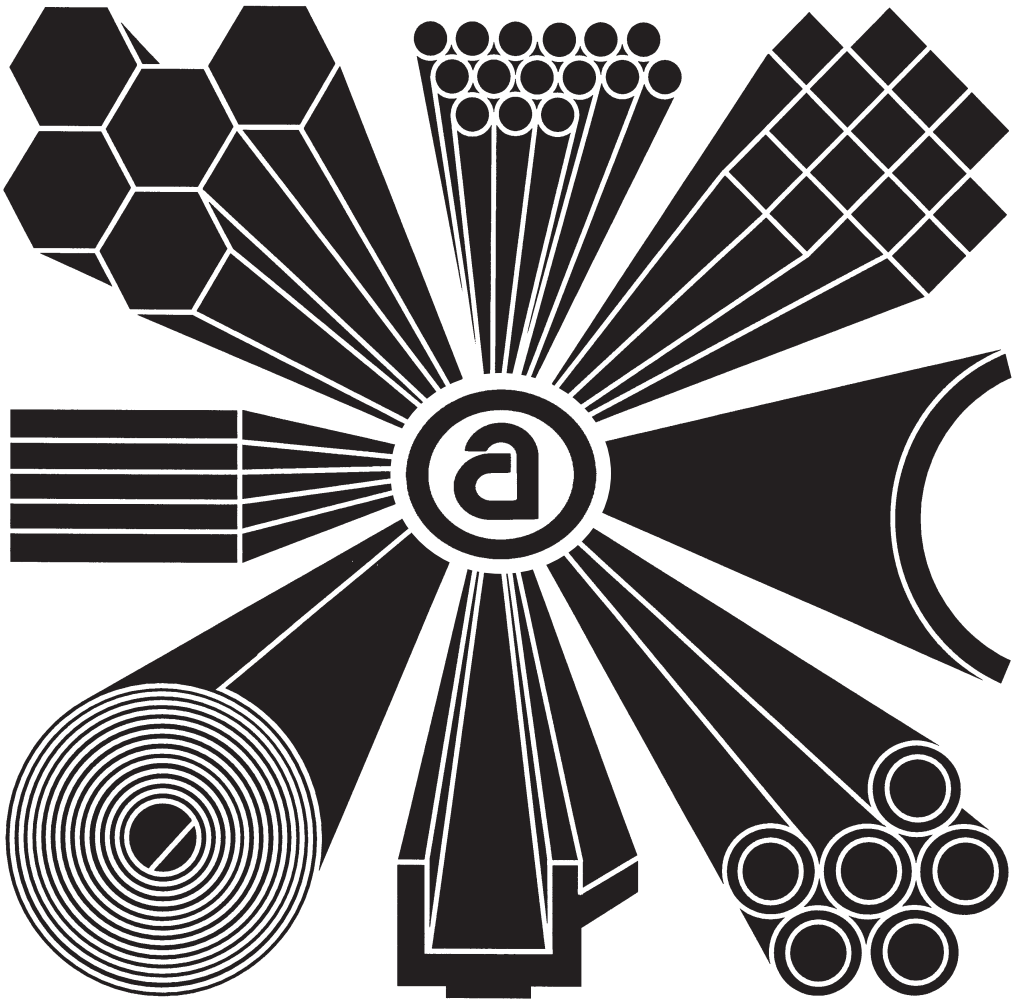
# Aluminum Standards and Data 2024



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Acknowledgement

This edition of *Aluminum Standards and Data* is the product of the efforts of the Aluminum Association Technical Committee on Product Standards, whose members are listed below.

The Aluminum Association Technical Committee on Product Standards

Jerome Fourmann, Rio Tinto, Chair
Peter Bittner, Constellium, Vice Chair
Kevin Anderson, Mercury Marine
Thomas Belliveau, Novelis
David Betz, Hydro
Steven Claves, Arconic
Andrea Collazo, Commonwealth Rolled Products
Tim Fargo, Kaiser Aluminum
Olivier Gabis, Wagstaff
Louis Gendreau, Alcoa
Ruben Hernandez, Ellwood Aluminum
Gary Jones, Ilsco Extrusions
Roy Nash, Novelis
Mike Niedzinski, Constellium
Paul Rometsch, Rio Tinto
Jason Scheuring, Kaiser Aluminum
Annie Song, Universal Alloy Corporation
Mark Timko, Weber Metals
Helen Weykamp, Hydro
Albert Wills, Hydro
Sam Muhamed, The Aluminum Association
John Newman, The Aluminum Association
Debra Weston, The Aluminum Association

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Inquiries

Technical inquiries to obtain an interpretation or request a revision to *Aluminum Standards and Data Metric (SI)* should be directed to:

The Standards Department
Standards@aluminum.org
The Aluminum Association
1400 Crystal Dr. Suite 430
Arlington, VA 22202
www.aluminum.org

Inquiries should include the inquirer's name, affiliation, and address.

Requests for interpretations should be phrased, where possible, to permit a "yes" or "no" answer and include the necessary background information, including figures where appropriate.

Requests for revisions should include proposed wording for the revision and technical justification.

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# Contents


1. GENERAL INFORMATION
- Characteristics . . . 1–1
- Alloy and temper designations . . . 1–3
- Metallurgical aspects . . . 1-13
- Nominal chemical compositions . . . 1-15
- AA wrought alloys and similar foreign alloys . . . 1-17
- Specification cross reference . . . 1-19
- Mill product specifications . . . 1-25

2. TYPICAL PROPERTIES
- Typical mechanical properties . . . 2–1
- Typical tensile properties at various temperatures . . . 2–6
- Typical physical properties . . . 2–11
- Density calculation procedure . . . 2–13
- Nominal densities . . . 2–15

3. APPLICATION AND FABRICATION
- Wrought alloy products and tempers . . . 3–1
- Specialty mill products . . . 3–8
- Comparative characteristics and applications . . . 3–9
- Typical heat treatments . . . 3–14
- Typical annealing treatments . . . 3–20

4. QUALITY CONTROL
- Sampling and testing . . . 4–1
- Tension testing of foil . . . 4–4
- Visual inspection . . . 4–5
- Ultrasonic inspection . . . 4–6
- Identification marking . . . 4–7
- Rivet identification markings . . . 4–12
- Color code . . . 4–13
- Handling and storing aluminum . . . 4–14
- Protective oil . . . 4–14
- Certification documentation . . . 4–15
- Appendix 1–Test specimen location . . . 4–16
- Appendix 2–Tolerances . . . 4–18

5. TERMINOLOGY . . . 5–1

6. STANDARDS SECTION
- Limits . . . 6–1
- Components of clad products . . . 6–4
- Chemical composition limits . . . 6–5
- Ultrasonic discontinuity limits . . . 6–7
- Acceptance criteria for corrosion . . . 6-9
- Location for electrical conductivity measurements . . . 6-11
- Fracture toughness limits . . . 6-11
- Corrosion test criteria . . . 6-12

7. SHEET AND PLATE
- Introduction . . . 7–1
- Mechanical property limits
- Non-heat-treatable alloys . . . 7–3
- Heat-treatable alloys . . . 7–12
- Brazing sheet . . . 7–22
- Weights per square foot . . . 7–23
- Weight conversion factors . . . 7–24
- Recommended bend radii for 90-degree cold bend . . . 7–24
- Tolerances . . . 7–26
- Painted sheet . . . 7–31
- Commercial roofing and siding . . . 7–34
- Duct sheet . . . 7–36
- Tread plate . . . 7–37

8. FIN STOCK
- Introduction . . . 8–1
- Mechanical property limits . . . 8–2
- Tolerances . . . 8–2

9. FOIL
- Introduction . . . 9–1
- Unmounted . . . 9–2
- Laminated . . . 9–3
- Printed . . . 9–4

10. WIRE, ROD AND BAR—ROLLED OR COLD FINISHED
- Introduction . . . 10–1
- Mechanical property limits
- Non-heat-treatable alloys . . . 10–3
- Heat-treatable alloys . . . 10–5
- Rivet and cold heading wire and rod . . . 10–6
- Computation of weight per foot . . . 10–6
- Tolerances . . . 10–7

11. WIRE, ROD, BAR AND PROFILES—EXTRUDED
- Introduction . . . 11–1
- Mechanical property limits . . . 11–2
- Tolerances . . . 11–6

12. TUBE AND PIPE
- Introduction . . . 12–1
- Extruded tube
- Mechanical property limits . . . 12–3
- Tolerances . . . 12–6
- Extruded coiled tube
- Mechanical property limits . . . 12–11
- Tolerances . . . 12–11
- Drawn tube
- Mechanical property limits . . . 12–12
- Tolerances . . . 12–15
- Heat-exchanger tube . . . 12–19
- Welded tube . . . 12–21
- Pipe
- Mechanical property limits . . . 12–23
- Tolerances . . . 12–23
- Diameters, wall thicknesses, weights . . . 12–24
- Rigid electrical conduit . . . 12–26

13. STRUCTURAL PROFILES
Introduction . . . . . 13–1
Mechanical property limits . . . . . 13–3
Aluminum Association channels and I-beams. . . . . 13–4
American standard profiles . . . . . 13–5

14. FORGING STOCK
Introduction . . . . . 14–1
Mechanical property limits . . . . . 14–1
Tolerances . . . . . 14–2

15. FORGINGS
Introduction . . . . . 15–1
Die forgings
Mechanical property limits . . . . . 15–2
Hand forgings
Mechanical property limits . . . . . 15–3
Tolerances . . . . . 15–6
Rolled rings
Mechanical property limits . . . . . 15–6

16. ELECTRIC CONDUCTORS
Introduction . . . . . 16–1
Mechanical and physical property limits . . . . . 16–3
Equivalent resistivity values. . . . . 16–5
Bend properties of bus bar . . . . . 16–6
Tolerances . . . . . 16–7

INDEX . . . . . 17–1

# Abbreviations Used in This Manual

| | |
|---|---|
| ACSR | aluminum cable steel reinforced |
| BHN | Brinell hardness number |
| Btu | British thermal unit |
| cu | cubic |
| diam, D | diameter |
| dim | dimension |
| °F | degree Fahrenheit |
| ft | foot |
| g | grams |
| hr | hour |
| kg | kilograms |
| IACS | International Annealed Copper Standard |
| ID | inside diameter |
| in | inch |
| klb | thousand pounds |
| ksi | thousand pounds per square inch or kips per square inch |
| lb | pound |
| max | maximum |
| MHz | megahertz |
| m | meter |
| mil | circular mil = 0.001 in. |
| min | minimum |
| mm | millimeter |
| OD | outside diameter |
| psi | pounds per square inch |
| sq | square |

Other uses of single and combined letters (A, B, D, Y, AA, etc.) can be found in this publication. They represent linear measurements, radii, angles, and so forth, as shown on diagrams, formulas, and so on, contained in tables and shown as specific to that table.

# Introduction

This manual contains useful information and data pertaining to chemical composition limits, mechanical and physical properties, tolerances and other characteristics of various aluminum and aluminum alloy wrought products. The content of the manual is subject to periodic revision to keep abreast of advances in production methods, to add data on new alloys and products, and to delete those that become inactive or whose usage becomes limited.

The criteria for adding or deleting alloy-tempers:

1. The alloy shall have been registered in accordance with the rules shown in the foreword to the "Registration Record of Aluminum Association Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys."
2. The temper shall have been registered as in accordance with the rules shown in the registration listing, "Tempers for Aluminum and Aluminum Alloy Products."
3. Entries shall be available for inclusion in all tables in Sections 1, 2, 3, 4, 6 and the applicable tolerance tables, unless the Technical Committee on Product Standards of The Aluminum Association considers some of the entries unnecessary or inappropriate.
4. Alloy-tempers shall be deleted when they become inactive or when their usage becomes limited.
5. All inclusions in or removals from ASD shall have been approved by formal ballot of the Technical Committee on Product Standards of The Aluminum Association.

Complete revision of the manual is customarily accomplished on a triennial basis. Important changes, additions or deletions that occur between issues are recorded in Addenda that may be published at appropriate intervals. Individual suppliers should be contacted for information concerning effectivity of changes included in the Addenda. This edition supersedes all previous editions and Addenda.

Conversion from Metric (SI) units in Aluminum Standards and Data to U.S. Customary units in this document follows procedures listed in The Aluminum Association publication "Tempers for Aluminum and Aluminum Alloy Products" (Yellow Sheets), APPENDIX A, titled "Guidelines for Transitioning Metric (SI) units into U.S. Customary units".

Cautionary note: Multiple conversions between U.S. Customary units and Metric (SI) units (and vice versa) should be avoided because significant errors may result.

To minimize confusion it is suggested that purchasers enter orders either in U.S. Customary or in Metric (SI) and to avoid entering orders containing items in both systems.

The first three sections of the manual (blue pages) contain information of a general nature that may be useful in comparing materials. The typical properties and characteristics listed are not guaranteed and should not be used for design purposes. The fourth section (blue pages) contains information relating to testing, inspection and identification and the fifth section (yellow pages) lists the definitions of many terms used in the wrought aluminum industry. The remaining twelve sections (white pages) comprise chemical composition limits, mechanical property limits, dimensional tolerances and other data classified by product form.

Since a completely Metric (SI) version is now available, the only metric values shown are those that have been customarily used.

Several typographical errors have been corrected from the previous edition. Changes are indicated by highlights in the text. These revisions are summarized chronologically on the following pages:

| Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data | | |
|---|---|---|
| DATE | PAGE (TABLE/PARAGRAPH) | DESCRIPTION OF CHANGE |
| 23-12-04 | 3-20 (3.5) | Alloys 2014, 2017, 2024, 2117, 2219, 3005, 6005, 6005A, 6053, 6060, 6061, 6063, 6066, 6082, 6360, 7075, 7175 and 7475: Change metal temperature from 775° to 760°F |
| 23-12-04 | 3-19 (3.4) | Change footnote 38 second of two-stage treatment from 6-8 hours at 355° F to 6-12 hours at 350° F |
| 23-12-04 | 3-19 (3.4) | Change footnote 37 second of two-stage treatment from 8-10 hours at 345° F to 8-12 hours at 350° F |
| 23-12-04 | 3-19 (3.4) | Change footnote 36 second of two-stage treatment from 10-14 hours at 345° F to 12-15 hours at 350° F |
| 23-12-04 | 3-19 (3.4) | Replace footnote 35 with: "Held at room temperature for a minimum of 48 hours, followed by a two-stage treatment comprised of 24 hours at 250° F, followed by 10-16 hours at 340° F to obtain T73 or by 8-12 hours at 330° F to obtain T7352." |
| 23-12-04 | 3-19 (3.4) | Replace footnote 34 with: "A two-staged treatment comprised of 3-6 hours at 250° F followed by 6-10 hours at 350° F ." |
| 23-12-04 | 3-19 (3.4) | Change footnote 33 temperature of second of two-stage treatment from 320° F to 325° F |
| 23-12-04 | 3-19 (3.4) | Change footnote 32 temperature of second of two-stage treatment from 330° F to 325° F |
| 23-12-04 | 3-19 (3.4) | Change footnote 31 temperature of second of two-stage treatment from 330° F to 325° F |
| 23-12-04 | 3-19 (3.4) | Change footnote 28 thours of first of two-stage treatment from 3-30 hours to 3-5 hours |
| 23-12-04 | 3-19 (3.4) | Remove entire footnote 23 and its references |
| 23-12-04 | 3-19 (3.4) | 7475-T62 Rod: Change PHT temp footnote from 47 to 46 and time footnote from 47 to 46 |
| 23-12-04 | 3-19 (3.4) | 7475-T761 Sheet: Change PHT temp footnote from 46 to 45 and time footnote from 46 to 45 |
| 23-12-04 | 3-19 (3.4) | 7475-T61 Sheet: Change PHT temp footnote from 45 to 44 and time footnote from 45 to 44 |
| 23-12-04 | 3-17 (3.4) | 6262-T9 Rolled or cold finished wire, rod and bar: Change PHT time from 12 hrs |
| 23-12-04 | 3-16 (3.4) | 6061 Rolled or cold finished wire, rod and bar: Add missing row for SHT 990° F to obtain T4 and PHT 320° F ⑬ for 18 hours to obtain T94⑭ |
| 23-12-04 | 3-15 (3.4) | 6053-T4 Rolled or cold finished wire and rod: Change SHT temp from 945° F to 970° F |
| 23-12-04 | 3-15 (3.4) | 2219-T62 Flat sheet: Change PHT time from 36 hrs to 18 hrs |
| 23-12-04 | 3-15 (3.4) | 2025-T6 Die forgings: Change PHT 240° F for 10 hrs to 350° F for 9 hrs |
| 23-12-04 | 3-15 (3.4) | 2024 Drawn tube: Add PHT 375° F for 12 hrs to obtain T8 |
| 23-12-04 | 3-14 (3.4) | 2014-T6, T652 Hand forgings and rolled rings: Change PHT 340° F for 10 hrs to 350° F for 9 hrs |
| 23-12-04 | 3-14 (3.4) | 2011-T8 Drawn Tube: Change PHT temp from 310° F to 320° F |
| 23-12-04 | 3-12 (3.3) | Add "Aircraft forgings" to 7175-T74, T7452, T7454 applications |
| 23-12-04 | 3-12 (3.3) | Add "Brazing, honecomb panels" to 6951-T42, T62 applications |
| 23-12-04 | 3-7 (3.1) | Add T74 and T7452 tempers to 7075 Forgings and Forging Stock |
| 23-12-04 | 3-7 (3.1) | Add F temper to 7072 Sheet |
| 23-12-04 | 3-7 (3.1) | Add T7454 temper to 7050 Forgings and Forging Stock |
| 23-12-04 | 3-7 (3.1) | Move footnote 4 earmarking to alloy column to apply to all |
| 23-12-04 | 4-20 | Replace text references to Chapter 11 |
| 23-12-04 | 11-7 | Add image to Open Space Dimensions |
| 23-12-04 | 11-8 (11.2) | Modify footnote 8 |
| 23-12-04 | 12-1 | Modify contents |
| 23-12-04 | 12-3 (12.1) | Modify table heading |
| 23-12-04 | 12-4 (12.1) | Modify table heading |
| 23-12-04 | 12-5 (12.1) | Modify table heading |
| 23-12-04 | 12-5 (12.1) | Add footnote 9 |
| 23-12-04 | 12-12 (12.19) | Modify table heading |
| 23-12-04 | 12-13 (12.19) | Modify table heading |
| 23-12-04 | 12-14 (12.19) | Modify table heading |
| 23-12-04 | 12-14 (12.19) | Add footnote 12 |

| Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data | | |
|---|---|---|
| DATE | PAGE (TABLE/PARAGRAPH) | DESCRIPTION OF CHANGE |
| 23-12-04 | 12-22 (12.48) | Replace table with references to Tables 12.1 and 12.19 |
| 22-12-06 | 1-4, 1-5, (2.2, 3) | Added deletion of impurities to modification and variation criteria |
| 22-12-06 | 11-6 (11.2) | Modified column 4 title and footnote 8 location |
| 22-12-06 | 11-8 (11.2) | Modified footnote 6 |
| 22-12-06 | 12-8 (12.9), 12-9 | Added footnote 20 |
| 22-12-06 | 1-6 (3.2.1) | Added xxx.2 ingot casting recommendations |
| 22-12-06 | 5-3, 5-10, 5-25 | Added terminology definitions for bending, fracture and yield |
| 22-12-06 | 12-9 | Modified footnote 7 |
| 22-12-06 | 7-26 (7.7a, b), 7-27 (7.10), 7-28 (7.33), 7-30 (7.18) | Updated plate tolerances for thickness > 8 in. |
| 22-12-06 | 1-8 (5) | Added powder alloy designation system information |
| 20-04-30 | 12-4 (12.1) | Added Alloy/Temper "6060" |
| 20-04-30 | 11-3 (11.1) | Added Alloy/Temper "6060" |
| 20-04-30 | 6-6 (6.2) | Added Alloy "6060" |
| 20-04-30 | 4-13 | Added Alloy 6060 and Color Code Brown/Gray |
| 20-04-30 | 3-20 (3.5) | Added Alloy "6060" |
| 20-04-30 | 3-15 (3.4) | Added Alloy "6060" |
| 20-04-30 | 3-11 (3.3) | Added Alloy/Temper "6060" |
| 20-04-30 | 3-5 (3.1) | Added Alloy "6060" |
| 20-04-30 | 2-15 (2.4) | Added Alloy "6060" |
| 20-04-30 | 2-12 (2.3) | Added Alloy "6060" |
| 20-04-30 | 2-9 (2.2) | Added Alloy/Temper "6060" |
| 20-04-30 | 2-4 (2.1) | Added Alloy/Temper "6060" |
| 20-04-30 | 1-20 (1.3) | Added "B221M" to Alloy "6060" |
| 20-04-30 | 1-14 (1.1) | Added Alloy "6060" |
| 20-06-24 | 7-17 (7.2) | Extend gauge range of 6061-T651 Plate up to 12.000 inch range |
| 20-02-06 | 11-6 (11.2) | Corrected Cross-Sectional Dimension Tolerances-Profiles for the following: 0.112 -vs- 0.122; 0.180 -vs- 1.800; 0.119 -vs- 1.188 |
| 20-01-02 | 7-29 (7.17) | Change table header title |
| 20-01-02 | 7-29 | Footnote (2) "Inactive" |
| 20-01-02 | 7-29 | Change FN3 definition |
| 20-01-02 | 7-29 | Replace FN 4 with new footnote |
| 19-10-11 | 11-3 | 6082-T6 T6511 Yield Strength to 35.0 -vs- 38.0 |
| 19-02-09 | 12-23 | Replace FN 3 with new footnote |
| 19-02-09 | 12-23 (12.53) | Delete "(D) MAX" from illustration |
| 19-02-09 | 12-23 (12.53) | Add FN 4 to "Allowable. . . Straight |
| 19-02-09 | 12-23 (12.53) | Add "(D)" to "Allowable. . . Straight" |
| 19-02-09 | 12-23 (12.53) | Delete FN 4 |
| 19-02-09 | 12-22 (12.45) | Replace FN 3 with new footnote |
| 19-02-09 | 12-22 (12.45) | Delete "(D) MAX" from illustration |
| 19-02-09 | 12-22 (12.45) | Add FN 3 to "Allowable. . . Straight" |
| 19-02-09 | 12-22 (12.45) | Add "(D)" to "Allowable. . . Straight" |
| 19-02-09 | 12-22 (12.45) | Delete FN 1 from "Tolerance" |
| 19-02-09 | 12-20 (12.38) | Delete "(D) MAX" from illustration |
| 19-02-09 | 12-20 (12.38) | Add FN 3 to "Allowable. . . Straight" |
| 19-02-09 | 12-20 (12.38) | Add "(D)" to "Allowable. . . Straight" |

| Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data | | |
|---|---|---|
| DATE | PAGE (TABLE/PARAGRAPH) | DESCRIPTION OF CHANGE |
| 19-02-09 | 12-20 (12.38) | Delete FN 3 from "Tolerance" |
| 19-02-09 | 12-20 | Replace FN 3 with new footnote |
| 19-02-09 | 12-18 | Add new FN 5 |
| 19-02-09 | 12-17 (12.25) | Add FN 5 to "Allowable. . . Straight" |
| 19-02-09 | 12-17 (12.25) | Delete "(D) MAX" from illustration |
| 19-02-09 | 12-17 (12.25) | Add "(D)" to "Allowable. . . Straight" |
| 19-02-09 | 12-17 (12.25) | Change FN1 to FN 2 |
| 19-02-09 | 12-9 | Replace FN 19 with new footnote |
| 18-01-20 | 11-6 (11.2) | Corrected Specified DUPLICATE Dimension in. from 0.125-0.249 to 0.250-0.499 |
| 19-02-09 | 12-8 (12.8) | Delete FN 9 "Tolerance" |
| 19-02-09 | 11-10 (11.6) | FN 9, replace with new footnote |
| 19-02-09 | 11-10 (11.6) | Add "Allowable Deviation (D). . . Straight" to illustration |
| 19-02-09 | 11-10 (11.6) | Delete FN 3 from "Tolerance" |
| 19-02-09 | 10-9 (10.16) | FN 1, replace with new footnote |
| 19-02-09 | 10-9 (10.16) | Add FN 1 to "Allowable . . . . . Straight" |
| 19-02-09 | 10-9 (10.16) | Delete FN 1 from "Tolerance" |
| 19-02-09 | 10-9 (10.15) | Add FN 1 to "Allowable . . . . . Straight" |
| 19-02-09 | 10-9 (10.15) | Delete FN 1 from "Tolerance" |
| 19-02-26 | 17-3 (Index) | Upder "Pipe, Definition of"  "Ecectrical Conductors" Changed page numbers |
| 19-02-26 | 16-1 | Under Electrical Conductors, added Table 16.31 Tube, Pipe, Rigid Electrical Conduit |
| 19-02-26 | 16-1 | Under Electrical Conductors, Added definition for "Electrical Conductor Tube and Pipe" |
| 19-02-26 | 16-1 | Under Electrical Conductors, added Table 16.30 Structual Profiles |
| 19-02-26 | 16-1 | Under Electrical Conductors, Change to definition to "Electrical Conductors Structural Profiles" |
| 19-02-26 | 16-1 | Under Electrical Conductors, Deleted Table information for "Pipe" |
| 19-02-25 | 16-10 (16.29) | Corrections to "Radius Tolerance" |
| 19-02-25 | 11-6 (11.2) | Corrections to Columns 7 (0.180  -vs- 1.800) |
| 19-02-25 | 11-6 (11.2) | Corrections to Columns 7 (0.119  -vs- 1.188) |
| 19-02-25 | 11-6 (11.2) | Corrections to Column 9 (0.112 -vs- 0.122) |
| 18-11-14 | 12-2 | Added information to table of contents under "Pipe" |
| 18-11-14 | 12-9 (12.10) | Added "Extruded Pipe" to Table 12.10 header |
| 18-11-14 | 12-9 (12.13) | Added "Extruded Pipe" to Table 12.13 header |
| 18-11-14 | 12-18 (12.29) | Added "Drawn Pipe" to Table 12.29 header |
| 18-11-14 | 12-18 (12.31) | Added "Drawn Pipe" to Table 12.31 header |
| 18-11-14 | 17-3 (Index) | Under "Pipe" added definition under "Diameter . . . . . " |
| 18-11-12 | 5-14 | Change to definition for "Mean Diameter" |
| 18-11-12 | 12-9 (Footnotes) | Change to definition to footnote 3 "Mean Diameter" |
| 18-11-12 | 12-15 (Footnotes) | Change to definition to footnote 3 "Mean Diameter" |
| 18-11-12 | 12-23 (Footnotes) | Change to definition to footnote 2 "Mean Diameter" |
| 18-11-05 | 4-13 | Add Color Code for Alloy 6361 "Lime and Blue" |
| 18-10-17 | 7-34 (7.23) | Correction to Nominal Pitch of Corrugation in. DIM C. from "5 1/8" to "5 1/3" |
| 18-10-12 | 1-7 | Added Footnote 8 definition that was inadvertenly missing |
| 18-06-19 | 1-9 | Definition change to the T_52 Temper |

| Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data | | |
|---|---|---|
| DATE | PAGE (TABLE/PARAGRAPH) | DESCRIPTION OF CHANGE |
| 18-06-19 | 12-24 (12.55) | Change to Table |
| 18-06-19 | 12-25 (12.55) | Change to Table |
| 18-06-12 | 12-22 (12.45) | Add "Temper" and add "All except O, TX510" |
| 18-06-12 | 13-4 (13.3) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-4 (13.4) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-5 (13.5) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-6 (13.6) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-7 (13.7) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-8 (13.8) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-8 (13.9) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-8 (13.10) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-9 (13.11) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-9 (13.12) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-9 (13.13) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-06-12 | 13-9 (13.13) | Added Footnote "2" to "WEIGHT/FOOT" |
| 18-03-26 | 7-13 (7.2) | Changed Specified Thickness fo Alclad 2024-O to 0.500-1.000 |
| 18-03-26 | 7-13 (7.2) | Deleted Specified Thickness for Alclad 2024-T351 (1.001-4.000) |
| 18-03-26 | 7-13 (7.2) | Deleted Specified Thickness for Alclad 2024-T42 (1.001-3.000) |
| 18-03-26 | 7-14 (7.2) | Changed Specified Thickness for 1 1/2 % Alclad 2024-O to 0.500-1.000 |
| 18-03-26 | 7-14 (7.2) | Deleted Specified Thickness for 1 1/2 % Alclad 2024-T351 (1.001-4.000) |
| 18-03-26 | 7-14 (7.2) | Deleted Specified Thickness for 1 1/2 % Alclad 2024-T42 (1.001-3.000) |
| 18-01-20 | 3-17 (3.4) | Corrected Temper Designation for 6560 from T5 to T6 |
| 18-01-20 | 11-6 (11.2) | Corrected Dimensioned Points from 0.250-0.642 to 0.250-0.624 |
| 18-06-12 | 12-24 (12.55) | Change column header to "WEIGHT/FOOT" and "lb/ft" |
| 18-01-20 | 11-10 (11.5) | Deleted "and minus" from heading: Tolerance - in. to read TOLERANCE - in. plus |
| 18-01-20 | 4-13 | Added color code for Alloy 7255 to the "Summary Page" |
| 18-01-20 | 4-13 | Added color codes Cyan and Lime to the "Summary Page" |
| 18-01-20 | 11-4 | Added Mechanical Property Limits for 6560-T5 and 6050-T6 to the "Summary Page" |
| 18-01-04 | 6-10 (6.5) | Corrected "7050-T74" -vs- "7050-T744" |

# 1. General Information

A unique combination of properties makes aluminum one of our most versatile engineering and construction materials. A mere recital of its characteristics is impressive. It is light in mass, yet some of its alloys have strengths greater than that of structural steel. It has high resistance to corrosion under the majority of service conditions, and no colored salts are formed to stain adjacent surfaces or discolor products with which it comes into contact, such as fabrics in the textile industry and solutions in chemical equipment. It has no toxic reaction. It has good electrical and thermal conductivities and high reflectivity to both heat and light. The metal can easily be worked into any form and readily accepts a wide variety of surface finishes.

Lightness is one of aluminum's most useful characteristics. The specific gravity is about 2.7. The mass ("weight") of aluminum is roughly 35 percent that of iron and 30 percent that of copper.

Commercially pure aluminum has a tensile strength of about 13,000 pounds per square inch. Thus its usefulness as a structural material in this form is somewhat limited. By working the metal, as by cold rolling, its strength can be approximately doubled. Much larger increases in strength can be obtained by alloying aluminum with small percentages of one or more other elements such as manganese, silicon, copper, magnesium or zinc. Like pure aluminum, the alloys are also made stronger by cold working. Some of the alloys are further strengthened and hardened by heat treatments so that today aluminum alloys having tensile strengths approaching 100,000 pounds per square inch are available.

A wide variety of mechanical characteristics, or tempers, is available in aluminum alloys through various combinations of cold work and heat treatment. In specifying the temper for any given product, the fabricating process and the amount of cold work to which it will subject the metal should be kept in mind. In other words, the temper specified should be such that the amount of cold work the metal will receive during fabrication will develop the desired characteristics in the finished products.

Aluminum and its alloys lose part of their strength at elevated temperatures, although some alloys retain good strength at temperatures from 400˚F to 500˚F. At subzero temperatures, however, their strength increases without loss of ductility, so that aluminum is a particularly useful metal for low-temperature applications.

When aluminum surfaces are exposed to the atmosphere, a thin invisible oxide skin forms immediately, which protects the metal from further oxidation. This self-protecting characteristic gives aluminum its high resistance to corrosion. Unless exposed to some substance or condition that destroys this protective oxide coating, the metal remains fully protected against corrosion. Aluminum is highly resistant to weathering, even in industrial atmospheres that often corrode other metals. It is also corrosion resistant to many acids. Alkalis are among the few substances that attack the oxide skin and therefore are corrosive to aluminum. Although the metal can safely be used in the presence of certain mild alkalis with the aid of inhibitors, in general, direct contact with alkaline substances should be avoided.

Some alloys are less resistant to corrosion than others, particularly certain high-strength alloys. Such alloys in some forms can be effectively protected from the majority of corrosive influences, however, by cladding the exposed surface or surfaces with a thin layer of either pure aluminum or one of the more highly corrosion-resistant alloys.

A word of caution should be mentioned in connection with the corrosion-resistant characteristics of aluminum. Direct contacts with certain other metals should be avoided in the presence of an electrolyte; otherwise galvanic corrosion of the aluminum may take place in the vicinity of the contact area. Where other metals must be fastened to aluminum, the use of a bituminous paint coating or insulating tape is recommended.

The fact that aluminum is nontoxic was discovered in the early days of the industry. It is this characteristic that permits the metal to be used in cooking utensils without any harmful effect on the body, and today we find also a great deal of aluminum equipment in use by food processing industries. The same characteristic permits aluminum foil wrapping to be used safely in direct contact with food products.

Aluminum is one of the two common metals having an electrical conductivity high enough for use as an electric conductor. The conductivity of electric conductor grade (1350) is about 62 percent that of the International Annealed Copper Standard. Because aluminum has less than one-third the specific gravity of copper, however, a pound of aluminum will go about twice as far as a pound of copper when used for this purpose. Alloying lowers the conductivity somewhat, so that wherever possible alloy 1350 is used in electric conductor applications.

The high thermal conductivity of aluminum came prominently into play in the very first large-scale commercial application of the metal in cooking utensils. This characteristic is important wherever the transfer of thermal energy from one medium to another is involved, either heating or cooling. Thus aluminum heat exchangers are commonly used in the food, chemical, petroleum, aircraft and other industries. Aluminum is also an excellent reflector of radiant energy through the entire range of wavelengths, from ultraviolet, through the visible spectrum to infrared and heat waves, as well as electromagnetic waves of radio and radar.

Aluminum has a light reflectivity of over 80 percent, which has led to its wide use in lighting fixtures. Aluminum roofing reflects a high percentage of the sun's heat, so that buildings roofed with this material are cooler in summer.

The ease with which aluminum may be fabricated into any form is one of its most important assets. Often it can compete successfully with cheaper materials having a lower degree of workability. The metal can be cast by any method known to foundrymen; it can be rolled to any desired thickness down to foil thinner than paper; aluminum sheet can be stamped, drawn, spun or roll-formed. The metal also may be hammered or forged. Aluminum wire, drawn from rolled rod, may be stranded into cable of any desired size and type. There is almost no limit to the different profiles in which the metal may be extruded.

The ease and speed with which aluminum may be machined is one of the important factors contributing to the low cost of finished aluminum parts. The metal may be turned, milled, bored, or machined in other manners at the maximum speeds of which the majority of machines are capable. Another advantage of its flexible machining characteristics is that aluminum rod and bar may readily be employed in the high-speed manufacture of parts by automatic screw machines.

Almost any method of joining is applicable to aluminum: riveting, welding, brazing or soldering. A wide variety of mechanical aluminum fasteners simplifies the assembly of many products. Adhesive bonding of aluminum parts is widely employed, particularly in joining aircraft components.

For the majority of applications, aluminum needs no protective coating. Mechanical finishes such as polishing, sand blasting or wire brushing meet the majority of needs. In many instances, the surface finish supplied is entirely adequate without further finishing. Where the plain aluminum surface does not suffice, or where additional protection is required, any of a wide variety of surface finishes may be applied. Chemical, electrochemical and paint finishes are all used. Many colors are available in both chemical and electrochemical finishes. If paint, lacquer or enamel is used, any color possible with these finishes may be applied. Vitreous enamels have been developed for aluminum, and the metal may also be electroplated.

Aluminum sheet, because of its superior corrosion resistance and smooth continuous surface, is an excellent base for the high quality paints used in producing painted sheet. The chemical pretreatment plus the application of high quality thermally cured paint assures a finish that will exhibit no cracking, blistering, or peeling. Accidental damage to products made of painted aluminum sheet will not result in unsightly rust areas or streaks. Experience has shown that paint in the quality used for this product, properly formulated, applied and cured, will show little change in color or loss of gloss after one year's service in the adverse climatic conditions of south-central Florida. Highly industrialized areas may cause some color change due to atmospheric contaminants.

Proper maintenance can extend the service life considerably—even the finest automobiles require occasional washing and polishing if they are to retain their original appearance.

Even after many years of service most advantages of the painted sheet remain. It can be repainted with any good grade of house paint with no danger of cracking or peeling, such as is often experienced when paint is applied to other types of base materials.

Painted sheet and the products made from it should be handled with care to avoid damage to the paint film. Repair of large damaged areas is not recommended, but for repair of small areas air drying touch-up paint intended for brush application is available from paint suppliers. Your painted sheet supplier should be contacted for precise information. This touch-up paint cannot be expected to exhibit the same weathering and other characteristics as the original painted sheet, and touched-up areas will present appearance differences after weather exposure. For this reason, use of touch-up paint should be held to a minimum.

Many types of paint systems are used, and it is difficult to establish reasonable and meaningful standards for all of them. Specific applications require consideration of life expectancy, forming requirements and methods, economics, and so forth. Paint systems generally in use exhibit general characteristics as shown on pages 7–31 to 7–33, but for specific applications consult the painted sheet supplier.

These are the characteristics that give aluminum its extreme versatility. In the majority of applications, two or more of these characteristics come prominently into play—for example, light weight combined with strength in airplanes, railroad cars, trucks and other transportation equipment. High resistance to corrosion and high thermal conductivity are important in equipment for the chemical and petroleum industries; these properties combine with non-toxicity for food processing equipment.

Attractive appearance together with high resistance to weathering and low maintenance requirements have led to extensive use in buildings of all types. High reflectivity, excellent weathering characteristics, and light weight are all important in roofing materials. Light weight contributes to low handling and shipping costs, whatever the application.

Many applications require the extreme versatility that only aluminum has. Almost daily its unique combination of properties is being put to work in new ways. The metal now serves as a basic raw material for more than 20,000 businesses scattered throughout the country.