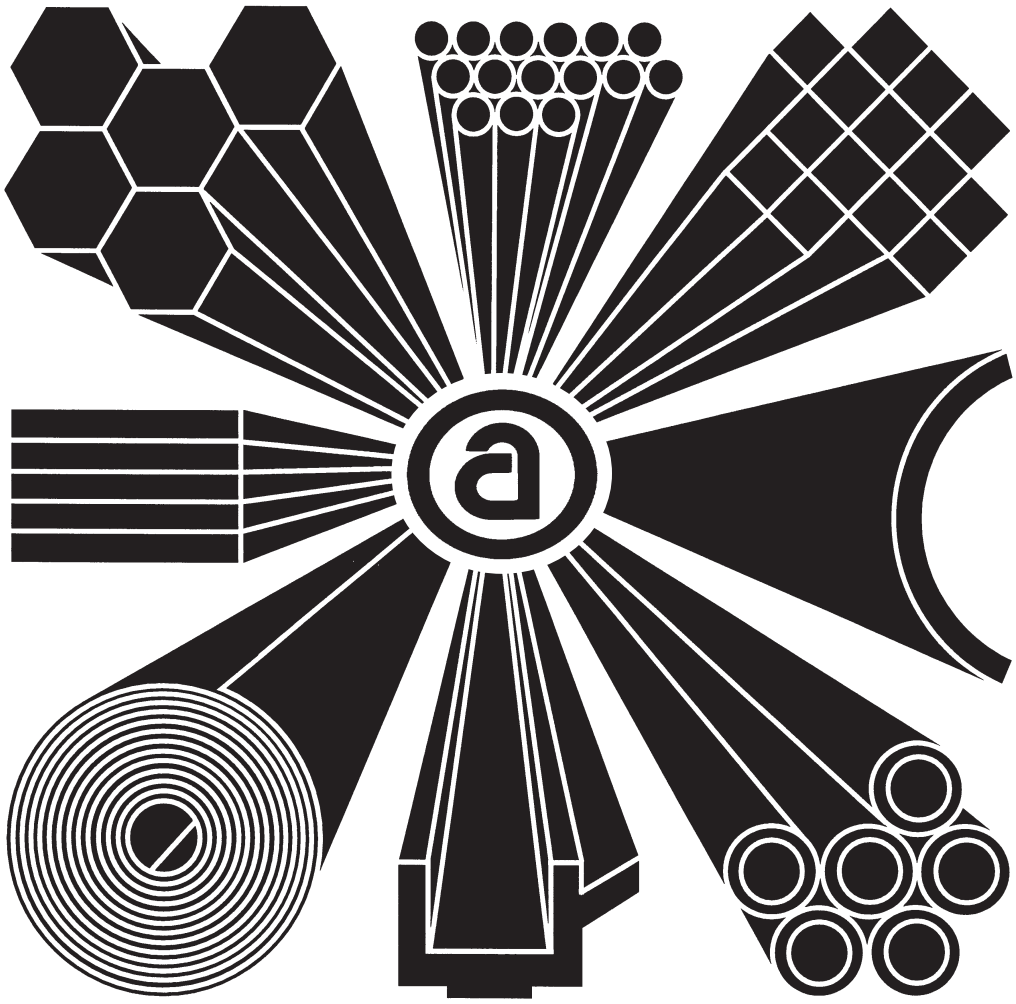
Aluminum Standards and Data 2024 Metric SI



© Copyright 2024, The Aluminum Association, Inc.
Unauthorized reproduction by photocopy or any other method is illegal.

About the Aluminum Association

The Aluminum Association represents U.S. and foreign-based companies and their suppliers throughout the value chain, from primary production to value added products to recycling. The Association is the industry's leading voice, providing global standards, business intelligence, sustainability research and industry expertise to member companies, policymakers and the general public. The aluminum industry helps manufacturers produce sustainable and innovative products, including more fuel efficient vehicles, recyclable packaging, greener buildings and modern electronics. In the U.S., the aluminum industry creates $176 billion in economic activity. For more information visit www.aluminum.org, on Twitter @AluminumNews or at Facebook.com/AluminumAssociation.

Acknowledgement

This edition of *Aluminum Standards and Data Metric (SI)* 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

Notice/Disclaimer

The data contained in this manual reflect a consensus of those substantially concerned with its development. The data are intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of the data does not in any respect preclude anyone, whether he has approved the data or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the data. Producers of goods made in conformity with the data contained herein are encouraged on their own responsibility to state in advertising, promotion material, or on tags or labels, that the goods are produced in conformity with the data contained herein, including any ANSI standards incorporated in the manual.

The use of any information contained herein by any member or non-member of The Aluminum Association is entirely voluntary. The Aluminum Association has used its best efforts in compiling the information contained in this book. While the Association believes that its compilation procedures are reliable, it does not warrant, either expressly or impliedly, the accuracy or completeness of this information, or that it is fit for any particular purpose. The Aluminum Association assumes no responsibility or liability for the use of the information herein.

Some of the registered alloys or tempers may be the subject of a U.S. patent or patent application, and their listing herein is not to be construed in any way as the granting of a license under such patent rights. The Aluminum Association provides information and resources about aluminum products and aluminum-related technology as a service to interested parties. Information provided by The Aluminum Association is generally intended for users with a technical background and may be inappropriate for use by laypersons.

All Aluminum Association published standards, data specifications and other technical materials, including this book, may be reviewed and revised, reaffirmed or withdrawn. Users are advised to contact The Aluminum Association to ascertain whether the information in this book has been superseded in the interim between publication and use.

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
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.

ISBN: 978-0-9863631-7-7 (Print)
978-0-9863631-9-1 (Digital)

Contents

1. GENERAL INFORMATION
Characteristics . . . 1–1
Alloy and temper designations . . . 1–3
Metallurgical aspects . . . 1–11
Nominal chemical compositions . . . 1–13
AA wrought alloys and similar foreign alloys . 1–15
Specification cross reference . . . 1–17
Mill product specifications . . . 1–23

2. TYPICAL PROPERTIES
Typical mechanical properties . . . 2–1
Typical tensile properties at various temperatures 2–5
Typical physical properties . . . 2–10
Density calculation procedure . . . 2–12
Nominal densities . . . 2–14

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 . . . 4–8
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 . . . 6–7
Location for electrical conductivity measurements . . . 6–10
Fracture toughness limits . . . 6–10
Corrosion test criteria . . . 6–11

7. SHEET AND PLATE
Introduction . . . 7–1
Mechanical property limits
Non-heat-treatable alloys . . . 7–3
Heat-treatable alloys . . . 7–13
Brazing sheet . . . 7–23
Weights per square foot . . . 7–24
Weight conversion factors . . . 7–25
Recommended bend radii for 90-degree cold bend . . 7–26
Tolerances . . . 7–27
Painted sheet . . . 7–32
Commercial roofing and siding . . . 7–35
Duct sheet . . . 7–37
Tread plate . . . 7–38

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 . . . 12–22
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 16–4
Bend properties of bus bar 16–5
Tolerances 16–6

INDEX 17–1

Abbreviations Used in This Manual

A	Cross-section area
BHN	Brinell hardness number
cm	centimetre
°C	degree Celsius
D	diameter
g	gram
hr	hour
IACS	International Annealed Copper Standard
ID	inside diameter
K	kelvin
kg	kilogram
kPa	kilopascal
m	metre
max	maximum
MHz	megahertz
MS/m	megasiemens per metre
min	minimum
mm	millimetre
MPa	megapascal
OD	outside diameter
s	second
S	Siemens
W	watt
°	degree (plane angle)

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 an Aluminum Association Technical Division (AATD) registration 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 which 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.

For most of this publication, the method of preparation has been to arrive at logical metric values for long-term metric use rather than to restate current U.S. Customary values in metric terms by use of conversion factors. The metric units in this publication are with few exceptions based on The International System of Units (SI). The values are recommended by The Aluminum Association Technical Committee on Product Standards for use in writing metric versions of current specification documents.

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

The SI system of units is a rationalized coherent system of units in which the seven basic units are:

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Luminous Intensity	candella	cd
Amount of Substance	mole	mol

Strength properties are shown in megapascals, for which the symbol is MPa. The derived SI unit for force is the newton (N), which is defined as that force which when applied to a body having a mass of one kilogram gives it an acceleration of one metre per second per second ($N = kgm/s^2$). The derived SI unit for pressure or stress is the newton per square metre (N/m^2), which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since 1 ksi = 6 894 757 Pa the metric equivalents are expressed as megapascal (MPa), which is the same as N/mm^2.

Several typographical errors have been corrected from the previous edition. Vertical bars have been inserted in the margins to help the reader identify technical revisions. These revisions are summarized chronologically on the following pages:

Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data (Metric SI)		
DATE	PAGE (TABLE/PARAGRAPH)	DESCRIPTION OF CHANGE
23-12-04	11-7	Add image to Open Space Dimensions
23-12-04	11-8 (11.2)	Modify footnote 8
23-12-04	4-20	Replace text with references to Chapter 11
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
23-12-04	12-22 (12.48)	Replace table with references to Tables 12.1 and 12.19
23-12-04	3-6 (3.1)	Move footnote 4 earmarking to alloy column to apply to all
23-12-04	3-6 (3.1)	Add T7454 temper to 7050 Forgings and Forging Stock
23-12-04	3-6 (3.1)	Add F temper to 7072 Sheet
23-12-04	3-7 (3.1)	Add T74 and T7452 tempers to 7075 Forgings and Forging Stock
23-12-04	3-11 (3.3)	Add missing tempers T51 and T61 to 6060
23-12-04	3-12 (3.3)	Add missing row for 6951-T42
23-12-04	3-12 (3.3)	Add "Aircraft forgings" to 7175-T74, T7452, T7454 applications
23-12-04	3-14 (3.4)	2011-T8 Drawn tube: Change SHT temp from 515^0C to 524^0C and PHT temp from 155^0C to 160^0C
23-12-04	3-14 (3.4)	2014-T6 Hand forgings and rolled rings: Change PHT from 170^0 for 10 hrs to 177^0 for 9 hrs
23-12-04	3-14 (3.4)	2018-T4 Die forgings: Change SHT temp from 570^0 C to 515^0 C
23-12-04	3-14 (3.4)	2025-T4 Die forgings: Change PHT from 170^0 C for 10 hrs to 177^0 C for 9 hrs
23-12-04	3-15 (3.4)	2218-T72 Die forgings: Change PHT temp from 460^0 C to 238^0 C
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)	2219-T87 Plate: Change PHT temp from 175^0 C to 163^0 C
23-12-04	3-15 (3.4)	2219-T6 Rolled or cold finished wire, rod and bar: Change PHT time from 36 hrs to 18 hrs
23-12-04	3-15 (3.4)	6053-T4 Rolled or cold finished wire and rod: Change SHT temp from 505^0 C to 520^0 C
23-12-04	3-15 (3.4)	6262-T9 Rolled or cold finished wire, rod and bar: Change PHT time 12 hrs to 8 hrs
23-12-04	3-19 (3.4)	Remove entire footnote 23 and its references
23-12-04	3-19 (3.4)	Change footnote 28 hours of first of two-stage treatment from 3-30 hours to 3-5 hours
23-12-04	3-19 (3.4)	Change footnote 32 temperature of first of two-stage treatment from 125 ^{0}C to 120^0 C
23-12-04	3-19 (3.4)	Change footnote 33 time of second of two-stage treatment from 18-22 hours to 15-18 hours
23-12-04	3-19 (3.4)	Replace footnote 34 with: "A two-stage treatment comprised of 3-6 hours at 120^0 C followed by 6-10 hours at 175^0 C."
23-12-04	3-19 (3.4)	Replace footnote 35 with: "Held at room temperature for a minumum of 48 hours, followed by a two-stage treatment comprised of 24 hours at 120^0 C, followed by 10-16 hours at 170^0 C to obtain T73 or by 8-12 hours at 165 C to 120^0 C to obtain T7352."

Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data (Metric SI)		
DATE	PAGE (TABLE/PARAGRAPH)	DESCRIPTION OF CHANGE
23-12-04	3-19 (3.4)	Change footnote 36 time of second of two-stage treatment from 10-14 hours to 12.15
23-12-04	3-19 (3.4)	Change footnote 37 second of two-stage treatment from 8-10 hours at 175^0 C to 8-12 hours at 170^0 C
23-12-04	3-19 (3.4)	Change footnote 41 temperature of first of two-stage treatment from 210^0 C to 120^0 C
23-12-04	3-20 (3.5)	Alloys 2014, 2017, 2024, 2117, 2219, 6005, 6005A, 6053, 6060, 6061, 6063, 6066, 6082, 6360, 7075, 7175 and 7475: Change metal temperature from 415^0 C to 404^0 C.
23-12-04	3-20 (3.5)	Alloy 3003: Change metal temperature from 415^0 C to 413^0 C
23-12-04	3-20 (3.5)	Alloy 3005: Change metal temperature from 415^0 C to 343^0 C
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	11-8	Corrected footnote 11
22-12-06	4-5	Corrected density formula
22-12-06	12-9	Modified footnote 7
22-12-06	7-27 (7.7a, b), 7-28 (7-10), 7-29(7.33), 7-31(7.18)	Updated plate tolerances for thicknesses > 200mm
22-12-06	7-18	7050-T7451 properties for thicknesses > 150mm
22-12-06	10-5	Updated 2014 data
22-12-06	1-8 (5)	Added powder alloy designation system information
	4-5	Correction to the Si Unit expression
21-01-06	7-19 (7.2)	7050-T7451 added properties up to 200.00mm Thickness
20-10-20	10-5 (10.2)	Corrected alignment for "2014" Alloy
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 "6060" to 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	2-14 (2.4)	Added Alloy "6060"
20-04-30	2-11 (2.3)	Added Alloy "6060"
20-04-30	2-8 (2.2)	Added Alloy/Temper "6060"
20-04-30	2-3 (2.1)	Added Alloy/Temper "6060"
20-04-30	1-20 (1.3)	Added "B221M"

Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data (Metric SI)		
DATE	PAGE (TABLE/PARAGRAPH)	DESCRIPTION OF CHANGE
20-04-30	2-3 (2.1)	Added Alloy/Temper "6060"
20-04-30	1-20 (1.3)	Added "B221M"
20-04-30	1-14 (1.2)	Added Alloy "6060"
20-06-24	7-17 (7.2)	Extend guage range of 6061-T651 Plate up to 12.000 inches
20-01-02	7-30	Footnote (2) "Inactive"
20-01-02	7-30	Changed footnote (3) definition
20-01-02	7-30	Replace FN 4 with new footnote
20-01-02	7-30 (7.17)	Change table header title
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"
19-02-09	12-23 (12.53)	Replace FN 4 with new footnote
19-02-09	12-23 (12.53)	Delete D(MAX) from "Allowable. . . length"
19-02-09	12-23 (12.53)	Add "(D)" to "Allowable. . . length"
19-02-09	12-23 (12.53)	Add FN 4 to "Allowable. . . length"
19-02-09	12-23 (12.53)	Delete D(MAX) from illustration
19-02-09	12-23 (12.53)	Delete FN 4 from "Tolerance"
19-02-09	12-22 (12.45)	Replace FN 3 with new footnote
19-02-09	12-22 (12.45)	Delete D(MAX) from "Allowable. . . length"
19-02-09	12-22 (12.45)	Add FN 3 to "Allowable. . . length"
19-02-09	12-20 (12.38)	Replace FN 3 with new footnote
19-02-09	12-22 (12.45)	Add "(D)" to "Allowable. . . length"
19-02-09	12-22 (12.45)	Delete D(MAX) from illustration
19-02-09	12-22 (12.45)	Delete FN 1 from "Tolerance"
19-02-09	12-20 (12.38)	Add "(D)" to "Allowable. . . length"
19-02-09	12-20 (12.38)	Add FN 5 to "Allowable. . . length"
19-02-09	12-20 (12.38)	Delete D(MAX) from illustration
19-02-09	12-20 (12.38)	Delete FN 5 from "Tolerance"
19-02-09	12-18	Add new FN 5
19-02-09	12-17 (12.25)	Delete D(MAX) from "Allowable. . . length"
19-02-09	12-17 (12.25)	Add "(D)" to "Allowable. . . length"
19-02-09	12-17 (12.25)	Add FN 5 to "Allowable. . . length"
19-02-09	12-17 (12.25)	Delete D(MAX) from illustration

Chronological Summary of Changes to the 2017 Edition of Aluminum Standards and Data (Metric SI)		
DATE	PAGE (TABLE/PARAGRAPH)	DESCRIPTION OF CHANGE
19-02-09	12-17 (12.25)	Delete "mm" from "Tolerance"
19-02-09	12-17 (12.25)	Delete FN 1 from "Tolerance"
19-02-09	12-9	Replace FN 19 with new footnote
19-02-09	12-8 (12.8)	Delete FN 9 from "Tolerance"
19-02-09	11-10 (11.6)	Replace FN 9 with new footnote
19-02-09	11-10 (11.6)	Delete FN 3 from "Tolerance"
19-02-09	10-9	Replace FN 1 with new footnote
19-02-09	10-9 (10.15)	Delete "(D) MAX" from illustration
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"
19-02-09	10-9 (10.16)	Add FN 1 to "Allowable . . . . . Straight"
19-02-09	10-9 (10.16)	Delete FN 1 from "Tolerance"
18-10-17	4-6	Revisions to Correct Defect Sizes
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 12.31header
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 for footnote 3, "Mean Diameter"
18-11-12	12-15 (Footnotes)	Change to definition for footnote 3, "Mean Diameter"
18-11-12	12-23 (Footnotes)	Change to definition for footnote 2, "Mean Diameter"
18-11-05	4-13	Added Color Code Lime and Blue for Alloy 6361
18-08-08	ii	Corrected "Abbreviations"
18-06-21	1-9	2.1.2 T_52 replaced the word "produce" to "target"
18-06-21	7-39 (7.41)	Corrected Tolerence/Specified Width to "Over 1000 thru 2000"
18-06-19	4-6	Changes to converted metric values
18-06-19	12-25 (12.55)	Changes to Table 12.55
18-03-26	7-14 (7.2)	Changed Specified Thickness fo Alclad 2024-O thru to 12.50 - 25.00 -vs- 12.50 - 45.00

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 90 megapascals. 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 700 megapascals 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 200˚C to 260˚C. 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 kilogram of aluminum will go about twice as far as a kilogram, 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 7–32 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 United States.