



# Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes<sup>1</sup>

This standard is issued under the fixed designation B 210; 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 approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

## 1. Scope \*

1.1 This specification<sup>2</sup> covers aluminum and aluminum-alloy drawn seamless tubes in straight lengths and coils for general purpose and pressure applications in alloys (Note 2), tempers, and thicknesses shown in Table 1. Coiled tubes are generally available only as round tubes with a wall thickness not exceeding 0.083 in. and only in nonheat-treatable alloys.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are those of Table 2 preceded by A9, for example, A91100 for aluminum designation 1100 in accordance with Practice E 527.

NOTE 1—See Specification B 483 for aluminum-alloy drawn tubes for general purpose applications; Specification B 234 for aluminum-alloy drawn seamless tubes for condensers and heat exchangers; and Specification B 241/B 241M for aluminum-alloy seamless pipe and seamless extruded tube.

NOTE 2—Throughout this specification, use of the term *alloy* in the general sense includes aluminum as well as aluminum alloy.

1.3 A complete metric companion to Specification B 210 has been developed—Specification B 210M; therefore, no metric equivalents are presented in this specification.

1.4 For acceptance criteria for inclusion of new aluminum and aluminum alloys in this specification, see Annex A2.

## 2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

### 2.2 ASTM Standards:

B 234 Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes for Condensers and Heat Exchangers<sup>3</sup>

B 241/B 241M Specification for Aluminum and Aluminum-

Alloy Seamless Pipe and Seamless Extruded Tube<sup>3</sup>

B 483 Specification for Aluminum and Aluminum-Alloy Drawn Tubes for General Purpose Applications<sup>3</sup>

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products<sup>3</sup>

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products<sup>3</sup>

B 666/B 666M Practice for Identification Marking of Aluminum and Magnesium Products<sup>3</sup>

B 918 Practice for Heat Treatment of Wrought Aluminum Alloys<sup>3</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>4</sup>

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys<sup>5</sup>

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition<sup>5</sup>

E 215 Practice for Standardizing Equipment for Electromagnetic Examination of Seamless Aluminum-Alloy Tube<sup>6</sup>

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique<sup>5</sup>

E 527 Practice for Numbering Metals and Alloys (UNS)<sup>7</sup>

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere<sup>5</sup>

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis<sup>5</sup>

E 1004 Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method<sup>6</sup>

E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge<sup>5</sup>

### 2.3 ANSI Standards:

H35.1 Alloy and Temper Designation Systems for Aluminum<sup>3</sup>

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum Alloy Wrought Products.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SB-210 in Section II of that Code.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.02.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 14.02.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.05.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 03.05.

<sup>7</sup> *Annual Book of ASTM Standards*, Vol 01.01.

\*A Summary of Changes section appears at the end of this standard.

H35.2 Dimensional Tolerances for Aluminum Mill Products<sup>3</sup>

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage<sup>8</sup>

2.5 *AMS Specification:*

AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials<sup>9</sup>

2.6 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)<sup>8</sup>

### 3. Terminology

3.1 *Definitions:*

3.1.1 *tube*—a hollow wrought product that is long in relation to its cross section, which is round, a regular hexagon, a regular octagon, elliptical, or square or rectangular with sharp

or rounded corners, and that has uniform wall thickness except as may be affected by corner radii.

3.1.2 *drawn seamless tube*—a tube produced from hollow extrusion ingot and brought to final dimensions by drawing through a die.

3.1.3 *alclad tube*—a composite tube product composed of an aluminum-alloy core having on either the inside or outside surface a metallurgically bonded aluminum or aluminum-alloy coating that is anodic to the core, thus electrolytically protecting the core against corrosion.

3.1.4 *producer*—the primary manufacturer of the material.

3.1.5 *supplier*—includes only the category of jobbers and distributors as distinct from producers.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capable of*—The term *capable of* as used in this specification means that the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

<sup>8</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>9</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

**TABLE 1 Tensile Property Limits<sup>A,B</sup>**

| Temper                     | Specified Wall Thickness, <sup>C</sup> in. | Tensile Strength, ksi |      | Yield Strength <sup>D</sup><br>(0.2 % offset),<br>min, ksi | Elongation in 2 in. or 4 × Diameter, <sup>E</sup> min, % |                  |
|----------------------------|--|-----------------------|------|--|--|------------------|
|                            |  | min                   | max  |  | Full-Section Specimen                                    | Cut-Out Specimen |
| Aluminum 1060 <sup>F</sup> |  |                       |      |  |  |                  |
| O                          | 0.018–0.500                                | 8.5                   | 13.5 | 2.5  | ...  | ...              |
| H12                        |  | 10.0                  | ...  | 4.0  | ...  | ...              |
| H14                        |  | 12.0                  | ...  | 10.0   | ...  | ...              |
| H18                        |  | 16.0                  | ...  | 13.0   | ...  | ...              |
| H113 <sup>G</sup>          |  | 8.5                   | ...  | 2.5  | ...  | ...              |
| Aluminum 1100 <sup>F</sup> |  |                       |      |  |  |                  |
| O                          | 0.018–0.500                                | 11.0                  | 15.5 | 3.5  | ...  | ...              |
| H12                        |  | 14.0                  | ...  | 11.0   | ...  | ...              |
| H14                        |  | 16.0                  | ...  | 14.0   | ...  | ...              |
| H16                        |  | 19.0                  | ...  | 17.0   | ...  | ...              |
| H18                        |  | 22.0                  | ...  | 20.0   | ...  | ...              |
| H113 <sup>G</sup>          |  | 11.0                  | ...  | 3.5  | ...  | ...              |
| Alloy 2011                 |  |                       |      |  |  |                  |
| T3                         | 0.018–0.049                                | 47.0                  | ...  | 40.0   | ...  | ...              |
|                            | 0.050–0.500                                | 47.0                  | ...  | 40.0   | 10   | 8                |
| T4511                      | 0.018–0.049                                | 44.0                  | ...  | 25.0   | ...  | ...              |
|                            | 0.050–0.259                                | 44.0                  | ...  | 25.0   | 20   | 18               |
|                            | 0.260–0.500                                | 44.0                  | ...  | 25.0   | 20   | 20               |
| Alloy 2014                 |  |                       |      |  |  |                  |
| O                          | 0.018–0.500                                | ...                   | 32.0 | 16.0 max   | ...  | ...              |
| T4, T42 <sup>H</sup>       | 0.018–0.024                                | 54.0                  | ...  | 30.0   | 10   | ...              |
|                            | 0.025–0.049                                | 54.0                  | ...  | 30.0   | 12   | 10               |
|                            | 0.050–0.259                                | 54.0                  | ...  | 30.0   | 14   | 10               |
|                            | 0.260–0.500                                | 54.0                  | ...  | 30.0   | 16   | 12               |
| T6, T62 <sup>H</sup>       | 0.018–0.024                                | 65.0                  | ...  | 55.0   | 7  | ...              |
|                            | 0.025–0.049                                | 65.0                  | ...  | 55.0   | 7  | 6                |
|                            | 0.050–0.259                                | 65.0                  | ...  | 55.0   | 8  | 7                |
|                            | 0.260–0.500                                | 65.0                  | ...  | 55.0   | 9  | 8                |
| Alloy 2024                 |  |                       |      |  |  |                  |
| O                          | 0.018–0.500                                | ...                   | 32.0 | 15.0 max   | ...  | ...              |
| T3 <sup>H</sup>            | 0.018–0.024                                | 64.0                  | ...  | 42.0   | 10   | ...              |
|                            | 0.025–0.049                                | 64.0                  | ...  | 42.0   | 12   | 10               |
|                            | 0.050–0.259                                | 64.0                  | ...  | 42.0   | 14   | 10               |
|                            | 0.260–0.500                                | 64.0                  | ...  | 42.0   | 16   | 12               |
| T42 <sup>H</sup>           | 0.018–0.024                                | 64.0                  | ...  | 40.0   | 10   | ...              |
|                            | 0.025–0.049                                | 64.0                  | ...  | 40.0   | 12   | 10               |

**TABLE 1** *Continued*

| Temper                         | Specified Wall Thickness, <sup>C</sup> in. | Tensile Strength, ksi |      | Yield Strength <sup>D</sup><br>(0.2 % offset),<br>min, ksi | Elongation in 2 in. or 4 × Diameter, <sup>E</sup> min, % |                  |
|--------------------------------|--|-----------------------|------|--|--|------------------|
|                                |  | min                   | max  |  | Full-Section Specimen                                    | Cut-Out Specimen |
|                                | 0.050–0.259                                | 64.0                  | ...  | 40.0   | 14   | 10               |
|                                | 0.260–0.500                                | 64.0                  | ...  | 40.0   | 16   | 12               |
| Alloy 3003 <sup>F</sup>        |  |                       |      |  |  |                  |
| O                              | 0.010–0.024                                | 14.0                  | 19.0 | 5.0  | ...  | ...              |
|                                | 0.025–0.049                                | 14.0                  | 19.0 | 5.0  | 30   | 20               |
|                                | 0.050–0.259                                | 14.0                  | 19.0 | 5.0  | 35   | 25               |
|                                | 0.260–0.500                                | 14.0                  | 19.0 | 5.0  | ...  | 30               |
| H12                            | 0.010–0.500                                | 17.0                  | ...  | 12.0   | ...  | ...              |
| H14                            | 0.010–0.024                                | 20.0                  | ...  | 17.0   | 3  | ...              |
|                                | 0.025–0.049                                | 20.0                  | ...  | 17.0   | 5  | 3                |
|                                | 0.050–0.259                                | 20.0                  | ...  | 17.0   | 8  | 4                |
|                                | 0.260–0.500                                | 20.0                  | ...  | 17.0   | ...  | ...              |
| H16                            | 0.010–0.024                                | 24.0                  | ...  | 21.0   | ...  | ...              |
|                                | 0.025–0.049                                | 24.0                  | ...  | 21.0   | 3  | 2                |
|                                | 0.050–0.259                                | 24.0                  | ...  | 21.0   | 5  | 4                |
|                                | 0.260–0.500                                | 24.0                  | ...  | 21.0   | ...  | ...              |
| H18                            | 0.010–0.024                                | 27.0                  | ...  | 24.0   | 2  | ...              |
|                                | 0.025–0.049                                | 27.0                  | ...  | 24.0   | 3  | 2                |
|                                | 0.050–0.259                                | 27.0                  | ...  | 24.0   | 5  | 3                |
|                                | 0.260–0.500                                | 27.0                  | ...  | 24.0   | ...  | ...              |
| H113 <sup>G</sup>              | 0.010–0.500                                | 14.0                  | ...  | 5.0  | ...  | ...              |
| Alloy Alclad 3003              |  |                       |      |  |  |                  |
| O                              | 0.010–0.024                                | 13.0                  | 19.0 | 4.5  | ...  | ...              |
|                                | 0.025–0.049                                | 13.0                  | 19.0 | 4.5  | 30   | 20               |
|                                | 0.050–0.259                                | 13.0                  | 19.0 | 4.5  | 35   | 25               |
|                                | 0.260–0.500                                | 13.0                  | 19.0 | 4.5  | ...  | 30               |
| H14                            | 0.010–0.024                                | 19.0                  | ...  | 16.0   | ...  | ...              |
|                                | 0.025–0.049                                | 19.0                  | ...  | 16.0   | 5  | ...              |
|                                | 0.050–0.259                                | 19.0                  | ...  | 16.0   | 8  | 4                |
|                                | 0.260–0.500                                | 19.0                  | ...  | 16.0   | ...  | ...              |
| H18                            | 0.010–0.500                                | 26.0                  | ...  | 23.0   | ...  | ...              |
| H113 <sup>G</sup>              | 0.050–0.500                                | 13.0                  | ...  | 4.5  | ...  | ...              |
| Alloy 3102 <sup>F</sup>        |  |                       |      |  |  |                  |
| O                              | 0.018–0.049                                | 11.0                  | 17.0 | 3.5  | 30'  | 20'              |
|                                | 0.050–0.065                                | 11.0                  | 17.0 | 3.5  | 35   | 25               |
| Alloy Alclad 3102 <sup>F</sup> |  |                       |      |  |  |                  |
| O                              | 0.018–0.049                                | 10.0                  | 17.0 | 3.5  | 30'  | 20'              |
|                                | 0.050–0.065                                | 10.0                  | 17.0 | 3.5  | 35   | 25               |
| Alloy 3303 <sup>F</sup>        |  |                       |      |  |  |                  |
| O                              | 0.010–0.024                                | 14.0                  | 19.0 | 5.0  | ...  | ...              |
|                                | 0.025–0.049                                | 14.0                  | 19.0 | 5.0  | 30   | 20               |
|                                | 0.050–0.065                                | 14.0                  | 19.0 | 5.0  | 35   | 25               |
| Alloy Alclad 3303 <sup>F</sup> |  |                       |      |  |  |                  |
| O                              | 0.010–0.024                                | 13.0                  | 19.0 | 4.5  | ...  | ...              |
|                                | 0.025–0.049                                | 13.0                  | 19.0 | 4.5  | 30   | 20               |
|                                | 0.050–0.065                                | 13.0                  | 19.0 | 4.5  | 35   | 25               |
| Alloy 5005 <sup>F</sup>        |  |                       |      |  |  |                  |
| O <sup>F</sup>                 | 0.018–0.500                                | 15.0                  | 21.0 | 5.0  | ...  | ...              |
| Alloy 5050 <sup>F</sup>        |  |                       |      |  |  |                  |
| O <sup>F</sup>                 | 0.018–0.500                                | 18.0                  | 24.0 | 6.0  | ...  | ...              |
| H32                            |  | 22.0                  | ...  | 16.0   | ...  | ...              |
| H34                            |  | 25.0                  | ...  | 20.0   | ...  | ...              |
| H36                            |  | 27.0                  | ...  | 22.0   | ...  | ...              |
| H38                            |  | 29.0                  | ...  | 24.0   | ...  | ...              |
| Alloy 5052 <sup>F</sup>        |  |                       |      |  |  |                  |
| O <sup>F</sup>                 | 0.018–0.450                                | 25.0                  | 35.0 | 10.0   | ...  | ...              |
| H32                            |  | 31.0                  | ...  | 23.0   | ...  | ...              |
| H34                            |  | 34.0                  | ...  | 26.0   | ...  | ...              |
| H36                            |  | 37.0                  | ...  | 29.0   | ...  | ...              |
| H38                            |  | 39.0                  | ...  | 24.0   | ...  | ...              |

**TABLE 1** *Continued*

| Temper                  | Specified Wall Thickness, <sup>C</sup> in. | Tensile Strength, ksi |      | Yield Strength <sup>D</sup><br>(0.2 % offset),<br>min, ksi | Elongation in 2 in. or 4 × Diameter, <sup>E</sup> min, % |                  |
|-------------------------|--|-----------------------|------|--|--|------------------|
|                         |  | min                   | max  |  | Full-Section Specimen                                    | Cut-Out Specimen |
| Alloy 5083 <sup>F</sup> |  |                       |      |  |  |                  |
| O <sup>F</sup>          | 0.018–0.450                                | 39.0                  | 51.0 | 16.0   | ...  | 14               |
| Alloy 5086 <sup>F</sup> |  |                       |      |  |  |                  |
| O <sup>F</sup>          | 0.018–0.450                                | 35.0                  | 46.0 | 14.0   | ...  | ...              |
| H32                     |  | 40.0                  | ...  | 28.0   | ...  | ...              |
| H34                     |  | 44.0                  | ...  | 34.0   | ...  | ...              |
| H36                     |  | 47.0                  | ...  | 38.0   | ...  | ...              |
| Alloy 5154 <sup>F</sup> |  |                       |      |  |  |                  |
| O                       | 0.010–0.450                                | 30.0                  | 41.0 | 11.0   | 10   | 10               |
| H34                     |  | 39.0                  | ...  | 29.0   | 5  | 5                |
| H38                     |  | 45.0                  | ...  | 34.0   | ...  | ...              |
| Alloy 5456 <sup>F</sup> |  |                       |      |  |  |                  |
| O                       | 0.018                                      | 41.0                  | 53.0 | 19.0   | ...  | 14               |
| Alloy 6061              |  |                       |      |  |  |                  |
| O                       | 0.018–0.500                                | ...                   | 22.0 | 14.0 max   | 15   | 15               |
| T4                      | 0.025–0.049                                | 30.0                  | ...  | 16.0   | 16   | 14               |
|                         | 0.050–0.259                                | ...                   | ...  | ...  | ...  | ...              |
|                         | 0.260–0.500                                | 30.0                  | ...  | 16.0   | 18   | 16               |
|                         |  | 30.0                  | ...  | 16.0   | 20   | 18               |
| T42 <sup>H</sup>        | 0.025–0.049                                | 30.0                  | ...  | 14.0   | 16   | 14               |
|                         | 0.050–0.259                                | 30.0                  | ...  | 14.0   | 18   | 16               |
|                         | 0.260–0.500                                | 30.0                  | ...  | 14.0   | 20   | 18               |
| T6, T62 <sup>H</sup>    | 0.025–0.049                                | 42.0                  | ...  | 35.0   | 10   | 8                |
|                         | 0.050–0.259                                | 42.0                  | ...  | 35.0   | 12   | 10               |
|                         | 0.260–0.500                                | 42.0                  | ...  | 35.0   | 14   | 12               |
| Alloy 6063              |  |                       |      |  |  |                  |
| O                       | 0.018–0.500                                | ...                   | 19.0 | ...  | ...  | ...              |
| T4, T42 <sup>H</sup>    | 0.025–0.049                                | 22.0                  | ...  | 10.0   | 16   | 14               |
|                         | 0.050–0.259                                | 22.0                  | ...  | 10.0   | 18   | 16               |
|                         | 0.260–0.500                                | 22.0                  | ...  | 10.0   | 20   | 18               |
| T6, T62 <sup>H</sup>    | 0.025–0.049                                | 33.0                  | ...  | 28.0   | 12   | 8                |
|                         | 0.050–0.259                                | 33.0                  | ...  | 28.0   | 14   | 10               |
|                         | 0.260–0.500                                | 33.0                  | ...  | 28.0   | 16   | 12               |
| T83                     | 0.025–0.259                                | 33.0                  | ...  | 30.0   | 5  | ...              |
| T831                    | 0.025–0.259                                | 28.0                  | ...  | 25.0   | 5  | ...              |
| T832                    | 0.025–0.049                                | 41.0                  | ...  | 36.0   | 8  | 5                |
|                         | 0.050–0.259                                | 40.0                  | ...  | 35.0   | 8  | 5                |
| Alloy 6262              |  |                       |      |  |  |                  |
| T6, T62 <sup>H</sup>    | 0.025–0.049                                | 42.0                  | ...  | 35.0   | 10   | 8                |
|                         | 0.050–0.259                                | 42.0                  | ...  | 35.0   | 12   | 10               |
|                         | 0.260–0.500                                | 42.0                  | ...  | 35.0   | 14   | 12               |
| T9                      | 0.025–0.375                                | 48.0                  | ...  | 44.0   | 5  | 4                |
| Alloy 7075              |  |                       |      |  |  |                  |
| O                       | 0.025–0.049                                | ...                   | 40.0 | 21.0 max   | 10   | 8                |
|                         | 0.050–0.500                                | ...                   | 40.0 | 21.0 max   | 12   | 10               |
| T6, T62 <sup>H</sup>    | 0.025–0.259                                | 77.0                  | ...  | 66.0   | 8  | 7                |
|                         | 0.260–0.500                                | 77.0                  | ...  | 66.0   | 9  | 8                |
| T73 <sup>J</sup>        | 0.025–0.259                                | 66.0                  | ...  | 56.0   | 10   | 8                |
|                         | 0.260–0.500                                | 66.0                  | ...  | 56.0   | 12   | 10               |

<sup>A</sup> See Annex A1.

<sup>B</sup> To determine conformance to this specification, each value for tensile strength and for yield strength shall be rounded to the nearest 0.1 ksi and each value for elongation to the nearest 0.5 % both in accordance with the rounding-off method of Practice E 29.

<sup>C</sup> Coiled tube is generally available with a maximum wall thickness of 0.083 in. and only in nonheat-treatable alloys.

<sup>D</sup> Yield strength to be determined only on straight tube.

<sup>E</sup> Elongation of full-section and cut-out sheet-type specimens is measured in 2 in. of cut-out round specimens, in 4× specimen diameter.

<sup>F</sup> In this alloy tube other than round is produced only in the F (as drawn) and O tempers. Properties for F temper are not specified or guaranteed.

<sup>G</sup> Beginning with the 1982 issue the requirements for the H112 tempers were replaced by the H113 temper, applicable to other than round tube, which is fabricated by cold-forming annealed round tube and acquires some temper in this forming operation.

<sup>H</sup> Material in the T42 or T62 tempers is not available from the material producers.

<sup>I</sup> For specified wall thickness under 0.025 in., elongation is not required.

<sup>J</sup> Material in this temper exhibits improved resistance to stress corrosion compared to that of the T6 temper. The stress-corrosion resistance capability of individual lots is determined by testing the previously selected tension-test samples in accordance with the applicable electrical conductivity acceptance criteria of Table 3.

**TABLE 2 Chemical Composition Limits<sup>A,B,C</sup>**

| Alloy                      | Silicon      | Iron | Copper    | Manganese | Magnesium | Chromium  | Zinc    | Titanium | Other Elements <sup>D</sup> |                    | Aluminum, min          |
|----------------------------|--------------|------|-----------|-----------|-----------|-----------|---------|----------|-----------------------------|--------------------|------------------------|
|                            |              |      |           |           |           |           |         |          | Each                        | Total <sup>E</sup> |                        |
| 1060                       | 0.25         | 0.35 | 0.05      | 0.03      | 0.03      | ...       | 0.05    | 0.03     | 0.03 <sup>F</sup>           | ...                | 99.60 min <sup>G</sup> |
| 1100                       | 0.95 Si + Fe |      | 0.05–0.20 | 0.05      | ...       | ...       | 0.10    | ...      | 0.05                        | 0.15               | 99.00 min <sup>G</sup> |
| 2011                       | 0.40         | 0.7  | 5.0–6.0   | ...       | ...       | ...       | 0.30    | ...      | 0.05 <sup>H</sup>           | 0.15               | remainder              |
| 2014                       | 0.50–1.2     | 0.7  | 3.9–5.0   | 0.40–1.2  | 0.20–0.8  | 0.10      | 0.25    | 0.15     | 0.05                        | 0.15               | remainder              |
| 2024                       | 0.50         | 0.50 | 3.8–4.9   | 0.30–0.9  | 1.2–1.8   | 0.10      | 0.25    | 0.15     | 0.05                        | 0.15               | remainder              |
| 3003                       | 0.6          | 0.7  | 0.05–0.20 | 1.0–1.5   | ...       | ...       | 0.10    | ...      | 0.05                        | 0.15               | remainder              |
| Alclad 3003 <sup>I</sup>   |              |      |           |           |           |           |         |          |                             |                    |                        |
| 3102                       | 0.40         | 0.7  | 0.10      | 0.05–0.40 | ...       | ...       | 0.30    | 0.10     | 0.05                        | 0.15               | remainder              |
| Alclad 3102 <sup>I</sup>   |              |      |           |           |           |           |         |          |                             |                    |                        |
| 3303                       | 0.6          | 0.7  | 0.05–0.20 | 1.0–1.5   | ...       | ...       | 0.30    | ...      | 0.05                        | 0.15               | remainder              |
| Alclad 3303 <sup>I</sup>   |              |      |           |           |           |           |         |          |                             |                    |                        |
| 5005                       | 0.30         | 0.7  | 0.20      | 0.20      | 0.50–1.1  | 0.10      | 0.25    | ...      | 0.05                        | 0.15               | remainder              |
| 5050                       | 0.40         | 0.7  | 0.20      | 0.10      | 1.1–1.8   | 0.10      | 0.25    | ...      | 0.05                        | 0.15               | remainder              |
| 5052                       | 0.25         | 0.40 | 0.10      | 0.10      | 2.2–2.8   | 0.15–0.35 | 0.10    | ...      | 0.05                        | 0.15               | remainder              |
| 5083                       | 0.40         | 0.40 | 0.10      | 0.40–1.0  | 4.0–4.9   | 0.05–0.25 | 0.25    | 0.15     | 0.05                        | 0.15               | remainder              |
| 5086                       | 0.40         | 0.50 | 0.10      | 0.20–0.7  | 3.5–4.5   | 0.05–0.25 | 0.25    | 0.15     | 0.05                        | 0.15               | remainder              |
| 5154                       | 0.25         | 0.40 | 0.10      | 0.10      | 3.1–3.9   | 0.15–0.35 | 0.20    | 0.20     | 0.05                        | 0.15               | remainder              |
| 5456                       | 0.25         | 0.40 | 0.10      | 0.50–1.0  | 4.7–5.5   | 0.05–0.20 | 0.25    | 0.20     | 0.05                        | 0.15               | remainder              |
| 6061                       | 0.40–0.8     | 0.7  | 0.15–0.40 | 0.15      | 0.8–1.2   | 0.04–0.35 | 0.25    | 0.15     | 0.05                        | 0.15               | remainder              |
| 6063                       | 0.20–0.6     | 0.35 | 0.10      | 0.10      | 0.45–0.9  | 0.10      | 0.10    | 0.10     | 0.05                        | 0.15               | remainder              |
| 6262                       | 0.40–0.8     | 0.7  | 0.15–0.40 | 0.15      | 0.8–1.2   | 0.04–0.14 | 0.25    | 0.15     | 0.05 <sup>J</sup>           | 0.15               | remainder              |
| 7072 cladding <sup>K</sup> | 0.7 Si + Fe  |      | 0.10      | 0.10      | ...       | ...       | 0.8–1.3 | ...      | 0.05                        | 0.15               | remainder              |
| 7075                       | 0.40         | 0.50 | 1.2–2.0   | 0.30      | 2.1–2.9   | 0.18–0.28 | 5.1–6.1 | 0.20     | 0.05                        | 0.15               | remainder              |

<sup>A</sup> Limits are in weight percent maximum unless shown as a range or otherwise stated.

<sup>B</sup> Analysis shall be made for the elements for which limits are shown in this table.

<sup>C</sup> For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding-off method of Practice E 29.

<sup>D</sup> *Others* includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered non-conforming.

<sup>E</sup> *Other elements*—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.

<sup>F</sup> Vanadium 0.05 % max.

<sup>G</sup> The aluminum content shall be calculated by subtracting from 100.00 % the sum of all metallic elements present in amounts of 0.010 % or more each, rounded to the second decimal before determining the sum.

<sup>H</sup> Bismuth and lead each 0.20 – 0.6 %.

<sup>I</sup> Alloy clad with Alloy 7072.

<sup>J</sup> Bismuth and lead each 0.40–0.7 %.

<sup>K</sup> Composition of cladding alloy as applied during the course of manufacture. The samples from finished tube shall not be required to conform to these limits.

**TABLE 3 Lot Acceptance Criteria for Resistance to Stress-Corrosion**

| Alloy and Temper | Lot Acceptance Criteria                        |   | Lot Acceptance Status     |
|------------------|--|---|---------------------------|
|                  | Electrical Conductivity, <sup>A,B</sup> % IACS | Level of Mechanical Properties  |                           |
| 7075–T73         | 40.0 or greater                                | per specified requirements  | acceptable                |
|                  | 38.0 through 39.9                              | per specified requirements and yield strength does not exceed minimum by more than 11.9 ksi | acceptable                |
|                  | 38.0 through 39.9                              | per specified requirements but yield strength exceeds minimum by 12.0 ksi or more           | unacceptable <sup>C</sup> |
|                  | less than 38.0                                 | any level   | unacceptable <sup>C</sup> |

<sup>A</sup> The electrical conductivity shall be determined in accordance with Practice E 1004 in the following locations:

|                     |  |
|---------------------|--|
| Wall Thickness, in. | Location   |
| Up through 0.100    | surface of tensile sample                                    |
| 0.101 and over      | subsurface after removal of approximately 10 % of thickness. |

<sup>B</sup> For curved surfaces, the conductivity shall be measured on a machined flat spot; however, for small size tubes, a cut-out piece may be flattened and the conductivity determined.

<sup>C</sup> When material is found to be unacceptable, it shall be reprocessed (additional precipitation heat treatment or resolution heat treatment and precipitation heat treatment).

#### 4. Ordering Information

4.1 Orders for material to this specification shall include the following information:

4.1.1 This specification designation (which includes the number, the year, and the revision letter, if applicable),

4.1.2 Quantity in pieces or pounds,

4.1.3 Alloy (Section 7),

4.1.4 Temper (Section 8),

4.1.5 Cross-sectional dimensions (outside diameter and wall thickness, or inside diameter and wall thickness for round tube; for tube other than round, square, rectangular, hexagonal, or octagonal with sharp corners, a drawing is required),

4.1.6 Length (straight or coiled),

4.1.7 Nominal inside diameter of coils and weight or maximum outside diameter, if applicable,

4.1.8 For alloy Alclad 3003, Alclad 3102, or Alclad 3303 state clad inside or outside (17.1).

4.2 Additionally, orders for material to this specification shall include the following information when required by the purchaser:

4.2.1 Whether heat treatment in accordance with Practice B 918 is required (11.2),

4.2.2 Whether flattening tests are required (Section 9 and Table 4),

4.2.3 Whether flare testing is required (Section 10),

4.2.4 Whether 7075-O material is required to develop requirements for T73 temper (12.3),

4.2.5 Whether testing for leaks is required and, when leaks are allowed, the number of leaks allowed and the manner of marking leaks (15.1.3.2),

4.2.6 Whether inside cleanness test is required on coiled tubes (16.2) and frequency of testing required,

4.2.7 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (Section 20),

4.2.8 Whether certification is required (Section 22),

4.2.9 Whether marking for identification is required (Section 23), and

4.2.10 Whether Practices B 660 applies, and if so, the levels of preservation, packaging, and packing required (Section 24).

#### 5. Materials and Manufacture

5.1 The tube shall be produced by drawing an extruded tube made from hollow extrusion ingot (cast in hollow form or pierced) and extruded by the use of the die and mandrel method.

5.2 The ends of coiled tube shall be crimped or otherwise sealed to avoid contamination during shipment.

#### 6. Responsibility for Quality Assurance

6.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser in the order or at the time of signing the contract. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

6.2 *Lot Definition*—An inspection lot shall be defined as follows:

6.2.1 For heat-treated tempers an inspection lot shall consist of an identifiable quantity of material of the same mill form, alloy, temper, and nominal dimensions traceable to a heat-treat lot or lots, and subjected to inspection at one time.

6.2.2 For nonheat-treated tempers, an inspection lot shall consist of an identifiable quantity of material of the same mill form, alloy, temper, and nominal dimensions subjected to inspection at one time.

#### 7. Chemical Composition

7.1 *Limits*—The tubes shall conform to the chemical composition limits prescribed in Table 2. Conformance shall be determined by the producer by analyzing samples taken at the time the ingots are poured, or samples taken from the finished or semi-finished product. If the producer has determined the chemical composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product.

NOTE 3—It is standard practice in the United States aluminum industry to determine conformance to the chemical composition limits prior to further processing of ingots into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

7.2 *Number of Samples*—The number of samples taken for determination of chemical composition shall be as follows:

**TABLE 4 Minimum Outside Diameter Flattening Factor**

| Alloy | Temper | Wall Thickness, in. | Minimum Diameter Flattening Factor, $F$ |   |
|-------|--------|---------------------|---|---|
| 1100  | O      | 0.014–0.500         | 2                                       |   |
|       | H12    | 0.014–0.500         | 3                                       |   |
|       | H14    | 0.014–0.500         | 6                                       |   |
|       | H16    | 0.014–0.500         | 8                                       |   |
| 3003  | O      | 0.025–0.500         | 2                                       |   |
|       | H12    | 0.025–0.500         | 3                                       |   |
|       | H14    | 0.025–0.500         | 6                                       |   |
|       | H16    | 0.025–0.500         | 8                                       |   |
| 2024  | O      | 0.018–0.049         | 3                                       |   |
|       |        | 0.050–0.500         | 4                                       |   |
|       | T3     | 0.018–0.500         | 8                                       |   |
| 5052  | O      | 0.010–0.450         | 3                                       |   |
|       | H32    | 0.010–0.450         | 6                                       |   |
|       | H34    | 0.010–0.450         | 8                                       |   |
| 5086  | O      | 0.010–0.450         | 3                                       |   |
|       | H32    | 0.010–0.450         | 8                                       |   |
| 6061  | O      | 0.018–0.120         | 3                                       |   |
|       |        | 0.121–0.238         | 4                                       |   |
|       |        | 0.239–0.500         | 6                                       |   |
|       | T4     | 0.025–0.500         | 6                                       |   |
|       |        | T6                  | 0.025–0.500                             | 8 |
|       |        |                     |   |   |
| 7075  | O      | 0.025–0.049         | 4                                       |   |
|       |        | 0.050–0.259         | 5                                       |   |
|       |        | 0.025–0.259         | 10                                      |   |