

AEROSPACE MATERIAL SPECIFICATION

Tube, Aluminum and Aluminum Alloy, Drawn, Seamless, General Specification for

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1. SCOPE AND CLASSIFICATION:

1.1 Scope:

This specification covers the general requirements for aluminum and aluminum alloy tube; drawn, seamless (see 6.1.1). Specific requirements for these products in a particular alloy are covered by the applicable detail specification (see 6.3).

1.2 Classification:

1.2.1 Tempers: Tube shall be classified in tempers as specified in the detail specification. The definitions of tempers shall be as specified in ANSI H35.1.

2. APPLICABLE DOCUMENTS:

The issues of the following documents, in effect on date of invitation for bids or solicitation for offers, form a part of this specification to the extent specified herein.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

FED-STD-123 Marking for Shipment (Civil Agencies)

FED-STD-151 Metals, Test Methods

MIL-H-6088 Heat Treatment of Aluminum Alloys

MIL-STD-105 Sampling Procedures and Tables for Inspections by Attributes

MIL-STD-649 Aluminum and Magnesium Products, Preparation for Shipment and Storage

(Activities outside the Federal Government may obtain copies of Federal specifications, standards, and commercial item descriptions, as outlined under General Information in the Index of Federal Specifications, Standards and Commercial Item Descriptions. The Index, which includes cumulative bimonthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

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2.2 ANSI Publications:

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ANSI H35.1 Alloy and Temper Designation System for Aluminum
ANSI H35.2 Dimensional Tolerances for Aluminum Mill Products

2.3 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 557 Tension Testing of Wrought and Cast Aluminum and Magnesium Alloy Products
ASTM B 666 Aluminum Products, Identification Marking of
ASTM E 215 Standardizing Equipment for Electromagnetic Testing of Seamless Aluminum-Alloy Tube, Recommended Practice for

3. REQUIREMENTS:

3.1 Specification sheets:

The individual item requirements shall be as specified herein and in accordance with the applicable detail specification.

3.2 Chemical composition:

The chemical composition shall conform to the requirements specified in the detail specification.

3.3 Mechanical properties:

3.3.1 Tensile strength, yield strength and elongation: The tensile strength, yield strength and elongation mechanical properties shall be as specified in the detail specification, when tested as specified in 4.4.2.1 through 4.4.2.1.5.

3.3.2 Flattening: When specified in the detail specification, round tube shall withstand, without cracking, the flattening test or the alternative bend test detailed in 4.4.2.2 through 4.4.2.2.3.

3.3.2.1 Cleanliness: When specified in the detail specification the inner surface of round tube shall be examined as specified in 4.4.2.2.4.1. The inner surface of the tube shall show no evidence of metallic flakes or particles when tested in accordance with 4.4.2.2.4.1.

3.3.3 Test for leaks: When specified in the detail specification, each length of round tube shall be tested as specified in either 3.3.3.1 or 3.3.3.2 (at the option of the producer), consistent with the size limitations indicated for each method.

3.3.3.1 Pressure: Each length of round tube shall withstand, without leakage, either an air pressure test of 250 psi or a hydrostatic test of 250 psi, applied to the inside of the tube for a period of not less than 5 seconds (see 4.4.2.3.1).

3.3.3.2 Electromagnetic (eddy current): Each length of tube, 1-1/2 inches or less in outside diameter and maximum wall thickness of 0.083 inch, shall produce eddy current indications less than those from the 2A holes of the applicable reference standard of ASTM E 215 or an equivalent secondary standard, when tested in accordance with 4.4.2.3.2.

3.3.4 Flaring: When specified in the detail specification, round tube with a nominal outside diameter of 0.375 inch or less, shall be capable of being double-flared; and round tube, with a nominal outside diameter over 0.375 inch, shall be capable of being single-flared without formation of cracks or other visible defects (see 4.4.2.4 through 4.4.2.4.2).

3.4 Tolerance:

Unless otherwise specified, the tolerances shall be those specified in ANSI H35.2.

3.5 Requirements for sizes not specifically covered:

Mechanical properties for sizes not covered by this specification and tolerances for sizes not covered in ANSI H35.2 shall be as specified in the contract or order (see 6.2).

3.6 Marking for identification:

All tubes shall be marked in accordance with ASTM B 666, regardless of diameter, and the detail specification, as required (see 6.3).

3.7 Heat treatment:

Unless otherwise specified in the detail specification, contract, or order, heat treatment for the applicable tempers designated in the detail specification shall be in accordance with the applicable requirements of MIL-H-6088.

3.8 Workmanship:

The tube shall be seamless and uniform in quality and temper. The exterior and interior surfaces shall be clean, smooth and free from slivers, laminations, folds, grooves, cracks, flakes or particles, die tears with sharp bottom defects and other injurious defects and contaminants within the limits consistent with the best commercial practice. Discoloration due to thermal treatment will not be cause for rejection.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Sampling:

4.2.1 Inspection lot: An inspection lot shall be as follows:

4.2.1.1 Heat treated material: For heat-treated tempers, an inspection lot shall consist of an identifiable quantity of tube of the same alloy, temper, form, type, nominal outside diameter and nominal wall thickness traceable to a heat-treated lot or lots and subjected to inspection at one time.

4.2.1.2 Non-heat-treated material: For non-heat-treated tempers, an inspection lot shall consist of an identifiable quantity of tube of the same alloy, temper, form, type, nominal outside diameter and nominal wall thickness subjected to inspection at one time.

4.2.2 Sampling for chemical analysis:

4.2.2.1 Ingot analysis: At least one sample shall be taken from each group of ingots of the same alloy poured simultaneously from the same source of molten metal by the producer and analyzed to determine conformance to 3.2. Ingots not conforming to the requirements of this specifications shall be rejected. Complete ingot analysis records shall be available, at the producer's plant, to the procuring activity.

4.2.2.2 Finish product analysis: When compliance with 4.2.2.1 cannot be established, samples shall be selected as follows: One sample shall be taken for each 4000 pounds, or fraction thereof, of each alloy in an inspection lot to determine conformance to 3.2.

4.2.3 Samples for mechanical property tests:

4.2.3.1 Samples for tensile tests: The number of test samples in temper supplied shall be as follows: From tube having a nominal weight of less than one pound per linear foot, one tension-test sample shall be selected from each lot weighing 1,000 pounds or less; from lots weighing more than 1,000 pounds, one additional sample shall be taken for each 1,000 pounds or fraction thereof in excess of the first 1,000 pounds. From tube having a nominal weight of 1 pound or more per linear foot, one tension-test sample shall be taken from each lot consisting of 1,000 feet or less; from lots consisting of more than 1,000 feet, one additional sample shall be taken for each 1,000 feet or fraction thereof in excess of the first 1,000 feet. Only one tension-test specimen shall be taken from any one piece when more than one piece is available.

- 4.2.3.2 Samples for flattening test: When flattening test is specified in the detail specification, flattening test samples equal in number to those required by 4.2.3.1 shall be taken and tested to determine compliance with 3.3.2 and when applicable, 3.3.2.1.
- 4.2.3.3 Samples for leak test: When leak test is specified in the detail specification, each length of round tube shall be leak tested to determine compliance with 3.3.3.
- 4.2.3.4 Samples for flaring test: When flare test is specified in the detail specification, five flaring test samples shall be selected from each lot to determine compliance with 3.3.4.
- 4.2.4 Sampling for visual and dimensional examination: Each inspection lot of tubing shall be examined to determine conformance to this specification with respect to dimensions, identification marking and workmanship. The supplier may use a statistical sampling plan for examination of each inspection lot that conforms to MIL-STD-105 inspection level I with an AQL of 1.5 expressed in terms of percent defective. On approval of the procuring activity the supplier may use other systems of statistical quality control for visual and dimensional examination.
- 4.3 Examination:
- 4.3.1 Visual and dimensional examination: Each sample tube selected in accordance with 4.2.4 shall be visually examined and measured to verify conformance to this specification.
- 4.3.2 Preservation, packaging, packing and marking for shipment: When specified (see 6.2), an examination shall be made by a representative of the procuring activity to determine compliance with the requirement of Section 5. The sample unit shall be one shipping container fully prepared for delivery. Sampling shall be in accordance with MIL-STD-105. The inspection level shall be S-2 with an AQL of 4.0 expressed in terms of percent defective. A lot shall be as specified in MIL-STD-105.
- 4.4 Test methods:
- 4.4.1 Chemical analysis: Chemical analysis shall be made by the wet chemical method in accordance with method 111 of FED-STD-151 or by the spectrochemical method in accordance with method 112 of FED-STD-151.
- 4.4.2 Mechanical properties:
- 4.4.2.1 Tension tests:
- 4.4.2.1.1 Types of specimens: Specimens for tensile testing shall conform to the requirements of ASTM B 557.
- 4.4.2.1.2 Location of test specimens: Tension test specimens shall be taken from the tube in the longitudinal direction as specified in the detail specification. For tube with a wall thickness 0.500 to 1.500 inches, inclusive, tension-test specimens shall be taken with the axis midway between the inside and outside diameter surfaces; from tube having wall thickness greater than 1.500 inches, the axis of the tension-test specimens shall be three fourths of the distance from one surface to the other.

- 4.4.2.1.3 Tensile strength: Tensile strength shall be determined in accordance with ASTM B 557.
- 4.4.2.1.4 Yield strength: The yield strength shall be determined either by the offset method of the extension-under-load method in accordance with ASTM B 557. In case of dispute, the offset method shall be used.
- 4.4.2.1.5 Elongation: Elongation shall be determined in accordance with ASTM B 557.
- 4.4.2.2 Flattening test (round tube):
- 4.4.2.2.1 Type of specimen: Flattening test specimens shall be of the full section of the material and shall have a length approximately equal to 1-1/2 times the outside diameter of the tube.
- 4.4.2.2.2 Method: Flattening test specimens shall be flattened sidewise under a gradually applied load until the minimum outside diameter under load is not more than "F" times the wall thickness of the tube as specified in the detail specification.
- 4.4.2.2.3 Alternative bend test: In case the tube does not flatten so as to give a uniform radius of bend, suitable jigs may be used to bring about this result, or a section of tube of not less than 1/2 inch in length, with the subtended arc not greater than one half nor less than one third of the circumference of the original tube, shall be removed from the material in question and without further treatment shall be bent around a mandrel having a diameter "N" times the wall thickness of the tube as specified in the detail specification. The bend shall be made with the pin placed on the inside surface of the specimen, with the longitudinal axis of the pin and specimen parallel. The bend shall be continued until specimen encloses at least 180° of the pin.
- 4.4.2.2.4 Examination: After the flattening test, the outer surface of the tube shall be visually examined for cracks and when applicable, as specified in 4.4.2.2.4.1. Any evidence of cracking shall be cause for rejection.
- 4.4.2.2.4.1 Cleanliness test: Immediately, after flattening the specimen (see 4.4.2.2.2), the flattened specimen shall be tapped in a vertical position on a dark surface. Evidence of powder flakes or particles shall be cause for rejection.
- 4.4.2.3 Leak test:
- 4.4.2.3.1 Pressure test: While the tube is completely immersed in water or other suitable liquid, an air pressure of 250 psi shall be applied to the inside of the tube for a period of not less than 5 seconds or the tube may be filled with water and 250 pounds of hydrostatic pressure applied to the inside of the tube for a period of not less than 5 seconds. The tube may be subjected to this test after reduction to size but before the final anneal. Any tube leakage, as indicated by the formation of air bubbles in the liquid or escaping water, shall be cause for rejection.
- 4.4.2.3.2 Electromagnetic (eddy current): The eddy current test shall be conducted in accordance with ASTM E 215. The reference standards specified in the appendix of ASTM E 215 shall be used to standardize the equipment and insure proper functioning.

4.4.2.3 Flaring test:

4.4.2.4.1 Preparation of specimen: Specimens for flaring may be cut from any portion of the tube or an entire tube may be used as a specimen. The end of the specimen to be flared shall be cut square, with the cut end smooth and free from burrs, but not rounded except for sizes 0.375 inch and under.

4.4.2.4.2 Method: When specified in the detail specification, specimens shall, at room temperature, be forced axially with steady pressure over a hardened and polished tapered steel pin having a 74° included angle, to produce a flare having the permanent expanded outside diameter specified in table I.

TABLE I. Flare dimensions ^{1/}

| Nominal OD, inch | Expanded OD minimum, inch | Nominal OD, inches | Expanded OD, minimum, inches |
|------------------|---------------------------|--------------------|------------------------------|
| 0.125 | 0.224 | 0.750 | 0.937 |
| 0.188 | 0.302 | 1.000 | 1.187 |
| 0.250 | 0.359 | 1.250 | 1.500 |
| 0.312 | 0.421 | 1.500 | 1.721 |
| 0.375 | 0.484 | 1.750 | 2.106 |
| 0.500 | 0.656 | 2.000 | 2.356 |
| 0.625 | 0.781 | - | - |

^{1/} Tube with intermediate nominal OD shall take the same percentage flare as that for the next larger OD. Tube with nominal OD greater than 2.000 or less than 0.125 inch shall have flareability as agreed upon by the purchaser and vendor

4.5 Rejection and retest:

If any specimen fails to conform to the requirements of this specification, it shall be cause for rejection of the material represented by the specimen subject to the retest provisions of FED-STD-151. When no sampling plan is provided, or approved by the procuring agency, and when there is evidence that indicates that a failed specimen was not representative of the lot of material, and when the detail specification does not specify otherwise, at least two specimens shall be selected to replace each test specimen which failed. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be rejected.