.1.2 Tube Preparation

Tube ends to be welded shall be in accordance with AS1577. Corrosion-resistant steel and nickel alloy 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 or equivalent, 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-inch depth x 0.015-inch 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 3X 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 inch, 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 inch 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.

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

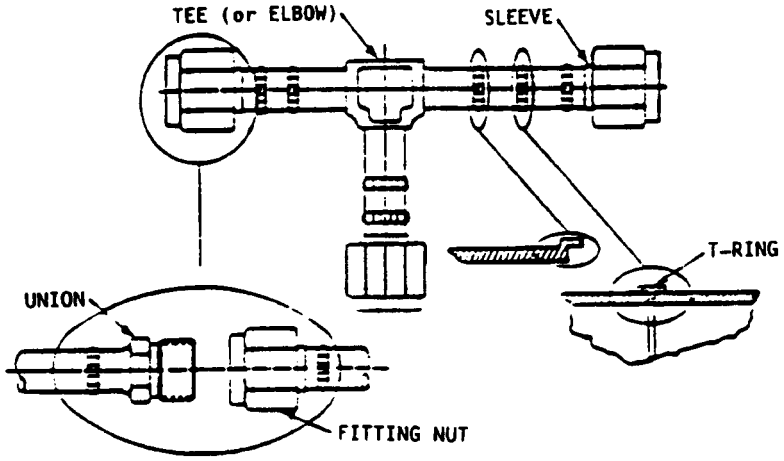
4.6.2.4 Examination of Product

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-degree angle, for compliance with the requirements under 4.6.2.

Table 3 - Qualification test samples

Part	Standard	Quantity	Test /1/	Material /2/	Paragraph
T-Ring (Tube-Tube)	AS1580, AS1893	3	Impulse	All	3.7.3, 4.6.5
		3	Burst		3.7.4, 4.6.6
		6	Flexure		3.7.5, 4.6.7
Tee	AS1583	3	Impulse	All	3.7.3, 4.6.5
		3	Burst		3.7.4, 4.6.6
Union, Sleeve, Nut, Flareless	AS1582, AS1581, AS5234 (T)	3	Impulse	All	3.7.3, 4.6.5
		3	Burst		3.7.4, 4.6.6
		6	Flexure		3.7.5, 4.6.7
Union, Sleeve, Nut, Short Flareless	AS4693, AS4695, AS4660 (T)	3	Impulse	All	3.7.3, 4.6.5
		3	Burst		3.7.4, 4.6.6
		6	Flexure		3.7.5, 4.6.7
Union, Sleeve, Nut,	/3/	4	Pneumatic	All	3.7.1, 4.6.3
		4	Repeated Assy		4.7.6, 4.6.8
Union, Sleeve, Nut, Short Flareless	/3/	4	Pneumatic	All	3.7.1, 4.6.3
		4	Repeated Assy		3.7.6, 4.6.8

Notes:
/1/ Specimens shall be welded to tubing with AS1577 weld ends or weld ends specified by the user and using a qualified weld process to be used in future fabrication.
/2/ All specimens shall be proof tested per 3.7.2 prior to impulse, burst, and flexure testing.
/3/ Each basic material type shall be separately tested.



NOTE: The minimum distance between welds is 3 in.

Figure 1 - Examples for proof, burst, and impulse test specimen (optional, combined, or single)

4.6.3 Pneumatic Pressure

The test assembly shall be connected to a source of pressure with one end unrestrained and pneumatic pressure tested per AS2094.

4.6.4 Proof Pressure

The test assembly shall be connected to a source of pressure with one end unrestrained. The test assembly exterior shall be clean and dry and shall show no evidence of test fluid prior to testing. Conduct the proof pressure test per AS2094 using the fluid specified therein.

Table 4 - Fitting nut tightening torque values

Nominal Tube Size	Minimum Torque lb-in	Maximum Torque lb-in
02	50	60
03	95	105
04	135	145
05	170	190
06	215	245
08	470	510
10	620	680
12	855	945
14	995	1100
16	1140	1260
20	1520	1680
24	1900	2100

4.6.5 Impulse Test

Test assemblies as illustrated in Figure 1 and Table 2 shall be tested to the requirements specified in AS603 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: 175000 to 300000 psi/s

4.6.6 Burst Test

The test assemblies with one half of the fitting nuts assembled at minimum and one half at maximum torque shall not rupture or show evidence of leakage at any pressure up to and including four times the operating pressure. Tubing expansion is permissible. Refer to AS2094. The pressure may continue to be increased above the specified minimum burst pressure until burst or leakage occurs.

4.6.7 Flexure Test Procedure

The flexure test for reconnectable titanium, CRES, or 718 nickel alloy fittings shall meet the minimum bending stress level shown in Table 2. The stress level shall be measured at the specified location on the test assembly. The total stress in Table 2 is defined as the axial tensile stress due to the internal pressure plus the dynamic tensile bending stress (see Equation 1). The axial tensile stress due to the internal pressure shall be determined as specified in 4.6.7.1. The dynamic tensile bending stress shall be determined as specified in 4.6.7.2.

$$S = Sa + Sb \quad \text{(Eq. 1)}$$

where:

S = total stress

Sa = axial tensile stress due to internal pressures (see 4.6.7.1, Equation 2)

Sb = dynamic tensile bending stress (see 4.6.7.2, Equation 3)

The flexure test procedure for Tables 3 shall meet the minimum dynamic tensile bending stress for 4.6.7.2.

4.6.7.1 Axial Tensile Stress Due to Internal Pressure

The axial tensile stress due to internal pressure may be calculated per Equation 2.

$$Sa = \frac{Pd^2}{D^2 - d^2} \quad \text{(Eq. 2)}$$

where:

Sa = axial tensile stress due to internal pressure

D = tube outside diameter

d = tube inside diameter

P = internal pressure

4.6.7.2 Dynamic Tensile Bending Stress

The dynamic bending strain shall be measured by one or more strain gages placed on the tube 0.188 inch ± 0.031 inch from the end of the sleeve. The dynamic strain reading shall be taken while the test specimen is being flexed at the rate given below. The dynamic tensile bending stress shall be determined as shown for the test method in 4.6.7.2.2.

During testing, a constant pressure equal to the operating pressure, noted in Tables 2 shall be imposed. The frequency of flexing shall be at any rate from 30 to 500 cps, depending on the method selected. The specimens shall be assembled with maximum torque values per Table 4. The duration of the testing shall be 10 million cycles or until prior failure or leakage occurs.

4.6.7.2.1 Modulus of Elasticity

For purposes of stress calculations, the modulus of elasticity for 304 CRES tubing shall be considered to be 28000000 psi, for 21-6-9 CRES tubing to be 28500000 psi, and for 3AL-2.5V titanium tubing to be 15000000 psi.

4.6.7.2.2 Rotary Beam Flexure Test Method

The dynamic tensile bending stress shall be imposed by the rotary beam test method in accordance with ARP1185, except that the tolerance on the L test specimen length shall be ±1%. If a different L length is used, the bending stress shall be adjusted by a factor determined experimentally for each type of test sample so that equivalent stress is applied. The bending stress from strain gage measurement shall be determined using Equation 3.

$$S_b = e_{max}E \quad \text{(Eq. 3)}$$

where:

S_b = maximum axial bending stress due to deflection

e_{max} = maximum measured axial unit bending strain - measured dynamically

E = modulus of elasticity for the tubing material

If the deflection method of ARP1185 is used in lieu of the determination of stress by the use of strain gages, the application of an equivalent stress shall be verified experimentally for each type of test sample.

4.6.8 Repeated Assembly Test Procedure

a. The test specimens shall be assembled to the fitting 24-degree cone seat, one half of the specimens at the minimum and one half of the specimens at the maximum fitting assembly torque values specified in AS18280, and tested per AS2094 except as noted below.

b. After the first tightening, the tube and fitting end shall be marked with a longitudinal stripe to indicate their in-line relationship. The test sample joint shall be assembled and disassembled eight successive times. Each disassembly operation shall include the complete removal of the tube from the seat. At reassembly the tube shall be rotated 90 degrees from the previous tube-to-fitting phase relationship. The direction of rotation shall be the same for each reassembly.

c. The pneumatic pressure test, per 4.6.3, shall be conducted after the first tightening operation. After the third tightening operation, the test assembly shall be subjected to the pneumatic pressure test per 4.6.3, followed by the proof pressure test per 4.6.4. After the eighth tightening operation, the test assembly shall be subjected to the pneumatic pressure test per 4.6.3, followed by the burst test per 4.6.6.

d. Sealing surfaces should be clean and dry before conducting pneumatic pressure tests.

e. Retesting: In the event of leakage or galling, the problem shall be found and corrected. The test shall be repeated using eight specimens.

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 ARP9013 with Classification of Aspects and Initial Reliability Requirement (I.R.R.), as shown in Tables 5A and 5B and Acceptance Number zero. Example sampling inspection tables are shown in Table 5C.

NOTE: ARP9013 allows for the use of a variety of both new and heritage statistical methods for product acceptance. Some heritage methods include ASQ Z1.4 and Squeglia C = 0 tables, continuous sampling for lot size = 1 applications, and SPC; however, each of these methods must be used per specific instructions to demonstrate an acceptable degree of protection for customers. ARP9013 gives guidance on how to achieve that protection. Simple guidelines to show that heritage plans meet an I.R.R. include ensuring that the AOQL is less than 1- I.R.R. in plans for ongoing production, or ensuring that the ERP (“Equal Risk Point” or “indifference quality”) is less than 1- I.R.R. in a plan for an isolated lot.

Table 5A - Classification of characteristics

Separable Fitting Ends - Design Standard AS1579, AS4458, AS4703		Weld Sleeves AS1581, AS4695, AS4696	
Class	Characteristics /1/	Class	Characteristics /1/
Major	A - Outside Diameter B - Weld End Diameter E - Weld End Depth D - Fitting End Diameter Machine Finish “B” Dia, “D” Dia Diameter, Bore Dia, Tube Butting Surface Black Residue, Weld Cup	Major	A - Gage Diameter C - Gage Depth D - Acorn Length M - Wire Recess Diameter Cleanliness/Finish, Globe Seal, ID Weld End Black Residue, Weld Cup
Minor A	C - Overlap Diameter F - Overlap Length Machining Finish	Minor A	A - Center - Acorn Radius C - Acorn Diameter D - Sleeve End Diameter E - Sleeve ID Bore L - Shoulder Diameter N - Nut Shoulder P - Sleeve Skirt Diameter T - Radius Cleanliness, Finish
Minor B	Remainder	Minor B	Remainder
Adapter Weld Union AS1582, AS4693		Weld Rings AS1580, AS1893	
Class	Characteristics /1/	Class	Characteristics /1/
Major	Weld Positioning Length (A/B) Gage Diameter (AS4658/AS4375) Cleanliness/Finish - Conical Sealing Surface and ID Weld End Black Residue, Weld Cup	Major	B - Weld End Diameter E - Weld End Depth R - Shoulder Radius Cleanliness/Finish - B Diameter, C Diameter, and Tube Butting Surface Black Residue, Weld Cup
Minor A	Finish	Minor A	A - Outside Diameter C - Inside Diameter 0.015/0.020 Shoulder Thickness (AS1580) 0.005/0.010 Shoulder Thickness (AS1593)
Minor B	Remainder	Minor B	Remainder
Elbow, Tee AS1583, AS1584		Reducer AS1585	
Class	Characteristics /1/	Class	Characteristics /1/
Major	A - Bore Diameter E - Weld Tool Clamp Length R 0.030/0.125 Intersection (AS1583) Black Residue, Weld Cup	Major	A - Weld Tool Clamp Length 1.300 Weld Tool Length Black Residue, Weld Cup
Minor A	Finish	Minor A	T_1, T_2 Thickness Finish,
Minor B	Remainder	Minor B	Squareness Remainder
Non-Separable Weld End - Design Standard AS1579		Preparation for Delivery	
Class	Characteristics /1/	Class	Characteristics /1/
Major	Weld Cup ID Black Residue, Weld Cup	Major Minor A Minor B	Damaged parts in package containers
Minor A	Remainder		

Note:
/1/ Refer to design standards and part standards for the 24-degree cone fitting for explanations of the terms used in this column.

Table 5B - Classes, aspect characteristics and quality parameters, sampling inspections

Major	Likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose.	98%
Minor A	May have a slight effect on usability.	95%
Minor B	Has essentially no effect on usability.	92%

Table 5C - Sampling inspection, tables for isolated lot applications

Initial Reliability Requirement (I.R.R.)	98%
Lot size up to 25	Sample size is All
26- 52	25
53- 57	26
58- 63	27
64- 74	28
75-104	29
105-126	30
127-181	31
182-303	32
304-693	33
694 or larger	34

Initial Reliability Requirement (I.R.R.)	95%
Lot size up to 10	Sample size is All
11- 22	10
23- 33	11
34- 80	12
81-4371	13
4372 or larger	14

Initial Reliability Requirement (I.R.R.)	92%
Lot size up to 6	Sample size is All
7-12	6
13-32	7
33 or larger	8

4.7.2 Penetrant Inspection

Fitting forgings shall be 100% penetrant inspected per ASTM E1417 until 30 consecutive pieces of each forging lot have been found defect free. Thereafter, a sampling plan in accordance with ARP9013 and I.R.R. = 95% 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. Inspection of forging parting planes may be done prior to machining. Defects may be removed if drawing tolerances are not exceeded and the part passes penetrant inspection after in-process correction, but the removal of the sample defects shall not eliminate the need for screening the rejected lot.

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.

4.7.4 Periodic Control Tests

Periodic control tests shall be conducted every 12 months to maintain PRI-QPL-AS1576 listings. The purpose of the periodic control test is to ensure manufacturing processes are maintained at the same level as when parts were qualified. Tests shall be conducted on titanium and 15-5PH CRES assemblies. Four sample fittings (or two welded tube assemblies) for each material shall be selected at random from the 12 months of production that includes MS, AS, and NAS standard fittings having weld ends per AS1579 and AS33514, AS33515, AS4375, AS4377, AS5863, and AS5864 fitting ends connected to NAS1760 or AS4703 fitting ends. This test is required regardless of production quantities, including if no fittings in a particular material was manufactured in the prior year. Periodic testing may be conducted at the manufacturer's facility. Manufacturer accreditation to ISO 17025 or PRI witnessing is not required (for periodic testing). Test results shall be submitted to PRI for review. Failure to submit periodic control test data to PRI when requested will result in the manufacturer's QPL listing being removed pending receipt and approval of the test data. If data is not received within 6 months of the requested date, additional testing may be required, including possible requalification. Test reporting shall be done using the AS1576 Periodic Control Test Summary format shown in Appendix B. First periodic test data submission shall be due 12 months after initial listing onto the corresponding AS1576 QPL.

NOTE 1: Periodic control tests on welded fittings shall be conducted with the mating threaded joints (union, sleeve, and nut) of each basic material to verify sealing performance and thread quality.

NOTE 2: The "12-month requirement" applies whether only one material is produced, or both based on the materials the manufacturer is QPL listed for. Periodic tests of both materials (if QPL approved for both) shall be conducted when the 12 months of production is reached and when requested by PRI.

NOTE 3: Periodic testing may be conducted at the manufacturer's facility; PRI witnessing not required.

NOTE 4: Periodic testing of AS1576 series standard parts in conjunction with AS18280 series periodic control tests do not have to be repeated and may be combined into one test.

NOTE 5: Suppliers qualified to manufacture short flareless fittings may perform the periodic test using size 16 flareless joints.

4.7.4.1 Test Specimens

Welded assemblies shall be connected to flareless fittings having AS4375, AS4377, AS5863, and AS5864 fitting ends. Welded fittings consisting of NAS1760 fitting ends or flareless fitting ends, per above, may be capped by tube assemblies with AS1581 welded-on sleeves, or by AS5233-type caps having AS1581 contoured seal plugs. Tests hall be conducted in any size that the manufacturer is qualified for.

4.7.4.2 Repeated Assembly Test

Assemblies shall be tested as specified in 4.6.8 and shall meet requirements, as specified under 3.7.6 (and 3.7.1).

NOTE: Retesting - In the event of leakage or galling, the problem shall be found and corrected. The test shall be repeated using eight specimens.

5. PREPARATION FOR DELIVERY

5.1 Cleaning

5.1.1 Parts Without Code Letter "C" or "E"

Parts shall be uniform in appearance and free from staining, fingerprints, grease, machining fluids, and lubricants.

NOTE: For cleaning of titanium alloy fittings, only solvents that are not chlorinated shall be used.

5.1.2 Parts with Code Letter “C”

Parts with a suffix code letter “C” in the part number (see 3.5) shall be hot alkaline cleaned per 5.1.4.

5.1.3 Titanium Alloy Parts with Code Letter “E”

Titanium alloy parts with a suffix code letter “E” in the part number (see 3.5) shall be nitric-hydrofluoric acid etched per 5.1.5. Dimensional controls shall be met after etching.

5.1.4 Hot Alkaline Cleaning Procedure

5.1.4.1 Precleaning

The parts shall have been cleaned to meet the requirement of 5.1.1 before start of alkaline cleaning to minimize the contamination of cleaning tanks and to ensure maximum alkaline cleaning effectiveness.

5.1.4.2 Soak Cleaning

Rack or position parts to permit circulation of solution over all of the surfaces. The cleaning solution shall be 6 to 12 ounces of alkaline cleaner per gallon of water at a temperature of 180 to 190 °F. Completely immerse parts in the cleaning solution for 10 minutes minimum or until soil is removed and the surface is water-break-free after rinsing. When possible, agitate part during processing. Use of ultrasonic agitation is permitted.

5.1.4.3 Rinsing

Whenever possible after processing, rinsing should include the use of a water-fog curtain above the processing tank to prevent the alkaline solution from drying on the part. After cleaning, immersion rinse or spray rinse without allowing the cleaner to dry on the parts. The spray must impinge on and drain from all surfaces. Parts shall be free of water breaks after rinsing. A spray rinse is preferred prior to the immersion rinse to remove excess cleaner and to avoid “dry on” of alkaline cleaner. When immersion rinsing, soak for at least 5 minutes using part or water agitation to facilitate rinsing. Sufficient water shall be flowing into the rinse tanks to maintain contaminant levels below 350 ppm maximum.

A final rinse prior to drying of the parts shall be accomplished by the use of heated deionized or distilled water. The intent of the hot rinse is to minimize drying time. It is recommended that the water deionizing unit be equipped with a conductivity meter.

5.1.4.4 Post-Rinse

Dry the parts except where a wet process follows immediately. Dry by blasting parts with filtered, dry, oil-free air or gaseous nitrogen. Use of a drying gas heater is optional. Keep parts dry and free of oil, grease, fingerprints, or other contamination.

5.1.4.5 Appearance

When visually examined without magnification after alkaline cleaning and rinsing, parts shall be free of residue, pitting, etching, dry-on, smut, and soil, including wax pencil marks, marking inks, printing ink, or other contaminants, and shall show a water-break-free surface.

5.1.5 Nitric-Hydrofluoric Acid Etch Procedure

5.1.5.1 Pre-Cleaning

The parts shall meet the requirement of 5.1.1 before start of alkaline cleaning to minimize the contamination of cleaning tanks and to ensure maximum alkaline cleaning effectiveness.

5.1.5.2 Cleaning and Etching

The parts shall be cleaned and nitric-hydrofluoric acid etched per Appendix A.

5.2 Packaging

Subsequent to cleaning, fitting shall be packaged as follows:

a. Individual fittings: Each fitting except weld end sleeves or weld rings shall be individually packaged in a clean, durable, clear polyethylene bag or container. Weld end sleeves or T-rings may be bulk packaged with the maximum quantity per package of 100 pieces for sizes 02 through 05, 50 pieces for sizes 06 through 08, 25 pieces for sizes 10 through 16, and 10 pieces for size 20 and larger. Packaging shall be sufficiently thick to prevent accidental rupture or tearing and shall prevent damage to the parts during shipment and handling. Thread or fitting end protectors, identification labels, or any item except the fittings shall not be placed in the bags.

   The purchase contract for un-etched parts may specify alternative packaging when shipping directly to users that etch and weld the fittings. The un-etched parts shall be cleaned to the level specified in 5.1.1 unless additional cleanliness is specified in the purchase contract. The alternative packaging shall maintain the cleanliness of the parts and provide the same protection as if packaged as specified for individual fittings. The user shall agree to the alternative packaging method prior to shipment.

b. Package identification: Packages shall be marked with the following identification on or in the package:

   1. Part name
   2. AS standard part number
   3. Manufacturer’s name, trademark, or CAGE code
   4. Lot number and date of manufacture
   5. Quantity per package

6. NOTES

6.1 Intended Use

Fittings covered by this standard are intended for welding CRES, titanium, and nickel alloy tube ends and assemblies of such welded fittings for use in aircraft 3000 psi hydraulic systems.

6.2 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY SAE SUBCOMMITTEE G-3B, AEROSPACE FITTINGS OF
COMMITTEE G-3, AEROSPACE COUPLINGS, FITTINGS, HOSE, AND TUBING ASSEMBLIES COMMITTEE

APPENDIX A - NITRIC-HYDROFLUORIC ACID ETCH OF TITANIUM ALLOYS

This appendix contains processing information which is essential to assure consistent and defect-free weld beads.

A.1 SCOPE

This appendix provides requirements for the acid-etch processing of weld fittings made of titanium, as defined in the main portion of this specification. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

A.2 FACILITIES CONTROL

A.2.1 Temperature

The etch shall be equipped with temperature indicating and regulating devices capable of controlling the solution within ±5 °F. A temperature indicator should be readily visible to the shop operator. Automatic regulators are recommended but are not mandatory.

A.2.2 Agitation

The etch tank shall be agitated slowly as required to minimize temperature and concentration gradients. The maximum temperature gradient shall be measured from the hottest to the coldest point in the tank and shall be within the specified range of that solution. When constant agitation is not used, agitation immediately prior to processing of parts is required to minimize etch variations and temperature and concentration gradients.

A.2.3 Air

Compressed air used for abrasive cleaning, blowing off dust, drying, and other process operations shall be free of water, oil, and solid particles.

A.2.4 Fixtures

Fixtures such as racks, clamps, and baskets used during etching require special construction to assure against damage to parts (see A.3.1.1a).

A.3 PROCESS CONTROL

A.3.1 General Notes

A.3.1.1 Racking

During etching, the following precautions shall be taken:

a. Position the parts to minimize contact with other material.

b. Rack parts to meet the requirements of A.6b.

c. When necessary, use fixtures such as racks, clamps, and baskets made from the materials, such as those listed in Table A1.

A.3.1.2 Final Surfaces

Bare metal surfaces shall be water-break-free following immersion in any final rinse. Reclean parts which develop water-breaks.