

Submitted for recognition as an American National Standard

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

1. **SCOPE:** This specification 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. **APPLICABLE DOCUMENTS:** The following specifications and standards, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:
  - 2.1 **Military:**
    - 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-I-6866 - Inspection, Penetrant Method of
    - 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
    - AMS 5561 - Steel Tubing, Welded and Drawn, Corrosion and Heat Resistant, 9.0Mn-20Cr-6.5Ni-0.28N, High-Pressure Hydraulic
    - Ø 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

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## 2.2 (Continued):

- 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
- Ø 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
- Ø 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 specification 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 I.

Table I  
Materials

| TYPE OF PART                              | MATERIAL                  | MATERIAL CODE | SPECIFICATION                  |
|-------------------------------------------|---------------------------|---------------|--------------------------------|
| Straight and Shape Fittings               | Corrosion Resistant Steel | V             | AMS 5659*<br>(15-5 PH, H-1075) |
| Ø Weld Ring                               | Corrosion Resistant Steel | -             | AMS5656<br>(21CR-6N : 9MN)     |
| Straight and Shape Fittings and Weld Ring | Titanium                  | T             | AMS 4928<br>(Ti-6AL-4V)        |

\*Solution heat treated, aged to H-1075 per MIL-H-6875 after machining

### 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.

### 3.3 Design and Construction: Fittings and other parts shall be per the following standards, as applicable:

|          |        |
|----------|--------|
| AS1577   | AS1582 |
| AS1578   | AS1583 |
| AS1579   | AS1584 |
| AS1580   | AS1585 |
| Ø AS1581 | 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 .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 the letters "AS", the material code letter and the manufacturer's identification or trademark. A numerical equivalent to the dash number indicating size is optional. All fittings larger than 3/8 inch tube size shall be marked with the part number exclusive of size.

#### 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 AS 1580 and AS 1893 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 II welded to tubing shall be capable of meeting the requirements of paragraphs 3.5.1, 3.5.2, 3.5.3, 3.5.4, and 3.5.5 below 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 Proof Pressure Test: The test assembly shall withstand proof pressure per MIL-H-5440 without leakage, as specified in paragraph 3.5.1, evidence of permanent deformation or, at separable connectors, 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 paragraph 3.5.1, or other failure.
- 3.5.4 Burst: The test assemblies shall not rupture or leak in excess of that specified in paragraph 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 paragraph 3.5.1 when flexure-fatigue tested to the requirements of ARP 1258 or MIL-F-18280.
- 3.6 Workmanship: All machined surfaces shall be smooth to 125 microinches 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 Ra as defined in ANSI B46.1.
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 supplier may utilize his 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 specification, 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 Section 3.2. Gas content of titanium shall be controlled per AMS 4928, except that forgings shall comply with requirements under 3.3.2. Records of these tests shall be made available to the user upon request.

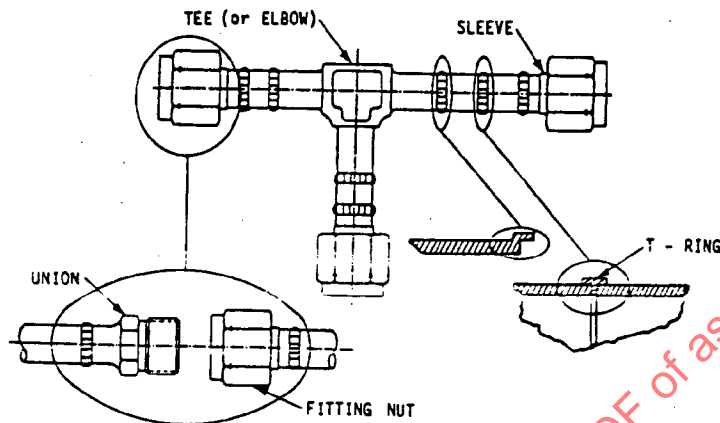
- 4.3 Inspection Lot: A lot shall consist of all parts of a given part number made from the same batch of material and processed at the same time. The supplier shall maintain a record of inspections applied to each lot.
- 4.4 Inspection Records: The supplier shall keep a complete record of all material certifications, examinations, inspections and tests performed to verify conformance to the requirements of this specification. 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 II and for the sizes and materials used.

TABLE II  
QUALIFICATION TEST SAMPLES

| PART                     | STANDARD                          | QUANTITY | TEST    | PARAGRAPH      |
|--------------------------|-----------------------------------|----------|---------|----------------|
| Tube End                 | AS 1577<br>AS 1578                | 3        | Impulse | 3.5.2, 4.6.3.3 |
|                          |                                   | 3        | Burst   | 3.5.3, 4.6.3.4 |
|                          |                                   | 6        | Flexure | 3.5.4, 4.6.3.5 |
| T-Ring<br>(Tube-Tube)    | AS 1580<br>AS 1893                | 3        | Impulse | 3.5.2, 4.6.3.3 |
|                          |                                   | 3        | Burst   | 3.5.3, 4.6.3.4 |
|                          |                                   | 6        | Flexure | 3.5.4, 4.6.3.5 |
| Tee                      | AS 1583                           | 3        | Impulse | 3.5.2, 4.6.3.3 |
|                          |                                   | 3        | Burst   | 3.5.3, 4.6.3.4 |
|                          |                                   | 2        | Flexure | 3.5.4, 4.6.3.5 |
| Union,<br>Sleeve,<br>Nut | AS 1582<br>AS 1581<br>MS21921 (T) | 3        | Impulse | 3.5.2, 4.6.3.3 |
|                          |                                   | 3        | Burst   | 3.5.3, 4.6.3.4 |
|                          |                                   | 6        | Flexure | 3.5.4, 4.6.3.5 |

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

- 4.6.1.1 **Test Specimen Preparation:** Specimens for burst and impulse tests shall be assembled as illustrated in Fig. 1. Flexure test specimens shall be in accordance with ARP 1185.



NOTE: Minimum Distance Between Welds 3 In

Fig. 1 Examples for 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 AS 1577 or AS 1578, 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 **Weldbeads:** Welds for test specimens shall be smooth and uniform in appearance, with one hundred percent 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: a local blended depression in the weld tail-out area in the middle of weld reinforcement width with a maximum of .005 in depth x .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 1/2 of the wall thickness in their largest dimension or .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 one-half 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.
- (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 deg angle, for compliance with the requirements under Section 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 five min. The test shall be conducted at room temperature. The test assembly shall meet the requirement of paragraph 3.5.1.

Ø 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 Fig. 1 and Table II shall be tested to the requirements specified in ARP 603 for:

Operating Pressure: 3000 psi  
Peak Pressure: 4500 psi  
Temperature: Room Temperature  
Specimen: Figure 1 or equivalent  
Speed: 70 Cycles per Minute  
Rate of Rise: 175,000 - 300,000 psi/sec.

- 4.6.3.4 Burst Test: Test assemblies as described in Fig. 1 and Table II shall be connected to a liquid source of pressure. The pressure shall be increased at a rate of 20,000 psi  $\pm$  5000 psi per minute until leakage occurs or the burst pressure is reached. This test shall be conducted at room temperature.

Ø 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 ARP 1185 or MIL-F-18280 as applicable.

- 4.7 Quality Conformance Inspection: Each lot of fittings shall be subjected to the inspections as listed below.

- 4.7.1 Sampling: Sampling for material, dimensions, finish and workmanship shall be random in accordance with MIL-STD-105. Unless otherwise specified in Section 6 of this specification, 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 thirty consecutive pieces of each part number have been found defect free. Thereafter, a sampling plan in accordance with 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 Micro Examination - Titanium Forgings: Sample fittings or forgings from each forging lot shall be microscopically examined for compliance with paragraph 3.2.2.2, in particular for microstructure and oxide scale.
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#### 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 III  
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:

- 4.8.2.1 AS 1579 Fitting End, Welded Girth Joint, Dimensions, 3000 psi Hydraulic:

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

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