



AEROSPACE STANDARD

AS1576™**REV. G**

Issued 1980-02
Reaffirmed 2007-08
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

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2024 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

Full document details: SAE AS1576G

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

Documents

Document Sharing Hub

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