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An American National Standard

# Standard Specification for Performance of Piping and Tubing Mechanically Attached Fittings[1]

This standard is issued under the fixed designation F1387; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope

1.1 This specification establishes the performance characteristics required for mechanically attached fittings (MAFs) for use in piping and tubing systems. These fittings directly attach to pipe or tube by mechanical deformation of the pipe or tube or fitting, or a combination thereof, creating a seal and a restrained joint. The seal may be created via the mechanical deformation or created independently. Successful completion of the tests described constitutes completion of the technical portion of the qualification process.

1.2 Supplementary requirements are provided for use when additional testing or inspection is desired. These shall apply only when specified in part or whole by the purchaser in the order. Unless otherwise specified, U.S. Navy contracts shall invoke the supplementary requirements in whole.

1.3 Unless specific MAF types are specified, the term "MAF" shall apply to all types described herein.

1.4 The tests specified in Section 13 and described in Annex A1 and Supplementary Requirements are applicable only to ascertain the performance characteristics of MAFs. These tests are not intended for use in the evaluation of non-MAF products.

1.5 A fire performance test is specified in Supplementary Requirement S7. This test provides general guidelines to determine the responsiveness of MAFs when subjected to fire. This test should not be considered for use to evaluate non-MAF products.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 The following safety hazards caveat applies only to the tests listed in Section 13 and the tests described in the Supplementary Section and the Annex of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

A105/A105M Specification for Carbon Steel Forgings for Piping Applications

A106/A106M Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A108 Specification for Steel Bar, Carbon and Alloy, Cold-Finished

A109/A109M Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled

A167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

A182/A182M Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

A213/A213M Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes

A234/A234M Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A240/A240M Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.11 on Machinery and Piping Systems.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

A249/A249M Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes
A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
A276 Specification for Stainless Steel Bars and Shapes
A312/A312M Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
A380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
A403/A403M Specification for Wrought Austenitic Stainless Steel Piping Fittings
A450/A450M Specification for General Requirements for Carbon and Low Alloy Steel Tubes
A479/A479M Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
A530/A530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe
A564/A564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
A576 Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
A766/A766M Specification for Forgings, Leaded, and Resulfurized Carbon Steel, for Pressure-Containing Applications (Withdrawn 1989)[3]
B16/B16M Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
B21/B21M Specification for Naval Brass Rod, Bar, and Shapes
B111/B111M Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
B117 Practice for Operating Salt Spray (Fog) Apparatus
B122/B122M Specification for Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar
B124/B124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
B154 Test Method for Mercurous Nitrate Test for Copper Alloys
B164 Specification for Nickel-Copper Alloy Rod, Bar, and Wire
B251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube (Metric) B0251_B0251M
B371/B371M Specification for Copper-Zinc-Silicon Alloy Rod
B564 Specification for Nickel Alloy Forgings
B633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel
B696 Specification for Coatings of Cadmium Mechanically Deposited
B766 Specification for Electrodeposited Coatings of Cadmium
E511 Test Method for Measuring Heat Flux Using a Copper-Constantan Circular Foil, Heat-Flux Transducer
E1529 Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies

2.2 *Federal Specifications:*[4]
QQ-P-35 Passivation Treatments for Corrosion-Resisting Steels
QQ-N-281 Nickel-Copper Alloy Bar, Rod, Plate, Sheet, Strip, Wire, Forgings and Structural and Special Shaped Sections
QQ-N-286 Nickel-Copper-Aluminum Alloy, Wrought (UNS N05500)
QQ-P-416 Plating, Cadmium (Electrodeposited)
QQ-B-626 Brass, Leaded and Nonleaded Rods, Shapes, Forgings and Flat Product, TH Finished Edges (Bar and Strip)
QQ-S-763 Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting

2.3 *Military Specifications:*[4]
MIL-S-901 Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-T-1368 Tube and Pipe, Nickel Copper Alloy Seamless and Welded
MIL-H-5606 Hydraulic Fluid, Petroleum Based, Aircraft, Missile, and Ordinance
MIL-L-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-148
MIL-T-8606 Tubing, Steel Corrosion-Resistant (18-8 Stabilized and Extra Low Carbon)
AND 10102 Tubing—Standard Dimensions for Round Alloy Steel
MIL-C-15726 Copper-Nickel Alloy, Rod, Flat Products (Flat Wire, Strip, Sheet, Bar, and Plate) and Forgings
DOD-P-16232 Phosphate Coatings, Heavy, Manganese or Zinc Base (for Ferrous Metals)
MIL-T-16420 Tube, Copper Nickel Alloy, Seamless and Welded (Copper Alloy Numbers 715 and 706)
MIL-F-18866 Fittings Hydraulic Tube, Flared, 37° and Flareless Steel
MIL-C-20159 Copper-Nickel Alloy Castings
MIL-T-24107 Tube, Copper, (Seamless) (Copper Numbers 102, 103, 108, 120, 122, and 142)
MIL-P-24691/1 Pipe and Tube, Carbon Steel, Seamless
MIL-P-24691/2 Pipe and Tube, Chromium-Molybdenum Steel, Seamless
MIL-P-24691/3 Pipe and Tube, Corrosion-Resistant, Stainless Steel, Seamless or Welded
MIL-R-83248/1 Rubber, Fluorocarbon Elastomer, High Temperature, Fluid and Compression Set Resistant, O-Rings, Class 1, 75 Hardness
MIL-H-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

2.4 *Military Standards:*[4]
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-167 Mechanical Vibration of Shipboard Equipment
MIL-STD-271 Nondestructive Testing Requirements of Metals
MIL-STD-278 Welding and Casting Standard
MIL-STD-753 Corrosion-Resistant Steel Parts, Sampling, Inspection and Testing for Surface Passivation
MIL-STD-777 Schedule of Piping Valves, Fittings, and Associated Piping Components for Naval Surface Ships
MIL-STD-889 Dissimilar Metals
MIL-STD-1235 Single- and Multi-Level Continuous Sampling Procedures and Table for Inspection by Attributes
MIL-STD-2175 Castings, Classification and Inspection of
MS 33531 Tolerances, Welded Corrosion-Resistant Steel Tubing
MIL-STD-45662 Calibration System Requirements

2.5 *American National Standards Institute (ANSI):*[5]
B 36.10 Welded and Seamless Wrought Steel Pipe
B 46.1 Surface Texture (Surface Roughness, Waviness and Lay)

2.6 *Society of Automotive Engineers (SAE):*[6]
AMS 5643 Bars, Forgings, Tubing and Rings—16 Cr 4.0 Ni 0.30 (Cb + Ta) 4.0 Cu
J 514 Hydraulic Tube Fittings
J 515 Hydraulic "O" Ring
SAE 1010 Carbon Steel: Nonsulfurized Manganese 10 % Minimum

2.7 *American Society of Mechanical Engineers (ASME):*[7]
ASME Code, Section IX

## 3. Terminology

3.1 *Definitions:*

3.1.1 *class, n*—a group of MAFs of a particular design with the dimensions proportional to pipe or tube outside diameters, made from the same material grade (or combination of grades), for the same rated pressure, or for a rated pressure inversely proportional to the diameter.

3.1.1.1 *Discussion*—Class designation for MAF is assigned based upon the rated pressure used to test the MAF design.

3.1.2 *failure, n*—any leakage or joint separation unless otherwise determined to be due to a tubing/pipe or fitting defect.

3.1.3 *fitting, n*—connecting device used to join multiple pipes or tubes or other MAFs together to create a working system.

3.1.3.1 *Discussion*—Shapes such as couplings, unions, elbows, tees, crosses, plugs, adapters, reducers, flanges, and special shapes are used as needed to fulfill MAF system design specifications.

3.1.4 *joint, n*—interface between pipe or tube and MAFs where the seal is maintained or mechanical holding strength is applied or maintained within the overall MAF design.

3.1.5 *leakage, n*—the escape of fluid or gas from any point of the MAF, including the MAF joint interface, sufficient to drop or flow from the point of formation or gas bubbles rising to the surface after the first minute of submersion.

3.1.6 *mechanically attached fitting (MAF), n*—a fitting that is directly attached to pipe or tube by mechanical deformation of the pipe/tube or fitting, or both, creating a seal and a restrained joint. The seal may be created via the mechanical deformation or created independently.

3.1.7 *penalty run, n*—a penalty run is performed with penalty run MAF specimens when the original MAF test specimen leaks or separates during testing as a result of any cause that is not related to the design of the MAF being qualified.

3.1.8 *penalty run MAF specimens, n*—additional specimen(s) that are tested in the place of the original specimen(s) (see 3.1.7).

3.1.8.1 *Discussion*—These additional MAF specimen(s) are assembled using the same methods along with additional MAFs of the same type, grade, class, and configuration and additional pipe or tube with the same wall thickness and material conditions as the original test specimen.

3.1.9 *permanent MAF, n*—a fitting whose joint(s) attach directly to the pipe or tube to join two or more pipes or tubes or other MAFs in a combination of pipes or tubes and components. In either case, the permanent MAFs cannot be disassembled and reused after initial assembly.

3.1.10 *pipe, n*—hollow round product conforming to the dimensional requirements for nominal pipe size (NPS) as tabulated in ANSI B36.10, Table 2.

3.1.11 *rated pressure, n*—the manufacturer's recommended in-service pressure assigned to the MAF (see 3.1.15).

3.1.12 *separable MAF, n*—a fitting whose joint(s) attach directly to the pipe or tube to join two or more pipes or tubes or other MAFs in a combination of pipes or tubes and components. Once assembled, the separable MAFs can be disassembled and reassembled a multiple number of times.

3.1.12.1 *Discussion*—Some subcomponents of separable MAFs may become permanently attached to the pipe or tube without affecting the function of the joint.

3.1.13 *specimen, n*—a prepared assembly consisting of a MAF assembled onto a preselected pipe or tube. The specimen is placed into a controlled environment and tested to determine if the MAF assembly meets the requirements specified in the test being performed.

3.1.14 *test pressure, n*—a selected pressure used during testing, which is based upon the rated pressure (see 3.1.13) of the MAF or pipe or tube, whichever is lower, times the factor specified for each test (that is, 1.25, 1.50, 2.00, 4.00, and so forth).

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.
[7] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

3.1.15 *tube, n*—hollow round product which is usually specified with respect to outside diameter and wall thickness.

## 4. Classification

4.1 MAFs are classified into the following design types:

NOTE 1—Each MAF type may consist of more than one material and class.

4.1.1 *Type I: Radially Swaged MAF (Permanent)*—A portion of the MAF diameter is reduced mechanically by means of an installation tool through radial compression to provide an intimate joint. The properly installed MAF has a circumferential deformation of predetermined dimensions.

4.1.2 *Type II: Flared MAF (Separable)*—An assembly that consists of a body, nut, and sleeve. The MAF is designed to mate with a tube or other component which has been flared or machined to a specific angle. The flared tube end is positioned onto the MAF body cone or seat. The nut is then tightened to the body thread, thus providing a tube-to-MAF seal through mechanical retention.

4.1.3 *Type III: Flareless (Bite-Type) MAF (Separable)*—An assembly having a ferrule, nut, and body. The ferrule penetrates the outside of the tubing, thus providing a pressure seal and holding mechanism.

4.1.4 *Type IV: Grip-Type MAF (Separable)*—An assembly having one or two ferrules that are compressed into the surface of the tube. In the case of the two-ferrule MAF, the forward ferrule provides the primary seal through radial compression around the outer diameter of the tube. The rear ferrule acts as the primary mechanical holding device. In the case of the single-ferrule design, the ferrule is used to seal and act as the primary mechanical holding device.

4.1.5 *Type V: Shape Memory Alloy (SMA) MAF (Permanent)*—Mechanically attached fittings that use SMA to provide the mechanical force required to produce a metal-to-metal seal between the pipe or tube and the MAF. The metal-to-metal seal that is formed is a "live crimp" since the pipe or tube and the SMA are in a state of dynamic equilibrium. The SMA maintains a permanent inward radial force on the pipe or tube at all times. The MAF body itself may be manufactured from a nonshape memory metal and used in conjunction with a driver made from SMA.

4.1.6 *Type VI: Axially Swaged MAF (Permanent)*—Mechanically attached fittings that have machined swaging rings telescopically "press fit" from the extremities toward the center of the MAF body. An installation tool advances the swaging rings axially over the MAF body into a seated and locked position. The swage rings compress the MAF body onto the pipe or tube forming a metal-to-metal seal. The seal is permanently maintained by the force radially exerted by the swaging rings onto the sealing interface.

4.2 The MAFs shall be made from one or more of the following material grades:

NOTE 2—When multiple components resulting in more than one material grade are specified within a MAF assembly, the combination of grades used shall be galvanically compatible.

4.2.1 *Grade A*—Carbon steel.
4.2.2 *Grade B*—Stainless steel.
4.2.3 *Grade C*—Nickel-copper.
4.2.4 *Grade D*—Copper-nickel.
4.2.5 *Grade E*—Brass.
4.2.6 *Grade F*—Nickel titanium.

4.3 The MAF rated pressure may be one of the following classes:

NOTE 3—The rated pressure may differ within the size range of a MAF being qualified (see 3.1.1).

4.3.1 *Class 1*—1.38 MPa (200 psi) maximum.
4.3.2 *Class 2*—2.76 MPa (400 psi) maximum.
4.3.3 *Class 3*—4.83 MPa (700 psi) maximum.
4.3.4 *Class 4*—6.90 MPa (1000 psi) maximum.
4.3.5 *Class 5*—10.34 MPa (1500 psi) maximum.
4.3.6 *Class 6*—13.79 MPa (2000 psi) maximum.
4.3.7 *Class 7*—20.69 MPa (3000 psi) maximum.
4.3.8 *Class 8*—25.86 MPa (3750 psi) maximum.
4.3.9 *Class 9*—34.48 MPa (5000 psi) maximum.
4.3.10 *Class 10*—41.37 MPa (6000 psi) maximum.

## 5. Ordering Information

5.1 Orders for MAFs under this specification shall include the following:

5.1.1 ASTM designation, title, number, and year of issue;
5.1.2 Quantity of fittings (MAF);
5.1.3 Size, nominal pipe size (NPS), or outer diameter (OD);
5.1.4 Type (I, II, III, IV, V, or VI);
5.1.5 Material grade (see 4.2, 6.1, or Table 1),
5.1.6 Class (see 3.1.1 and 4.3);
5.1.7 MAF shape (that is, straight, elbow, cross, union, coupling, and so forth) (see 3.1.3);
5.1.8 Supplementary requirements, if any;
5.1.9 Other requirements agreed to between the purchaser and the manufacturer; and
5.1.10 Inspection and acceptance of MAFs as agreed upon between the purchaser and the supplier (see Section 14).

5.2 *Optional Ordering Requirements:*
5.2.1 Certification (see Section 15).
5.2.2 Special marking requirements (see Section 16 and S1.5).

## 6. Materials and Manufacture

6.1 *MAF Material*—The MAF material used may be as specified in Table 1 or may be other materials not specified in Table 1, as agreed to between the manufacturer and the purchaser.

6.1.1 All types may be manufactured from wrought bars, forgings, castings, pipe, or tube.

6.1.2 *Flow of Grain*—MAFs machined from hot- or cold-drawn bars shall have their longitudinal axis parallel to the longitudinal axis of the bar with at least the center one third of the bar removed during the manufacturing process unless testing shows the center material to be free of injurious defects.

6.2 *Material Quality*—The material shall be of such quality and purity that the finished product shall have the properties and characteristics to meet the performance requirements of this specification.

**TABLE 1 Material Specifications for MAFs**

| Type | Straight | Shape | Nut/Ring (Body, Lock, Jam) | Sleeve or Ferrule | Backup Washer | Seal Material |
|---|---|---|---|---|---|---|
| | | | Grade A: Carbon Steel | | | |
| I | A108[A] | A576 | A108 | . . . | . . . | MIL-R-83248/1 |
| II | A108 | A576 | A576[B] | A108 | A109/A109M | [C] |
| III | A108 | A576 | A576 | A108 | A109/A109M | [D] |
| IV | A108 | A576[B] | A576 | A108 | A109/A109M | [D] |
| VI | A108[A] | A576[E] | A108[A] | . . . | . . . | [D] |
| | | | Grade B: Stainless Steel | | | |
| I | A312/A312M[F] | QQ-S-763[G] | A312/A312M[F] | . . . | . . . | MIL-R-83248/1 |
| II | A479/A479M | A182/A182M | A479/A479M[H] | A479/A479M[H] | A167[I] | [C] |
| III | A479/A479M | A182/A182M | A479/A479M[H] | A564/A564M[J] | A167[I] | [D] |
| IV | A479/A479M | A182/A182M | A479/A479M | A276<br>A240/A240M | A167[I] | [D] |
| VI | A312/A312M[F] | A182/A182M[K] | A312/A312M[F] | . . . | . . . | [D] |
| | | | Grade C: Nickel Copper | | | |
| II | B164 | B564 | B164 | B164 | A167[I] | [C] |
| III | B164 | A564/A564M | B164 | B164 | A167[I] | [D] |
| IV | B164[L] | B564[L] | B164[L] | B164[L]<br>QQ-N-286 | A167[I] | [D] |
| | | | Grade D: Copper Nickel | | | |
| I | MIL-C-15726[M] | MIL-C-20159[M] | MIL-C-15726[M] | . . . | . . . | MIL-R-83248/1 |
| II | B122/B122M | B122/B122M | B122/B122M | B122/B122M | A167[I] | [C] |
| III | B122/B122M | B122/B122M | B122/B122M | A564/A564M[I] | A167[I] | [D] |
| VI | MIL-C-15726[M] | MIL-C-20159[M] | MIL-C-15726[M] | . . . | . . . | [D] |
| | | | Grade E: Brass | | | |
| II | B16/B16M | B124/B124M | B16/B16M[N] | B111/B111M[O] | . . . | [C] |
| IV | B16/B16M[P] | B124/B124M[P] | B16/B16M[P] | B16/B16M[P] | . . . | [D] |
| | | | Grade F: Nickel Titanium | | | |
| V | [Q] | [Q] | [Q] | . . . | . . . | [D] |

[A] Alternate material in conformance to Specification A106/A106M (Grade B) may be used.
[B] Alternate material in conformance to Specification A108 may be used.
[C] When required by the MAF design, O-rings in accordance with SAE J515 shall be used to connect the MAF end.
[D] No O-rings used to connect the MAF end.
[E] Alternate material in conformance to Specification A234/A234M may be used.
[F] Alternate material in conformance to MIL-P-24691/3 may be used.
[G] 304, 304L or 316, 316L material may be used.
[H] Alternate material in conformance to Specification A276 may be used.
[I] Grade 302.
[J] Alternate material in conformance to AMS 5643 may be used.
[K] Alternate material in conformance to Specification A403/A403M may be used.
[L] Alternate material in conformance to QQ-N-281 may be used.
[M] Alternate material in conformance to MIL-T-16420 may be used.
[N] Alternate material in conformance to Specification B21/B21M may be used.
[O] Alternate material in conformance to Specification B371/B371M may be used.
[P] Alternate material in conformance to QQ-B-626 may be used.
[Q] In accordance with the manufacturer's specification.



6.2.1 The manufacturer is encouraged to use materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. Used or rebuilt products shall not be used.

NOTE 4—The term "recovered materials" is interpreted as those materials that have been collected or recovered from solid waste and reprocessed to become a source of raw material, as opposed to extra virgin raw materials.

6.3 *Seal Materials*—Seals used with MAFs shall be as specified in Table 1.

6.4 *Surface Applications and Coatings*—urface applications and coatings if applicable, shall be applied and tested in accordance with the requirements specified in Table 2.

6.5 *MAF Fabrication*—MAFs fabricated from two or more parts may be welded. The use of brazing or soldering is not permitted.

6.5.1 Welding procedure qualification and welding operator performance qualification shall be in accordance with ASME Section IX. Welding process shall be in accordance with

**TABLE 2 Finishes and Coatings Applied to MAFs[A]**

| Material Grade | Type of Finish or Coating | Applicable Document | Test Requirement | Applicable Document | Test Results |
|---|---|---|---|---|---|
| A<br>A | Cadmium Coating[B,C] | B766[D]<br>B696[D] | Salt Spray (Fog) | B117 | 72 h before red rust |
| A | Zinc Coating[B] Type II, Surface Condition 1 | B633 | Salt Spray (Fog) | B117 | 72 h before red rust |
| A | Phosphate Coat[B] Class 1 | DOD-P-16232 | Salt Spray (Fog) | B117 | 32 h before red rust |
| B | Passivation | A380<br>QQ-P-35 | Copper Sulphate Test | MIL-STD-753 Method 102 | pass copper sulphate test |

[A] Other finishes or coatings not specified herein may be used upon mutual agreement between the manufacturer and the purchaser.
[B] Coating shall be a minimum of 0.0002 followed by a chromate treatment or with a phosphate coating with oil finish.
[C] Cadmium plating shall not be used on MAFs intended for use on U.S. Navy vessels.
[D] Federal Specification QQ-P-416 plating may also be used.

MIL-STD-278. Welded MAFs shall be tested in accordance with the requirements as specified in 13.4.3.

6.5.2 The welding procedure qualification test shall duplicate the joint configuration to be used in production.

6.6 *Processing Stainless Steel Forgings*—Austenitic stainless steel components manufactured by hot forge or other sensitizing processes shall be solution annealed and certified free of intergranular precipitation. Practice A262 shall be used to evaluate carbide precipitation in stainless steels.

## 7. Performance Requirements

7.1 *Testing Requirements*—MAFs shall be subjected to the standard performance tests specified in 13.1 and Table 3. The tests are described in the Annexes. Supplementary tests specified in 13.2 and Table S1.1 shall be performed when invoked in the order or contract by the purchaser.

7.1.1 These tests shall be repeated any time changes are made in the design, material, or manufacturing process, which in the opinion of the purchaser, may degrade the performance of MAFs.

7.2 *Intermixing of MAF Subcomponents*—The intermixing by the purchaser of subcomponents of the same design, but of different brands or trade names, is not permitted unless specifically authorized by the manufacturer.

7.2.1 When subcomponents of different brands, trade names, or manufacturers are used, the manufacturer testing the MAF design shall specify this information in the test report.

7.3 *Qualification Requirements*—MAFs shall be tested using specimens of the same type, grade (or combination of grades), and class. The pipe or tube selected for the technical qualification to this specification shall meet the requirement specified in 7.3.4. Technical qualification of the MAF assembly shall be based upon successful completion of all required testing. Each MAF design is only qualified for use with the pipe or tube material and minimum to maximum wall thickness tested or extended by interpolation (see 7.3.2 and 7.3.3).

7.3.1 Except as required by Annex A11 (Mercurous Nitrate Test), all MAFs tested shall be comprised of an equal number of specimens from the smallest and largest sizes within the size range of the MAF type, grade, and class being tested.

**TABLE 3 Specimen Geometry and Testing Requirements[A]**

| Description of Test | Number of Specimens | | Applicability of Test | |
|---|---|---|---|---|
| | Permanent | Separable | Permanent | Separable |
| Examination of specimen | 22 | 28 | yes | yes |
| Pneumatic proof test | 22 | 28 | yes | yes |
| Hydrostatic proof test | 22 | 28 | yes | yes |
| Impulse test[B] | 6 | 6[C] | yes | yes |
| Flexure fatigue test[B] | 6 | 6[C] | yes | yes |
| Tensile test | 6 | 6 | yes | yes |
| Burst test[B,D] | 4 | 4 | yes | yes |
| Repeat assembly test[B] | . . . | [C] | no | yes |
| Rotary flexure test[B] | . . . | 6 | no | yes |
| Mercurous nitrate test | 2 | 2 | . . .[E] | . . .[E] |

[A] Number of specimens does not include any specimens for supplementary tests (see Table S1.1). When supplementary requirements in S1.3.8 are invoked, the number of specimens for all tests (annex and supplementary) shall be as specified in the supplementary requirements section.
[B] Specimens can be reused for other primary tests as long as all requirements herein are complied with for each test.
[C] A minimum of 50 % of specimens selected for impulse and flexure fatigue testing shall be subjected to repeat assembly testing.
[D] When the Supplementary Requirements of this standard are invoked, burst test specimens shall be comprised only with passed specimens from elevated temperature soak (see S3) and shock test (see S6). When the Supplementary Requirements are not invoked, new or passed specimens from other tests in the Annex can be used. In any event, the minimum quantity of specimens used for this test shall be as specified.
[E] Two MAFs from each size and shape made from either copper zinc alloys containing more than 15 % zinc or copper-aluminum alloys shall be tested. These specimens shall be assembled onto pipe or tube, but do not have to be capped for pneumatic and hydrostatic testing before performing the mercurous nitrate test.

7.3.1.1 Test one or more intermediate sizes if the ratio of the minimum and maximum pipe or tube outside diameter to be tested is equal to or more than five.

7.3.2 Through reasonable interpolations between the MAF sizes tested, all other sizes of MAFs within the same type, grade (or combination of grades), and class, will be considered acceptable if the MAF specimens pass all of the testing requirements specified by the purchaser. Extrapolation is not acceptable.

7.3.3 Acceptance of tees, elbows, and other shapes within the same class, may be accomplished by parametric analysis

(see 7.3.3.1), as agreed to between the manufacturer and the purchaser based on the acceptance of couplings.

7.3.3.1 If tees, elbows, and other shapes are made from a different raw material form than the coupling (for example, tees and elbows manufactured from castings versus couplings manufactured from solid bar or round tube), this alternate material form shall undergo the same test regimen as the coupling. Once this is complete, parametric analysis may be used to qualify the remainder of the shapes as agreed to between the purchaser and the manufacturer.

7.3.4 Recommended pipe or tube for use with MAFs may be qualified throughout its wall thickness range, when pipe or tube of a minimum and maximum wall thickness are used within the test specimens being qualified.

7.3.5 The MAFs may incorporate non-MAF features (that is, bolted flanges, and so forth). Those non-MAF features that are part of a MAF configuration shall meet the current issue of existing military and commercial documents (as applicable). Qualification of the non-MAF features are not within the scope of this specification.

7.4 *Test Report*—Upon completion of testing, a test report shall be written and maintained on file during the life cycle of the design. A copy of this report shall be made available upon request from the purchasing activity.

7.4.1 A failure during testing shall be analyzed and the failure analysis (see 11.3.1 and 11.3.2) and corrective action shall be included in the test report.

7.4.2 A retest as specified in Section 11 may be allowed when failure of the original assembly occurs during testing. When retesting is permitted, the failure analysis and corrective action shall be included in the test report as specified in 7.4.1.

7.5 *Test Equipment and Inspection Facilities*—The manufacturer shall ensure that test equipment and inspection facilities of sufficient accuracy, quality, and quantity are established and maintained to permit the performance of required inspections.

7.5.1 *Calibration System Requirements*—The manufacturer shall maintain a calibration system for all measuring and test equipment (M & TE) in accordance with MIL-STD-45662 with traceability to the National Institute of Standards and Technology (NIST).

7.5.1.1 Accuracy of the M & TE used to measure allowable variables during testing shall be within one third of the tolerances permitted (see 7.6).

7.6 *Test Conditions*—Unless otherwise specified in the test, the following tolerances shall be used to control conditions of the tests specified in the Annex:

7.6.1 *Ambient Conditions*—When ambient is specified, standard ambient conditions shall be maintained at 25 ± 10°C (77 ± 18°F).

7.6.2 *Pressure*—Unless otherwise specified, the tolerance for the internal pressure applied to the test specimen during testing shall be maintained at ±5 %.

7.6.3 *Test Fluids*—Unless otherwise specified, the test fluids used in the testing of MAF shall include those fluids specified within the test. Water and other fluids such as SAE Grade 10W, MIL-H-5606, MIL-L-7808, or MIL-H-83282 may be used without affecting the validity of the test.

7.6.4 *Temperature*—Unless otherwise specified, the allowable tolerance for temperature applied to the test specimen during testing shall be ±5°C (±10°F).

7.7 *Pass or Fail Criteria*—Pass or fail criteria for each test shall be based upon meeting or exceeding the performance requirements specified in each test.

## 8. Dimensions

8.1 *MAF Dimensions:*

8.1.1 Type I MAF dimensions shall be as specified by the manufacturer.

8.1.2 Types II and III MAF dimensions shall be as specified in MIL-F-18866 or SAE J514 or as agreed to between the manufacturer and the purchaser.

8.1.3 Type IV MAF dimensions shall be as specified by the manufacturer.

8.1.4 Type V MAF dimensions shall be as specified by the manufacturer.

8.1.5 Type VI MAF dimensions shall be as specified by the manufacturer.

## 9. Workmanship, Finish, and Appearance

9.1 *Machined Surfaces*—Machined surfaces shall be free from burrs, cracks, laps, or seams which would affect the suitability for the intended service.

9.1.1 All machined surfaces shall be 3.2-µm roughness, average ($R_a$) (125-µin. $R_a$) as specified in ANSI B46.1 or duplicate of that qualified.

9.1.1.1 External surfaces that do not affect the overall function of MAFs shall be excluded from the requirement specified in 9.1.1.

9.2 *Unmachined Surfaces*—Unmachined surfaces, such as forging or casting surfaces and bar stock flats, shall be free from scale, blisters, fins, folds, seams, laps, segregations, or cracks which may be injurious to personnel or equipment or affect MAF performance.

## 10. Sampling for Testing

10.1 *Inspection Sampling of Raw Material*—Except when specified herein, the number of samples required for inspection of raw materials for conformance of products during manufacturing and processing shall be in accordance with established quality assurance procedures maintained by the manufacturer and approved by the purchaser.

10.2 *In-Process Inspection Sampling of MAFs*—Inspection sampling plans of MAFs being manufactured or processed shall be mutually agreed upon between the manufacturer and the purchaser. MIL-STD-105 shall be used when specified in the purchase order or contract. Level of inspection and acceptable quality level (AQL) shall be in accordance with the manufacturer's quality assurance procedures.

10.3 *Lot Acceptance*—Lot acceptance sampling plans shall be mutually agreed upon between the manufacturer and the purchaser. MIL-STD-105 shall be used when specified in the purchase order or contract.

10.4 *Sampling for Inspection of Type III Ferrules*—A random sample of ferrules shall be selected from each lot in accordance with MIL-STD-105, Special Inspection Level S-2, AQL of 2.5, and tested in accordance with 13.4.1. Other inspection or sampling plans may be used upon mutual agreement between the manufacturer and the purchaser.

10.4.1 A minimum of five ferrules shall be randomly selected from each lot and subjected to the testing specified in 13.4.2.

10.5 *Sampling for Inspection of Fabricated MAFs*—A minimum of four samples shall be selected at random from each lot of welded products and subjected to the tests specified in 13.4.3.

## 11. Number of Tests and Retests

11.1 *Number of Test Specimens*—The tests used to qualify MAFs and the number of specimens required for each test shall be as specified in Table 3.

11.2 *Replacement of Test Specimens*—When untested specimens are rejected as a result of overtightening, inferior workmanship or materials, or assembly, the specimens shall be dispositioned in accordance with the manufacturer's quality assurance procedures.

11.2.1 The original unique numbers assigned in accordance with 12.3.1 shall be recorded in the test report along with the reason for rejection.

11.2.1.1 New test specimens with MAFs of the same type, grade, and class, and pipe or tube of the same outside diameter and wall thickness shall be prepared in accordance with Section 12.

11.3 *Penalty Runs*—In the event of a test failure, the manufacturer shall proceed with one of the following options:

11.3.1 If the failure is determined to be design related, the manufacturer shall redesign the MAF and start all tests from the beginning. The requirements in 11.3.2 shall not apply to redesigned MAF.

11.3.2 If the failure is determined to be unrelated to the design, the test specimen shall be rerun. A replacement test specimen shall be prepared in accordance with the requirements in 11.2 and Section 12.

11.3.3 If the failure cannot be determined to be either design related or not design related, the manufacturer shall test three additional penalty specimens. The requirements specified in 11.3.2 shall apply.

11.4 *Penalty Run Specimen Preparation*—Penalty run specimens shall be prepared when MAF has failed any of the tests specified in the Annexes.

11.4.1 The MAF used for penalty runs shall be of the same type, grade, and class as the failed MAF being replaced.

11.4.2 The pipe or tube used in penalty runs shall be of the same material (inlcuding form and condition), outer diameter, and wall thicknesses as the pipe or tube being replaced.

11.4.3 Preparation of the penalty run specimens shall be in accordance with Section 12.

11.4.4 Penalty run specimens shall be identified in accordance with 12.3 and 11.4.5.

11.4.5 In addition to the part number and test specimen number, a designator shall be placed after the test specimen number which would allow the specimen to be identified as a penalty run specimen. The method used to identify penalty run specimens shall be at the manufacturer's option.

## 12. Specimen Preparation

12.1 Specimen preparation and installation of MAFs on appropriate testing apparatus shall be in accordance with the manufacturer's recommended procedures.

12.1.1 Permanent MAFs shall be assembled at the minimum allowable insertion depth permitted by the manufacturer's recommended procedure.

12.1.2 Separable MAFs shall be assembled using the minimum value (that is, torque, nut rotation, and so forth) permitted by the manufacturer's recommended procedure.

12.2 *Assembly of Specimens*—MAFs qualified under the requirements of this specification shall be tested and qualified as a completed assembly. The acceptance of similar, but different, MAF designs shall not permit the intermixing of their subcomponents such as sleeves, nuts, and ferrules.

12.2.1 Test specimens used in testing shall be assembled using a MAF of a single type, grade (or combination of grades), and pipe or tube material.

12.2.2 The wall thickness and outer diameter size of the pipe or tube shall be selected in accordance with the MAF sizes (see 7.3.4) being qualified.

12.2.3 The test specimens shall be assembled using the specimen geometry specified in Fig. 1.



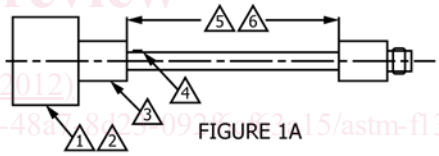


FIGURE 1A

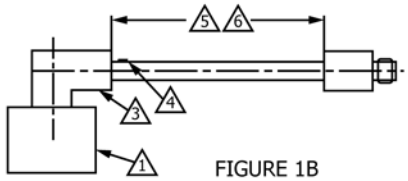


FIGURE 1B

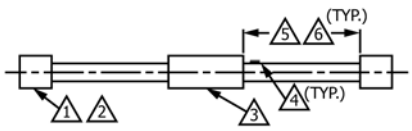


FIGURE 1C

1 CAPPED END WITH PORT (2 PLACES TYP.)
2 TENSILE SPECIMENS DO NOT REQUIRE CAPPED ENDS
3 MAF TEST SPECIMEN
4 ℄ STRAIN GAGE LOCATED ON THE HIGH STRESS SIDE OF THE PIPE/TUBE 4.6 MM (.18 IN.) FROM MAF (2 PLACES) (AS REQUIRED)
5 FIRE TEST SPECIMENS SHALL BE A MINIMUM OF TEN TIMES (10X) PIPE/TUBE O.D. VIBRATION TEST SPECIMEN LENGTH SHALL BE AS SPECIFIED IN TABLE S8. SPECIMEN GEOMETRY SHALL BE AS SHOWN IN FIGURE S8.
6 FREE PIPE/TUBE LENGTH (MIN) FIVE TIMES (5X) PIPE/TUBE O.D.

**FIG. 1 Typical Specimen Geometries**

12.3 *Identification of Test Specimens*—Each test specimen shall be identified with a unique number to provide traceability back to the test records.

12.3.1 Identification of test specimens shall be permanent. In those cases in which size or design does not permit permanent markings, tagging or bagging may be used.

12.3.2 When, as a result of testing, a test specimen is sectioned into two or more pieces, the identification method shall be as specified in 12.3.1.

## 13. Test Methods

13.1 *Standard Qualification Tests*—All tests used to qualify MAFs shall be as specified in the Annexes. The following primary tests are described:

| Name of Test | Section |
|---|---|
| Performance Tests for MAFs | A1 |
| Examination of Specimen | A2 |
| Pneumatic Proof Test | A3 |
| Hydrostatic Proof Test | A4 |
| Impulse Test | A5 |
| Flexure Fatigue Test | A6 |
| Tensile Test | A7 |
| Hydrostatic Burst Test | A8 |
| Repeated Assembly Test | A9 |
| Rotary Flexure Test | A10 |
| Mercurous Nitrate Test | A11 |

13.2 *Supplementary Tests*—When one or more of the supplementary requirements are requested by the purchaser (see 1.2), the following applicable test(s) shall also be performed:

| Name of Test | Section |
|---|---|
| General Requirements | S1 |
| Thermal Cycling Test | S2 |
| Elevated Temperature Soak Test | S3 |
| Stress Corrosion Test | S4 |
| Torsion Test | S5 |
| Shock Test | S6 |
| Fire Test | S7 |
| Vibration Test | S8 |

13.3 *Certification of Test Results*—If certified test results are required, a certification shall be provided to the purchaser as specified in the contract or purchase order.

13.4 *In-Process Inspection Tests*—The following tests shall be performed by the manufacturer in accordance with in-house practices and when specified in the contract or purchase order:

13.4.1 Metallographically prepare, microexamine, and test for hardness and microstructural conformance to the manufacturer's appropriate specification a random sample of Type III ferrules, as specified in 10.4.1. An appropriate specification is defined as the documented procedures that the manufacturer uses on a continuing basis to produce ferrules. Such ferrules shall be of the same quality as those used in the assemblies that were previously tested and found to satisfy the performance requirements of this specification.

13.4.2 Randomly select a minimum of five Type III ferrules from each lot as specified in 10.5 and test for cut bite quality.

13.4.2.1 Preset the Type III ferrules onto tubing as specified in 13.4.2.2. After disassembly, drive back each ferrule to expose the ring cut for examination. The cut bite shall completely encircle the periphery of the tube. The cut bite shall be clean, smooth, and uniform. A jagged irregular cut bite is unacceptable. There shall be no longitudinal or circumferential cracks on the ferrule before driving it back.

13.4.2.2 Use Type 304 tubing in accordance with Specifications A213/A213M, A249/A249M, or A269 for testing corrosion-resistant steel MAFs. Use SAE 1010 tubing to test carbon steel MAFs. The tubing materials as specified will assure consistent results of testing. Preset Type III ferrules onto the tubing in accordance with the manufacturer's recommended procedures using either a presetting machine, presetting tool, or the MAF.

13.4.2.3 When the Type III ferrules are manufactured from materials other than those specified in 13.4.2.2, conduct the test using tubing material as recommended by the manufacturer.

13.4.3 Fracture test a minimum of four MAFs selected at random from each lot of welded MAFs as specified in 13.4.3.1 and then either crush test in accordance with 13.4.3.2 or macroexamine in accordance with 13.4.3.3.

13.4.3.1 Test two MAFs. Cut each MAF into two or more sections. Cut the sections so that the weld is perpendicular to the longitudinal axis of the section. The total width of the sections taken from each MAF shall be equal to or exceed one fourth of the circumference of the MAF. Remove all weld flashing. Load each section laterally in such a way that the root of the weld is in tension. Bend the section until it fractures or is bent 90°. If the specimen fractures, the fractured surface shall show no evidence of preexisting cracks or incomplete fusion, and the sum of the lengths of inclusions and porosity visible on the fractured surface shall not exceed 10 % of the total area. Cracking or tearing of the parent material is acceptable.

13.4.3.2 Two MAFs shall be tested. Remove all weld flashing. Position each MAF between two parallel plates in a manual or hydraulic press, or between the jaws of a multiple-jaw hydraulic press. The weld shall be located 3.2 mm (⅛ in.) from the face of the plates or jaws. Flatten the MAF against itself between the parallel plates or crush the MAF to within 50 % of its original diameter between the multiple jaws. There shall be no indication of cracking or tearing in the weld joints. Cracking or tearing of parent material is acceptable.

13.4.3.3 Test two MAFs. Take a cross section of the weld from each MAF. Smooth and etch one face of each cross section to give a clear definition of the weld metal and heat-affected zone. When examined, the weld and the heat-affected zone shall show complete fusion and freedom from cracks.

## 14. Inspection

14.1 *Terms of Inspection*—Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection requirements (examination and tests) specified herein.

14.2 *Raw Material Inspection*—Each lot of raw material used to produce MAFs in accordance with this specification shall be inspected for conformance to the applicable material specification. A lot of raw material shall consist of bars, pipe, tube, forgings, or castings of the same heat, produced at essentially the same time and submitted for inspection at the same time.

14.3 *Quality Conformance Inspection*—MAFs shall be visually and dimensionally examined to verify compliance with the appropriate drawings. Quality conformance inspection shall be performed on each lot of MAFs produced under this specification.

14.3.1 The inspection lot of MAFs shall include MAFs of the same size and shape manufactured under essentially the same conditions from the same lot of material and submitted for inspection at one time.

14.4 *Process Control Inspection*—MAFs shall be inspected throughout the entire manufacturing and processing cycle. Methods of inspection shall be in compliance with the manufacturer's quality assurance procedures.

14.5 *Inspection Records*—Inspection records shall be maintained by the manufacturer. The length of time on file shall be in accordance with the manufacturer's quality assurance procedures.

14.6 *Performance Testing Records*—The manufacturer shall maintain a record of all performance tests throughout the life of the MAF design.

14.6.1 The original test specimens, as well as replacement or penalty run specimens, used in performance testing to meet qualification shall be maintained by the manufacturer for a minimum of two years.

14.6.2 Inspection records relating to the performance tests shall be maintained in accordance with 14.5.

## 15. Certification

15.1 *Certification of Testing or Inspection*—When requested by the purchaser, the manufacturer shall supply written certifications that the MAF has been tested and qualified in accordance with this specification.

15.2 *Certification of Raw Material*—A certificate of compliance or mill certificate shall be obtained from the material supplier. This certificate shall state that all applicable requirements of the raw material are met. As a minimum, the material specification shall specify the chemical and mechanical requirements of the material.

## 16. Product Marking

16.1 *Product Marking*—Each MAF shall be marked with the manufacturer's name or trademark, size, and material (material marking is not required for Type V MAF). When shape or size does not permit inclusion of all required markings, the information may be omitted in the reverse order presented.

16.1.1 When MAFs are comprised of multiple components that are assembled, the marking methods used to identify the assembly (and each of its components) shall be as agreed to between the manufacturer and the purchaser.

16.2 *Additional Markings*—When specified in the contract or purchaser order, additional markings other than those specified shall be applied.

## 17. Keywords

17.1 axially swaged; bite-type; elastic strain preload (esp); fittings; flared; flareless; grip type; mechanically attached fittings (MAFs); piping; radially swaged; shape memory alloy (SMA)tubing



# SUPPLEMENTARY REQUIREMENTS



The following supplementary requirements shall apply only when specified in part or whole by the purchaser in the contract or purchase order.

## S1. GENERAL REQUIREMENTS

### S1.1 Scope

S1.1.1 This section covers the general requirements that, unless otherwise specified, apply to the Annex or this section whenever invoked individually or collectively by the purchaser of MAFs in the contract or purchase order. The testing requirements specified herein are applicable to all the tests described in Sections S2 through S8 (see Table S1.1). The requirements covered herein are outlined as follows:

S1.3 Testing Requirements
S1.4 Quality Assurance Requirements
S1.5 Product Marking Requirements

S1.1.2 Cadmium plating shall not be used on MAFs intended for use on U.S. Navy vessels.

S1.1.3 This section is applicable to MAFs that are designed for the following pipe or tube sizes:

S1.1.3.1 This supplementary section is applicable to MAFs suitable for pipe outside diameters for NPS 3.2 mm (⅛ in.) through 63.5 mm (2½ in.).

S1.1.3.2 This supplementary section is applicable to MAFs suitable for tube outside diameters from 6.4 mm (0.250 in.) to 73.0 mm (2.875 in.).

S1.1.3.3 Other pipe or tube sizes, with supporting data, may be submitted to the purchaser for evaluation and approval.

S1.1.4 The following supplementary tests listed herein are as follows: