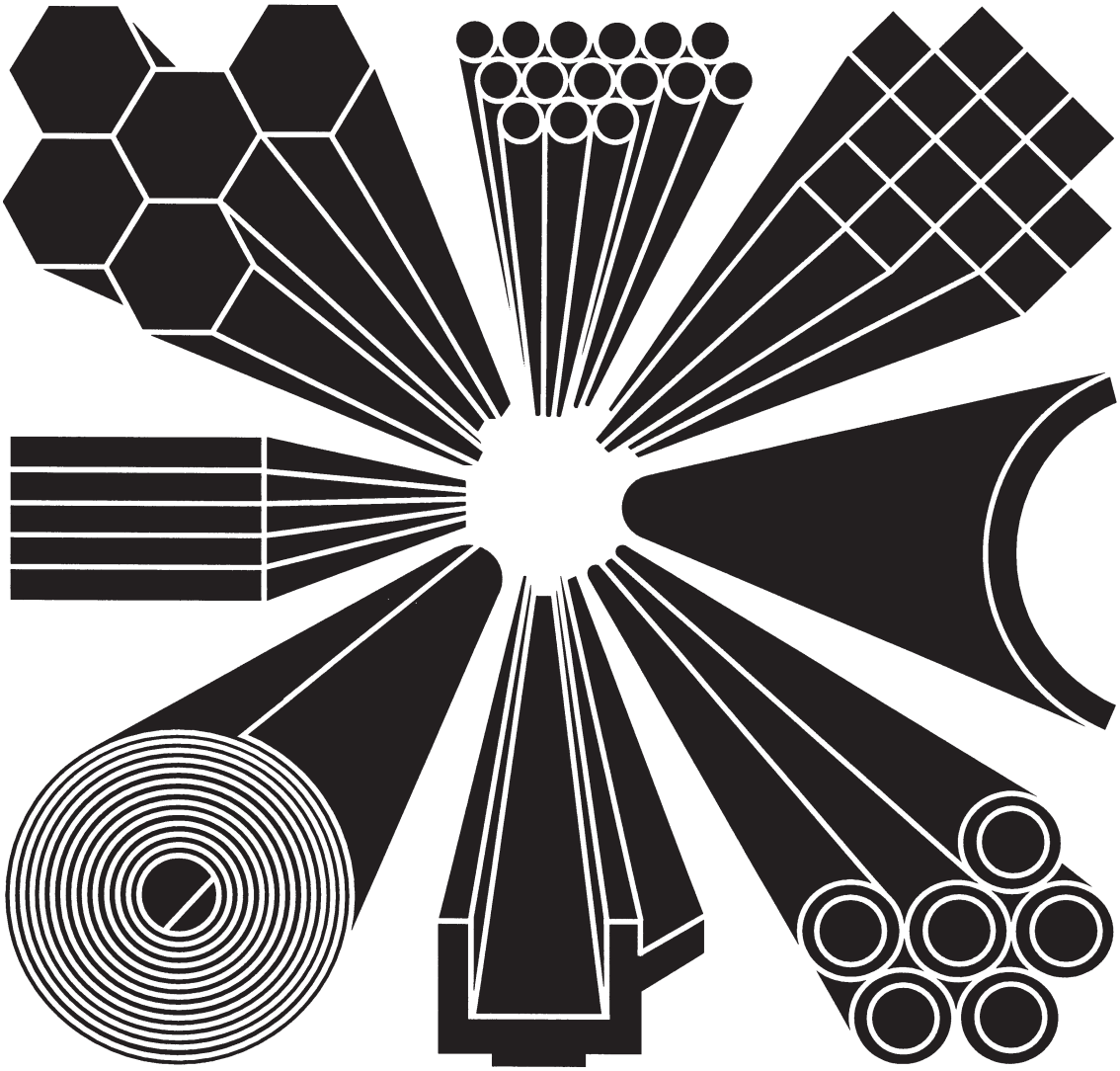
Aluminum standards and data 2009 Metric SI

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Abbreviations Used in This Manual

A Cross-section area
BHN Brinell hardness number
cm centimetre
°C degree Celsius
D diameter
h hour
IACS International Annealed Copper Standard
I.D. inside diameter
K k elvin
kg kilogram
kPa kilopascal
m metre
max maximum
MHZ me gahertz
MS/m megasiemen per metre
min minimum
mm millimetre
MPa me gapascal
O.D. outside diameter
s second
S Siemens
W w att
° de gree (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.

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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 AA TD 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.

This is the fifth publication of Aluminum Standards and Data—Metric Edition. For the most part, the method of preparation has been to arrive at logical metric values for long-term metric use rather than to restate current inch-pound system 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 customary units in Aluminum Standards and Data to metric units, in this document, follow procedures list in The Aluminum Association publication "Tempers for Aluminum and Aluminum Alloy Products Metric Edition" (Tan Sheets), APPENDIX A, titled "Guidelines for Metric Conversion of Yellow Sheets".

Cautionary note: Multiple conversions between U.S. customary units and metric S.I. units (and visa versa) should be avoided because significant errors may result.

To minimize confusion it is suggested that purchasers enter orders either in the metric system or in the inch-pound system 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 defnitions 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 = 6894 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 below:

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Chronological Summary of Changes to the 2009 Edition of Aluminum Standards and Data (Metric)		
DATE	**PAGE (TABLE/PARAGRAPH)**	**DESCRIPTION OF CHANGE**
09-04-15	Cover Page	Changed date to 2009
09-04-15	1-3	Changed ANSI Date to 2009
09-04-15	1-4	Changed Definition for National Variations
09-04-15	1-4	Changed “Plus” to “Together With”
09-04-15	1-6	Changed Section Title
09-04-15	1-6	Changed to “Applicable” section
09-04-15	1-8	Correction to Footnote 9
09-04-15	1-9	Changed Section Title
09-04-15	1-9	Added Footnote 12
09-04-15	1-9	Corrected “Capability”
09-04-15	1-10	Changed Section Title
09-04-15	1-22	Correction to “AMS” Section
09-03-20	2-13 (Table II)	Added Density Factors for Scandium and Sodium
09-03-16	5-8	Modified Definition for Foil
09-03-16	5-17	Modified Definition for Sheet
09-03-16	9-2 (9.2)	Addition of New Gage Ranges
09-02-13	7-10 (7.1)	Deleted Yield Strength Max for 5083-H32
09-02-13	7-10 (7.1)	Deleted Yield Strength Max for 5456-H32 and 5456-H321
09-02-03	7-19 (7.2)	Correction to Minimum Tensile Yield Strength
08-12-22	6-1	Changes to Mechanical Properties Definition
08-10-08	6-7 (6.4)	Replaced Footnotes 6 an 7 with Footnotes 4 and 9 to 7050-T74
08-10-08	6-8 (6.4)	Replaced Footnote 7 with Footnote 9 to 7175-T74
08-10-08	6-8 (6.4)	Added Definition for Footnote 9
08-10-08	6-8 (6.4)	Added “Suspect” to Lot Acceptance Status Column for 7075 and 7178
08-10-08	6-8 (6.4)	Corrected SCF for 7050-T76510/T76511
08-10-08	6-8 (6.4)	EC Condition for Unacceptable Status of 7075
08-10-08	6-8 (6.4)	EC Condition for Unacceptable Status of 7178
08-05-30	3-17 (3.5)	Corrected Anneal Temperature for Alloy 6082
08-05-30	3-17 (3.5)	Added Foornote 4 to Alloy 7175
08-05-30	3-17 (3.5)	Added Footnote 4 to Alloy 6005
08-05-30	15-3 (15.2)	Corrections to Elongations of 2014-T6 & 2014-T652
08-03-29	11-7	Correction to Format
08-03-06	6-1	Changes to Mechanical Properties Definition
08-03-06	6-5 (6.2)	Correction to Footnote 4 Location
08-03-06	6-6 (6.2)	Correction to Footnote 4 Location
08-03-06	6-8 (6.4)	Added 7475-T7651 Criteria
08-03-06	11-3 (11.1)	Added T6 Temper for 6082
08-03-20	15-2 (15.1)	Reformatted Elongation Columns
08-03-20	15-2 (15.1)	Correction to Yield Strength of 7175-T7452
08-03-20	15-3 (15.2)	Correction to Alloy-Temper 5083
08-03-20	15-3 (15.2)	Inserted Short Transverse data for 2618-T61
08-03-20	15-3 (15.2)	Corrected Yield Strength to 2618-T61
08-03-20	15-4 (15.2)	Corrected Elongation of 7050-T7452
08-03-20	15-4 (15.2)	Correction to Yield Strength of 7050-T7452
08-03-20	15-5 (15.2)	Corrections to Elongation of 7075 -T652 & 7175-T74
08-01-25	10-5 (10.2)	Correction to Yield Strength of 2024-T42
07-10-31	2-2 (2.1)	Added Footnote 11 to 5083-H321
07-10-25	2-9 (2.2)	Added 7475-T651 Plate
07-10-31	6-8 (6.4)	Added Alclad 7475-T761 Criteria
07-10-31	6-9 (6.6)	Added Alclad 7475-T61 and Alclad 7475-T761
07-10-31	6-9 (6.6)	Corrected Thickness
07-10-25	6-9 (6.6)	Expanded Thickness Range for 7475-T651
07-10-25	7-9 (7.1)	Added Footnote 9 to 5083-H321
07-10-25	7-10 (7.1)	Added Footnote 9 to 5456-H321
07-10-25	7-20 (7.2)	Added 7475-T651

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07-10-31	7-21 (7.2)	Added Longitudinal Properties for Alclad 7475-T61 Sheet and Alclad 7475-T761 Sheet
07-10-31	7-25 (7.6)	Added 5083-H32
07-10-31	7-25 (7.6)	Added 5456-H32
07-10-31	7-37 (7.35)	Correction to Ultimate Tensile Strength and Yield Strength for 6061 -T6 and T62
07-09-19	6-8 (6.4)	Added 7475-T761 Criteria
07-09-19	7-20 (7.2)	Added 7475-T61 Longitudinal Properties
07-09-19	7-21 (7.2)	Added 7475-T761 Longitudinal Properties
07-09-19	5-8	Added Definition for 'Lot, Cast'
07-09-19	5-8	Added Definition for 'Lot, Continuous Casting'
07-07-25	5-13	Modified the Definition for 'Sheet' in the Terminology Section
07-06-05	5-6	Modified the Definition for 'Foil' in the Terminology Section
07-06-01	3-10 (3.3)	Added B and A Corrosion Resistance Ratings for 6005
07-06-01	3-10 (3.3)	Correction to T52 Temper for 6063
07-04-24	11-3 (11.1)	Added Footnote 14 to 6063 -T52
07-04-24	11-5 (11.1)	Added Footnote 14
07-04-24	12-4 (12.1)	Added Footnote 7 to 6063 -T52
07-04-24	12-5 (12.1)	Added Footnote 7
07-02-16	5-3	Added Definitions for Hard and Soft Conversion
07-02-16	5-7	Added Hard Conversion
07-02-16	5-13	Added Soft Conversion
07-01-25	2-2 (2.1)	Added 5083-H32
07-01-25	2-3 (2.1)	Added 5456-H32
07-01-25	2-7 (2.2)	Added 5083-H32
07-01-25	2-8 (2.2)	Added 5456-H32
07-01-25	3-3 (3.1)	Added Sheet H32 & Plate H32 for 5083
07-01-25	3-4 (3.1)	Added Sheet H32 & Plate H32 for 5456
07-01-25	3-9 (3.3)	Added H32 to 5083
07-01-25	3-9 (3.3)	Added H32 to 5456
07-01-25	7-8 (7.1)	Added H32 to 5083
07-01-25	7-10 (7.1)	Added H32 to 5456
06-11-29	5-7	Added Definition for Furnace Solution Heat Treatment

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.

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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.

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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 highspeed 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 nontoxicity 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.

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Alloy and Temper Designation Systems for Aluminum (ANSI H35.1 / H35.1(M)-2009)

Information Note: The Aluminum Association is the registrar under ANSI H35.1 / H35.1(M) with respect to the designation and composition of aluminum alloys and tempers registered in the United States, and is also the registrar under an international accord on the composition and designation of registered wrought aluminum alloys. Since there is no international accord on designation and registration of tempers for wrought aluminum alloys and wrought aluminum alloy products, reference to ANSI H35.1 / H35.1(M) properties and characteristics of wrought aluminum alloy tempers registered with the Aluminum Association under ANSI H35.1 / H35.1(M) may not always reflect actual properties and characteristics associated with the particular aluminum alloy temper. The user may wish to confirm that expected properties denoted by specific temper designation(s) are furnished.

NOTE: The user of this Aluminum Standards and Data manual should be aware that the alloy and temper designation systems, as reprinted from ANSI H35.1 / H35.1(M), are those in effect at the time of this manual's publication but are subject to supersession by subsequent revisions of this ANSI standard as it is updated.

1. Scope

This standard provides systems for designating wrought aluminum and wrought aluminum alloys, aluminum and aluminum alloys in the form of castings and foundry ingot, and the tempers in which aluminum and aluminum alloy wrought products and aluminum alloy castings are produced. Specific limits for chemical compositions and for mechanical and physical properties to which conformance is required are provided by applicable product standards.

NOTE: A numerical designation assigned in conformance with this standard should only be used to indicate an aluminum or an aluminum alloy having chemical composition limits identical to those registered with The Aluminum Association and, for wrought aluminum and wrought aluminum alloys, with the signatories of the Declaration of Accord on an International Alloy Designation System for Wrought Aluminum and Wrought Aluminum Alloys.

2. Wrought Aluminum and Aluminum Alloy Designation System ①

A system of four-digit numerical designations is used to identify wrought aluminum and wrought aluminum alloys. The first digit indicates the alloy group as follows:

Aluminum, 99.00 percent and greater 1xxx
Aluminum alloys grouped by major alloying elements ②③④
- Copper 2xxx
- Manganese 3xxx
- Silicon 4xxx
- Magnesium 5xxx
- Magnesium and silicon 6xxx
- Zinc 7xxx
- Other element 8xxx

Unused series 9xxx

The designation assigned shall be in the 1xxx group whenever the minimum aluminum content is specified as 99.00 percent or higher. The alloy designation in the 2xxx through 8xxx groups is determined by the alloying element (Mg_2Si for 6xxx alloys) present in the greatest mean percentage, except in cases in which the alloy being registered qualifies as a modification or national variation of a previously registered alloy. If the greatest mean percentage is common to more than one alloying element, choice of group will be in order of group sequence Cu, Mn, Si, Mg, Mg_2Si, Zn or others.

The last two digits identify the aluminum alloy or indicate the aluminum purity. The second digit indicates modifications of the original alloy or impurity limits.

① Chemical composition limits and designations conforming to this standard for wrought aluminum and wrought aluminum alloys, and aluminum and aluminum alloy castings and foundry ingot may be registered with The Aluminum Association provided: (1) the aluminum or aluminum alloy is offered for sale, (2) the complete chemical composition limits are registered, and (3) the composition is significantly different from that of any aluminum or aluminum alloy for which a numerical designation already has been assigned.

② For codification purposes an alloying element is any element that is intentionally added for any purpose other than grain refinement and for which minimum and maximum limits are specified.

③ Standard limits for alloying elements and impurities are expressed to the following places:

Less than .001 percent 0.000X
.001 but less than .01 percent 0.00X
.01 but less than .10 percent
- Unalloyed aluminum made by a refining process . . . 0.0XX
- Alloys and unalloyed aluminum not made by a refining process 0.0X

.10 through .55 percent 0.XX
(It is customary to express limits of 0.30 percent through 0.55 percent as 0.X0 or 0.X5)
Over .55 percent . . . . . 0.X, X.X, etc.
(except that combined Si + Fe limits for 1xxx designations must be expressed as 0.XX or 1.XX)

④ Standard limits for alloying elements and impurities are expressed in the following sequence: Silicon; Iron; Copper; Manganese; Magnesium; Chromium; Nickel; Zinc; Titanium (see Note 1); Other (see Note 2) Elements, Each; Other (see Note 2) Elements, Total; Aluminum (see Note 3).

Note 1—Additional specified elements having limits are inserted in alphabetical order according to their chemical symbols between Titanium and Other Elements, Each, or are listed in footnotes.

Note 2—"Other" 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 registration or specification. However, such analysis is not required and may not cover all metallic "other" elements. Should any analysis by the producer or the purchaser establish that an "other" element exceeds the limit of "Each" or that the aggregate of several "other" elements exceeds the limit of "Total", the material shall be considered non-conforming.

Note 3—Aluminum is specified as minimum for unalloyed aluminum, and as a remainder for aluminum alloys.

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2.1 Aluminum

In the 1xxx group for minimum aluminum purities of 99.00 percent and greater, the last two of the four digits in the designation indicate the minimum aluminum percentage.⑤ These digits are the same as the two digits to the right of the decimal point in the minimum aluminum percentage when it is expressed to the nearest 0.01 percent. The second digit in the designation indicates modifications in impurity limits or alloying elements. If the second digit in the designation is zero, it indicates unalloyed aluminum having natural impurity limits; integers 1 through 9, which are assigned consecutively as needed, indicate special control of one or more individual impurities or alloying elements.

2.2 Aluminum Alloys

In the 2xxx through 8xxx alloy groups the last two of the four digits in the designation have no special significance but serve only to identify the different aluminum alloys in the group. The second digit in the alloy designation indicates alloy modifications. If the second digit in the designation is zero, it indicates the original alloy; integers 1 through 9, which are assigned consecutively, indicate alloy modifications. A modification of the original alloy is limited to any one or a combination of the following:

(a) Change of not more than the following amounts in arithmetic mean of the limits for an individual alloying element or combination of elements expressed as an alloying element or both.

Arithmetic Mean of Limits for Alloying Elements in Original Alloy	*Maximum Change*
Up thru 1.0 percent	0.15
Over 1.0 thru 2.0 percent	0.20
Over 2.0 thru 3.0 percent	0.25
Over 3.0 thru 4.0 percent	0.30
Over 4.0 thru 5.0 percent	0.35
Over 5.0 thru 6.0 percent	0.40
Over 6.0 percent	0.50

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the arithmetic mean of such a combination is compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Addition or deletion of not more than one alloying element with limits having an arithmetic mean of not more than 0.30 percent or addition or deletion of not more than one combination of elements expressed as an alloying element with limits having a combined arithmetic mean of not more than 0.40 percent.

(c) Substitution of one alloying element for another element serving the same purpose.

(d) Change in limits for impurities expressed singly or as a combination.

(e) Change in limits for grain refining elements.

(f) Maximum iron or silicon limits of 0.12 percent and 0.10 percent, or less, respectively, reflecting use of high purity base metal.

An alloy shall not be registered as a modification if it meets the requirements for a national variation.

2.3 Experimental Alloys

Experimental alloys are also designated in accordance with this system, but they are indicated by the prefix X. The prefix is dropped when the alloy is no longer experimental. During development and before they are designated as experimental, new alloys are identified by serial numbers assigned by their originators. Use of the serial number is discontinued when the X number is assigned.

2.4 National Variations

National variations of wrought aluminum and wrought aluminum alloys registered by another country in accordance with this system are identified by a serial letter following the numerical designation. The serial letters are assigned internationally in alphabetical sequence starting with A but omitting I, O and Q.

A national variation has composition limits that are similar but not identical to a modification or an original alloy registered by another country, with differences such as:

(a) Change of not more than the following amounts in arithmetic mean of the limits for an individual alloying element or combination of elements expressed as an alloying element, or both:

Arithmetic Mean of Limits for Alloying Elements in Original Alloy or Modification	*Maximum Change*
Up thru 1.0 percent	0.15
Over 1.0 thru 2.0 percent	0.20
Over 2.0 thru 3.0 percent	0.25
Over 3.0 thru 4.0 percent	0.30
Over 4.0 thru 5.0 percent	0.35
Over 5.0 thru 6.0 percent	0.40
Over 6.0 percent	0.50

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the arithmetic mean of

⑤ The aluminum content for unalloyed aluminum made by a refining process is the difference between 100.00 percent and the sum of all other metallic elements together with silicon present in amounts of 0.0010 percent or more, each expressed to the third decimal before determining the sum, which is rounded to the second decimal before subtracting; for unalloyed aluminum not made by a refining process it is the difference between 100.00 percent and the sum of all other metallic elements together with silicon present in amounts of 0.010 percent or more, each expressed to the second decimal before determining the sum. For unalloyed aluminum made by a refining process, when the specified maximum limit is 0.0XX, an observed value or a calculated value greater than 0.0005 but less than 0.0010% is rounded off and shown as "less than 0.001"; for alloys and unalloyed aluminum not made by a refining process, when the specified maximum limit is 0.XX, an observed value or a calculated value greater than 0.005 but less than 0.010% is rounded off and shown as "less than 0.01".

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such a combination is compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Substitution of one alloying element for another element serving the same purpose.

(c) Different limits on impurities except for low iron. Iron maximum of 0.12 percent, or less, reflecting high purity base metal, should be considered as an alloy modification.

(d) Different limits on grain refining elements.

(e) Inclusion of a minimum limit for iron or silicon, or both.

Wrought aluminum and wrought aluminum alloys meeting these requirements shall not be registered as a new alloy or alloy modification.

3. Cast Aluminum and Aluminum Alloy Designation System ①

A system of four digit numerical designations is used to identify aluminum and aluminum alloys in the form of castings and foundry ingot. The first digit indicates the alloy group as follows:

Aluminum, 99.00 percent minimum and greater	1xx.x
Aluminum alloys grouped by major alloying elements ②③④	
Copper	2xx.x
Silicon, with added copper and/or magnesium	3xx.x
Silicon	4xx.x
Magnesium	5xx.x
Zinc	7xx.x
Tin	8xx.x
Other element	9xx.x
Unused series	6xx.x

The alloy group in the 2xx.x through 9xx.x excluding 6xx.x alloys is determined by the alloying element present in the greatest mean percentage, except in cases in which the alloy being registered qualified as a modification of a previously registered alloy. If the greatest mean percentage is common to more than one alloying element, the alloy group will be determined by the sequence shown above.

The second two digits identify the aluminum alloy or indicate the aluminum purity. The last digit, which is separated from the others by a decimal point, indicates the product form: that is, castings or ingot. A modification of the original alloy or impurity limits is indicated by a serial letter before the numerical designation. The serial letters are assigned in alphabetical sequence starting with A but omitting I, O, Q and X, the X being reserved for experimental alloys.

A modification of the original alloy is limited to any one or a combination of the following:

(a) Change of not more than the following amounts in the arithmetic mean of the limits for an individual alloying element or combination of elements expressed as an alloying element or both:

Arithmetic Mean of Limits for Alloying Elements in Original Alloy	*Maximum Change*
Up thru 1.0 percent	0.15
Over 1.0 thru 2.0 percent	0.20
Over 2.0 thru 3.0 percent	0.25
Over 3.0 thru 4.0 percent	0.30
Over 4.0 thru 5.0 percent	0.35
Over 5.0 thru 6.0 percent	0.40
Over 6.0 percent	0.50

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the arithmetic mean of such a combination is compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Addition or deletion of not more than one alloying element with limits having an arithmetic mean of not more than 0.30 percent or addition or deletion of not more than one combination of elements expressed as an alloying element with limits having a combined arithmetic mean of not more than 0.40 percent.

(c) Substitution of one alloying element for another element serving the same purpose.

(d) Change in limits for impurities expressed singly or as a combination.

(e) Change in limits for grain refining elements.

(f) Iron or silicon maximum limits of 0.12 percent and 0.10 percent, or less, respectively, reflecting use of high purity base metal.

3.1 Aluminum Castings and Ingot

In the 1xx.x group for minimum aluminum purities of 99.00 percent and greater, the second two of the four digits in the designation indicate the minimum aluminum percentage.⑤ These digits are the same as the two digits to the right of the decimal point in the minimum aluminum percentage when it is expressed to the nearest 0.01 percent. The last digit, which is to the right of the decimal point, indicates the product form: 1xx.0 indicates castings, and 1xx.1 indicates ingot.

3.2 Aluminum Alloy Castings and Ingot

In the 2xx.x through 9xx.x alloy groups the second two of the four digits in the designation have no special significance but serve only to identify the different aluminum alloys in the group. The last digit, which is to the right of the decimal point, indicates the product form: xxx.0 indicates castings, xxx.1 indicates ingot that has chemical composition limits conforming to 3.2.1, and xxx.2 indicates ingot that has chemical composition limits that differ but fall within the limits of xxx.1 ingot.

For all number footnotes, see page 1-3 and 1-4.

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3.2.1 Limits for Alloying Elements and Impurities

Limits for alloying elements and impurities for xxx.1 ingot are the same as for the alloy in the form of castings, except for the following:

Maximum Iron Percentage:

For All Forms of Castings	*For Ingot, Fe Shall be at Least*
Up thru 0.15	0.03 less than castings
Over 0.15 thru 0.25	0.05 less than castings
Over 0.25 thru 0.6	0.10 less than castings
Over 0.6 thru 1.0	0.2 less than castings
Over 1.0	0.3 less than castings

Minimum Magnesium Percentage*:

For All Forms of Castings	*For Ingot*
Less than 0.50	0.05 more than castings*
0.50 and greater	0.1 more than castings*

Maximum Zinc Percentage:

For Die Castings	*For Ingot*
Over 0.25 thru 0.6	0.10 less than castings
Over 0.6	0.1 less than castings

3.2.2 Identifiers for 3xx.x and 4xx.x Foundry Ingot containing Structure Modifiers

One of the applicable suffixes in the table below should be added to the registered alloy designation whenever a structure modifier is intentionally added to that alloy.

Alloy Designation Suffix	Structure Modifying Element	Chemical Composition Limits	
		Minimum (%)	Maximum (%)
N	Na	0.003	0.08
S	Sr	0.005	0.08
C	Ca	0.005	0.15
P	P	--	0.060

(a) The letter suffix follows and is separated from the registered foundry ingot designation by a hyphen (e.g., "A356.1-S")

(b) In cases where more than one modifier is intentionally added, only the modifier of greater concentration shall be identified by suffix letter affixed to the registered alloy designation.

(c) Where a foundry alloy is sold with a suffix added to its alloy designation, the modifying element's concentration is not to be included in "Others, Each" or "Others, Total".

(d) It is not intended that these structure modifier identifiers be treated as new alloy registration, not should these designations be listed in the Registration Record.

3.3 Experimental Alloys

Experimental alloys are also designated in accordance with this system, but they are indicated by the prefix X. The prefix is dropped when the alloy is no longer experimental. During development and before they are designated as experimental, new alloys are identified by serial numbers assigned by their originators. Use of the serial number is discontinued when the X number is assigned.

*Applicable only if Magnesium is an alloying element (i.e. has a registered minimum and maximum percentage).

4. Temper Designation System ⑥

The temper designation system is used for all forms of wrought and cast aluminum and aluminum alloys except ingot. It is based on the sequences of basic treatments used to produce the various tempers. The temper designation follows the alloy designation, the two being separated by a hyphen. Basic temper designations consist of letters. Subdivisions of the basic tempers, where required, are indicated by one or more digits following the letter. These designate specific sequences of basic treatments, but only operations recognized as significantly influencing the characteristics of the product are indicated. Should some other variation of the same sequence of basic operations be applied to the same alloy, resulting in different characteristics, then additional digits are added to the designation.

4.1 Basic Temper Designations

F **as fabricated.** Applies to the products of shaping processes in which no special control over thermal conditions or strain hardening is employed. For wrought products, there are no mechanical property limits.

O **annealed.** Applies to wrought products that are annealed to obtain the lowest strength temper, and to cast products that are annealed to improve ductility and dimensional stability. The O may be followed by a digit other than zero.

H **strain-hardened (wrought products only).** Applies to products that have their strength increased by strain-hardening, with or without supplementary thermal treatments to produce some reduction in strength. The H is always followed by two or more digits.

W **solution heat-treated.** An unstable temper applicable only to alloys that spontaneously age at room temperature after solution heat-treatment. This designation is specific only when the period of natural aging is indicated; for example: W ½ hr.

T **thermally treated to produce stable tempers other than F, O, or H.** Applies to products that are thermally treated, with or without supplementary strain-hardening, to produce stable tempers. The T is always followed by one or more digits.

4.2 Subdivisions of Basic Tempers

4.2.1 Subdivision of H Temper: Strain-hardened

(a) The first digit following the H indicates the specific combination of basic operations, as follows:

H1 **strain-hardened only.** Applies to products that are strain-hardened to obtain the desired strength without supplementary thermal treatment. The number following this designation indicates the degree of strain-hardening.

H2 **strain-hardened and partially annealed.** Applies to products that are strain-hardened more than the desired final amount and then reduced in strength to the desired level by partial annealing. For alloys that age-soften at room temperature, the H2 tempers have the same minimum ultimate tensile strength as the corresponding H3 tempers. For other alloys, the H2 tempers have the same minimum ultimate tensile strength as the corresponding H1 tempers and slightly higher elongation. The number following this designation indicates the degree of strain-hardening remaining after the product has been partially annealed.

⑥ Temper designations conforming to this standard for wrought aluminum and wrought aluminum alloys, and aluminum alloy castings may be registered with the Aluminum Association provided: (1) the temper is used or is available for use by more than one user, (2) mechanical property limits are registered, (3) the characteristics of the temper are significantly different from those of all other tempers that have the same sequence of basic treatments and for which designations already have been assigned for the same alloy and product, and (4) the following are also registered if characteristics other than mechanical properties are considered significant: (a) test methods and limits for the characteristics or (b) the specific practices used to produce the temper.

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H3 strain-hardened and stabilized. Applies to products that are strain-hardened and whose mechanical properties are stabilized either by a low temperature thermal treatment or as a result of heat introduced during fabrication. Stabilization usually improves ductility. This designation is applicable only to those alloys that, unless stabilized, gradually age-soften at room temperature. The number following this designation indicates the degree of strain-hardening remaining after the stabilization treatment.

H4 strain-hardened and lacquered or painted. Applies to products which are strain-hardened and which are subjected to some thermal operation during the subsequent painting or lacquering operation. The number following this designation indicates the degree of strain-hardening remaining after the product has been thermally treated, as part of painting/lacquering cure operation. The corresponding H2X or H3X mechanical property limits apply.

(b) The digit following the designation H1, H2, H3, and H4 indicates the degree of strain-hardening as identified by the minimum value of the ultimate tensile strength. Numeral 8 has been assigned to the hardest tempers normally produced. The minimum tensile strength of tempers HX8 may be determined from Table 1 and is based on the minimum tensile strength of the alloy in the annealed temper. However, temper registrations prior to 1992 that do not conform to the requirements of Table 1 shall not be revised and registrations of intermediate or modified tempers for such alloy/temper systems shall conform to the registration requirements that existed prior to 1992.

Table 1

US Customary Units

Minimum tensile strength in annealed temper *ksi*	*Increase in tensile strength to HX8 temper* *ksi*
up to 6	8
7 to 9	9
10 to 12	10
13 to 15	11
16 to 18	12
19 to 24	13
25 to 30	14
31 to 36	15
37 to 42	16
43 and over	17

Metric Units

Minimum tensile strength in annealed temper *MPa*	*Increase in tensile strength to HX8 temper* *MPa*
up to 40	55
45 to 60	65
65 to 80	75
85 to 100	85
105 to 120	90
125 to 160	95
165 to 200	100
205 to 240	105
245 to 280	110
285 to 320	115
325 and over	120

Tempers between O (annealed) and HX8 are designated by numerals 1 through 7.

(a) Numeral 4 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the HX8 tempers;

(b) Numeral 2 designates tempers whose ultimate tensile strength is approximately midway between that of the O temper and that of the HX4 tempers;

(c) Numeral 6 designates tempers whose ultimate tensile strength is approximately midway between that of the HX4 tempers and that of the HX8 tempers;

(d) Numerals 1, 3, 5 and 7 designate, similarly, tempers intermediate between those defined above.

(e) Numeral 9 designates tempers whose minimum ultimate tensile strength exceeds that of the HX8 tempers by 14 MPa or more. (For Metric Units by 10 MPa or more).

The ultimate tensile strength of the odd numbered intermediate (-HX1, -HX3, -HX5, and -HX7) tempers, determined as described above, shall be rounded to the nearest multiple of 0.5 ksi. (For Metric Units when not ending in 0 or 5, shall be rounded to the next higher 0 or 5 MPa).

(c) The third digit,[7] when used, indicates a variation of a two-digit temper. It is used when the degree of control of temper or the mechanical properties or both differ from, but are close to, that (or those) for the two-digit H temper designation to which it is added, or when some other characteristic is significantly affected. (See Appendix for assigned three-digit H tempers.) NOTE: The minimum ultimate tensile strength of a three-digit H temper must be at least as close to that of the corresponding two-digit H temper as it is to the adjacent two-digit H tempers. Products in the H temper whose mechanical properties are below H__1 shall be variations of H__1.

4.2.2 Subdivision of T Temper: Thermally Treated

(a) Numerals 1 through 10 following the T indicate specific sequences of basic treatments, as follows: [8]

T1 cooled from an elevated temperature shaping process and naturally aged to a substantially stable condition. Applies to products that are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

T2 cooled from an elevated temperature shaping process, cold worked, and naturally aged to a substantially stable condition. Applies to products that are cold worked to improve strength after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

[7] Numerals 1 through 9 may be arbitrarily assigned as the third digit and registered with the Aluminum Association for an alloy and product to indicate a variation of a two-digit H temper (see note [6]).

[8] A period of natural aging at room temperature may occur between or after the operations listed for the T tempers. Control of this period is exercised when it is metallurgically important.

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T3 **solution heat-treated,[9] cold worked, and naturally aged to a substantially stable condition.** Applies to products that are cold worked to improve strength after solution heat-treatment, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

T4 **solution heat-treated[9] and naturally aged to a substantially stable condition.** Applies to products that are not cold worked after solution heat-treatment, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

T5 **cooled from an elevated temperature shaping process and then artificially aged.** Applies to products that are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

T6 **solution heat-treated[9] and then artificially aged.** Applies to products that are not cold worked after solution heat-treatment, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical property limits.

T7 **solution heat-treated[9] and overaged/stabilized.** Applies to wrought products that are artificially aged after solution heat-treatment to carry them beyond a point of maximum strength to provide control of some significant characteristic[10]. Applies to cast products that are artificially aged after solution heat-treatment to provide dimensional and strength stability.

T8 **solution heat-treated,[9] cold worked, and then artificially aged.** Applies to products that are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

T9 **solution heat-treated,[9] artificially aged, and then cold worked.** Applies to products that are cold worked to improve strength.

T10 **cooled from an elevated temperature shaping process, cold worked, and then artificially aged.** Applies to products that are cold worked to improve strength, or in which the effect of cold work in flattening or straightening is recognized in mechanical property limits.

(b) Additional digits,[11] the first of which shall not be zero, may be added to designations T1 through T10 to indicate a variation in treatment that significantly alters the product characteristics that are or would be obtained using the basic treatment. (See Appendix for specific additional digits for T tempers.)

[9] Solution heat treatment is achieved by heating cast or wrought products to a suitable temperature, holding at that temperature long enough to allow constituents to enter into solid solution and cooling rapidly enough to hold the constituents in solution. Some 6xxx and some 7xxx series alloys attain the same specified mechanical properties whether furnace solution heat treated or cooled from an elevated temperature shaping process at a rate rapid enough to hold constituents in solution. In such cases the temper designations T3, T4, T6, T7, T8, and T9 are used to apply to either process and are appropriate designations.

[10] For this purpose, *characteristic* is something other than mechanical properties. The test method and limit used to evaluate material for this characteristic are specified at the time of the temper registration.

[11] Additional digits may be arbitrarily assigned and registered with The Aluminum Association for an alloy and product to indicate a variation of tempers T1 through T10 even though the temper representing the basic treatment has not been registered (see note [6]). Variations in treatment that do not alter the characteristics of the product are considered alternate treatments for which additional digits are not assigned.

APPENDIX

4.3 Variations of O Temper: Annealed

A digit following the O, when used, indicates a product in the annealed condition having special characteristics. NOTE: As the O temper is not part of the strain-hardened (H) series, variations of O temper shall not apply to products that are strain-hardened after annealing and in which the effect of strain-hardening is recognized in the mechanical properties or other characteristics.

A1 Three-Digit H Tempers

(a) The following three-digit H temper designations have been assigned for wrought products in all alloys:

H_11 Applies to products that incur sufficient strain hardening after the final anneal that they fail to qualify as annealed but not so much or so consistent an amount of strain hardening that they qualify as H_1.

H112 Applies to products that may acquire some temper from working at an elevated temperature and for which there are mechanical property limits.

(b) The following three-digit H temper designations have been assigned for

pattern or embossed sheet	fabricated from
H114	0 temper
H124, H224, H324	H11, H21, H31 temper, respectively
H134, H234, H334	H12, H22, H32 temper, respectively
H144, H244, H344	H13, H23, H33 temper, respectively
H154, H254, H354	H14, H24, H34 temper, respectively
H164, H264, H364	H15, H25, H35 temper, respectively
H174, H274, H374	H16, H26, H36 temper, respectively
H184, H284, H384	H17, H27, H37 temper, respectively
H194, H294, H394	H18, H28, H38 temper, respectively
H195, H295, H395	H19, H29, H39 temper, respectively

(c) The following three-digit H temper designations have been assigned only for wrought products in the 5xxx series, or which the magnesium content is 3% nominal or more:

H116 Applies to products manufactured from alloys in the 5xxx series, for which the magnesium content is 3% nominal or more. Products are normally strain hardened at the last operation to specified stable tensile property limits and meet specified levels of corrosion resistance in accelerated type corrosion tests. They are suitable for continuous service at temperature no greater than 66^0 C (150^0C). Corrosion tests include inter-granular and exfoliation.

H321 Applies to products from alloys in the 5xxx series, for which the magnesium content is 3% nominal or more. Products are normally thermally stabilized at the last operation to specified stable tensile property limits and meet specified levels of corrosion resistance in accelerated type corrosion tests. They are suitable for continuous service at temperatures no greater than 66^0 C (150^0C). Corrosion tests include inter-granular and exfoliation.

A2 Additional Digits for T Tempers

A2.1 Assigned Additional Digits for Stress-Relieved Tempers

The following specific additional digits have been assigned for stress-relieved tempers of wrought products:

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A2.1.1 Stress relieved by stretching ⑫

T_51 Applies to plate and rolled or cold-finished rod or bar, die or ring forgings and rolled rings when stretched the indicated amounts after solution heat treatment or after cooling from an elevated temperature shaping process. The products receive no further straightening after stretching.

Plate . . . . . .1½% to 3% permanent set.

Rolled or
Cold-Finished
Rod and Bar . . . . . 1% to 3% permanent set.

Die or Ring
Forgings and
Rolled Rings . . . . . 1% to 5% permanent set.

T_510 Applies to extruded rod, bar, profiles and tube and to drawn tube when stretched the indicated amounts after solution heat treatment or after cooling from an elevated temperature shaping process. These products receive no further straightening after stretching.

Extruded Rod
Bar, Profiles
and Tube . . . . . 1% to 3% permanent set.
Drawn Tube . . . . . .½% to 3% permanent set.

T_511 Applies to extruded rod, bar, profiles and tube and to drawn tube when stretched the indicated amounts after solution heat treatment or after cooling from an elevated temperature shaping process. These products may receive minor straightening after stretching to comply with standard tolerances.

Extruded Rod,
Bar, Profiles
and Tube . . . . . 1% to 3% permanent set.
Drawn Tube . . . . . .½% to 3% permanent set.

A2.1.2 Stress relieved by compressing ⑫

T_52 Applies to products that are stress-relieved by compressing after solution heat treatment or cooling from an elevated temperature shaping process to produce a permanent set of 1 percent to 5 percent.

A2.1.3 Stress relieved by combined stretching and compressing ⑫

T_54 Applies to die forgings that are stress relieved by restriking cold in the finish die.

A2.2 Assigned Additional Digits for T7 Temper Variations

The following temper designations have been assigned to wrought products which are artificially overaged to obtain a good compromise among exfoliation corrosion resistance, stress corrosion resistance, fracture toughness, and tensile strength.

These designations shall be applied when standardizing new alloy-temper-product combinations.

T79 Very limited overaging to achieve some improved corrosion resistance with limited reduction in strength as compared to the T6 temper.

T76 Limited overaged condition to achieve moderate corrosion resistance with some reduction in strength. The T76 temper has lower strength and better corrosion resistance than the T79 temper.

T74 Overaged condition to achieve good corrosion resistance with a greater reduction in strength than the T76 temper. The T74 temper strength and corrosion resistance properties are between those of the T73 and T76 tempers.

T73 Fully overaged condition to achieve the best corrosion resistance of the T7X tempers with a greater reduction in strength than the T74 temper.

T77 Aged condition which provides strength at or near T6 temper and corrosion resistance similar to T76 temper corrosion resis

tance similar to T76 temper.

The evolution of material properties from temper T79 to T73 is illustrated in Figure 1.*

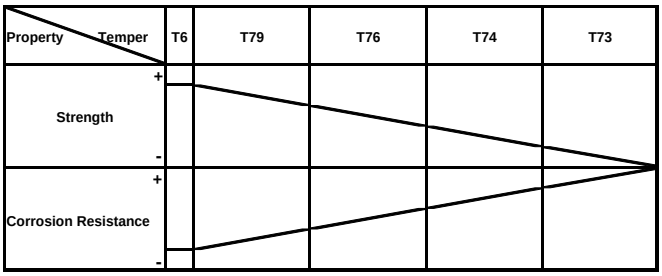


Figure 1

* The T77 temper does not fall within the continuous progression of the T7X tempers depicted in Figure 1.

A2.3 Assigned Temper Designations for Producer/Supplier and Purchaser/User Heat Treatment

A2.3.1 Temper Designations for Producer/Supplier Laboratory Demonstration of Response to Heat Treatment

The following temper designations have been assigned for wrought products test material, furnace heat-treated from annealed (O, O1, etc.) or F temper, to demonstrate response to heat-treatment.

T42 Solution heat-treated from annealed or F temper and naturally aged to a substantially stable condition.

T62 Solution heat-treated from annealed or F temper and artificially aged.

T7_2 Solution heat-treated from annealed or F temper and artificially overaged to meet the mechanical properties and corrosion resistance limits of the T7_ temper.

A2.3.2 Temper Designations for Producer/Supplier Demonstration of Response to Temper Conversion

Temper designation T_2 shall be used to indicate wrought product test material, which has undergone furnace heat-treatment for capability demonstration of temper conversion. When the purchaser requires capability demonstrations from T-temper, the seller shall note "Capability Demonstration" adjacent to the specified and ending tempers. Some examples are:

(a) "T3 to T82 Capability Demonstration for response to aging";

⑫ The same digits (51, 510, 511, 52, 54) may be added to the designation W to indicate unstable solution heat-treated and stress-relieved tempers.

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(b) "T4 to T62 Capability Demonstration for response to aging";

(c) "T4 to T762 Capability Demonstration for response to overaging";

(d) "T6 to T732 Capability Demonstration for response to overaging";

(e) "T351 to T42 Capability Demonstration for response to re-solution heat-treatment".

A2.3.3 Temper Designation for Purchaser/User Heat-treatment:

Temper designation T_2 should also be applied to wrought products heat-treated by the purchaser/user, in accordance with the applicable heat treatment specification, to achieve the properties applicable to the final temper.

A3 Assigned O Temper Variations

The following temper designation has been assigned for wrought products high temperature annealed to accentuate ultrasonic response and provide dimensional stability.

O1 Thermally treated at approximately same time and temperature required for solution heat treatment and slow cooled to room temperature. Applicable to products that are to be machined prior to solution heat treatment by the user. Mechanical property limits are not applicable.

A4 Designation of Unregistered Tempers

The letter P has been assigned to denote H, T and O temper variations that are negotiated between manufacturer and purchaser. The letter P immediately follows the temper designation that most nearly pertains. Specific examples where such designation may be applied include the following:

(a) The use of the temper is sufficiently limited so as to preclude its registration. (Negotiated H temper variations were formerly indicated by the third digit zero.)

(b) The test conditions (sampling location, number of samples, test specimen configuration, etc.) are different from those required for registration with The Aluminum Association.

(c) The mechanical property limits are not established on the same basis as required for registration with The Aluminum Association.

(d) For products such as Aluminum Metal Matrix Composites which are not included in any registration records.

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Metallurgical Aspects

In high-purity form aluminum is soft and ductile. Most commercial uses, however, require greater strength than pure aluminum affords. This is achieved in aluminum first by the addition of other elements to produce various alloys, which singly or in combination impart strength to the metal. Further strengthening is possible by means that classify the alloys roughly into two categories, non-heat-treatable and heat-treatable.

non-heat-treatable alloys—The initial strength of alloys in this group depends upon the hardening effect of elements such as manganese, silicon, iron and magnesium, singly or in various combinations. The non-heat-treatable alloys are usually designated, therefore, in the 1xxx, 3xxx, 4xxx, or 5xxx series. Since these alloys are work-hardenable, further strengthening is made possible by various degrees of cold working, denoted by the "H" series of tempers. Alloys containing appreciable amounts of magnesium when supplied in strain-hardened tempers are usually given a final elevated-temperature treatment called stabilizing to ensure stability of properties.

heat-treatable alloys—The initial strength of alloys in this group is enhanced by the addition of alloying elements such as copper, magnesium, zinc, and silicon. Since these elements singly or in various combinations show increasing solid solubility in aluminum with increasing temperature, it is possible to subject them to thermal treatments that will impart pronounced strengthening.

The first step, called heat treatment or solution heat treatment, is an elevated-temperature process designed to put the soluble element or elements in solid solution. This is followed by rapid quenching, usually in water, which momentarily "freezes" the structure and for a short time renders the alloy very workable. It is at this stage that some fabricators retain this more workable structure by storing the alloys at below freezing temperatures until they are ready to form them. At room or elevated temperatures the alloys are not stable after quenching, however, and precipitation of the constituents from the super-saturated solution begins. After a period of several days at room temperature, termed aging or room-temperature precipitation, the alloy is considerably stronger. Many alloys approach a stable condition at room temperature, but some alloys, particularly those containing magnesium and silicon or magnesium and zinc, continue to age-harden for long periods of time at room temperature.

By heating for a controlled time at slightly elevated temperatures, even further strengthening is possible and properties are stabilized. This process is called artificial aging or precipitation hardening. By the proper combination of solution heat treatment, quenching, cold working and artificial aging, the highest strengths are obtained.

clad alloys—The heat-treatable alloys in which copper or zinc are major alloying constituents are less resistant to corrosive attack than the majority of non-heat-treatable alloys. To increase the corrosion resistance of these alloys in sheet and plate form, they are often clad with high-purity aluminum, a low magnesium-silicon alloy, or an alloy containing 1 percent zinc. The cladding, usually from 2½ percent to 5 percent of the total thickness on each side, not only protects the composite due to its own inherently excellent corrosion resistance but also exerts a galvanic effect, which further protects the core material.

Special composites may be obtained such as clad non-heat-treatable alloys for extra corrosion protection, for brazing purposes, or for special surface finishes. Some alloys in wire and tubular form are clad for similar reasons, and on an experimental basis extrusions also have been clad.

annealing characteristics—All wrought aluminum alloys are available in annealed form. In addition, it may be desirable to anneal an alloy from any other initial temper, after working, or between successive stages of working such as in deep drawing.

Effect of Alloying Elements

1xxx series—Aluminum of 99 percent or higher purity has many applications, especially in the electrical and chemical fields. These compositions are characterized by excellent corrosion resistance, high thermal and electrical conductivity, low mechanical properties and excellent workability. Moderate increases in strength may be obtained by strain-hardening. Iron and silicon are the major impurities.

2xxx series—Copper is the principal alloying element in this group. These alloys require solution heat-treatment to obtain optimum properties; in the heat treated condition mechanical properties are similar to, and sometimes exceed, those of mild steel. In some instances artificial aging is employed to further increase the mechanical properties. This treatment materially increases yield strength, with attendant loss in elongation; its effect on tensile (ultimate) strength is not so great. The alloys in the 2xxx series do not have as good corrosion resistance as most other aluminum alloys, and under certain conditions they may be subject to intergranular corrosion. Therefore, these alloys in the form of sheet are usually clad with a high-purity alloy or a magnesium-silicon alloy of the 6xxx series, which provides galvanic protection to the core material and thus greatly increases resistance to corrosion. Alloy 2024 is perhaps the best known and most widely used aircraft alloy.

3xxx series—Manganese is the major alloying element of alloys in this group, which are generally non-heat-treatable. Because only a limited percentage of manganese, up to about 1.5 percent, can be effectively added to aluminum, it is used as a major element in only a few instances. One of these, however, is the popular 3003, which is widely used as a general purpose alloy for moderate-strength applications requiring good workability.

4xxx series—The major alloying element of this group is silicon, which can be added in sufficient quantities to cause substantial lowering of the melting point without producing brittleness in the resulting alloys. For these reasons aluminum-silicon alloys are used in welding wire and as brazing alloys where a lower melting point than that of the parent metal is required. Most alloys in this series are non-heat-treatable, but when used in welding

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heat-treatable alloys they will pick up some of the alloying constituents of the latter and so respond to heat treatment to a limited extent. The alloys containing appreciable amounts of silicon become dark grey when anodic oxide finishes are applied, and hence are in demand for architectural applications.

5xxx series—Magnesium is one of the most effective and widely used alloying elements for aluminum. When it is used as the major alloying element or with manganese, the result is a moderate to high strength non-heat-treatable alloy. Magnesium is considerably more effective than manganese as a hardener, about 0.8 percent magnesium being equal to 1.25 percent manganese, and it can be added in considerably higher quantities. Alloys in this series possess good welding characteristics and good resistance to corrosion in marine atmosphere. However, certain limitations should be placed on the amount of cold work and on the safe operating temperatures permissible for the higher magnesium content alloys (over about 3½ percent for operating temperatures above about 65^0 C) to avoid susceptibility to stress corrosion.

6xxx series—Alloys in this group contain silicon and magnesium in approximate proportions to form magnesium silicide, thus making them heat-treatable. The major alloy in this series is 6061, one of the most versatile of the heat-treatable alloys. Though less strong than most of the 2xxx or 7xxx alloys, the magnesium-silicon (or magnesium-silicide) alloys possess good formability and corrosion resistance, with medium strength. Alloys in this heat-treatable group may be formed in the T4 temper (solution heat-treated but not artificially aged) and then reach full T6 properties by artificial aging.

7xxx series—Zinc is the major alloying element in this group, and when coupled with a smaller percentage of magnesium results in heat-treatable alloys of very high strength. Usually other elements such as copper and chromium are also added in small quantities. The outstanding member of this group is 7075, which is among the highest strength alloys available and is used in air-frame structures and for highly stressed parts.

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TABLE 1.1 Nominal Chemical Composition—Wrought Alloys

The following values are shown as a basis for general comparison of alloys and are not guaranteed. Refer to Standards Section, Table 6.2, for composition limits.

PERCENT OF ALLOYING ELEMENTS—Aluminum and Normal Impurities Constitute Remainder								
Alloy	**Silicon**	**Copper**	**Manganese**	**Magnesium**	**Chromium**	**Nickel**	**Zinc**	**Titanium**
1050	..	..	99.50 percent minimum aluminum			..	..	..
1060	..	..	99.60 percent minimum aluminum			..	..	..
1100	..	0.12	99.00 percent minimum aluminum			..	..	..
1145	..	..	99.45 percent minimum aluminum			..	..	..
1175	..	..	99.75 percent minimum aluminum			..	..	..
1200	..	..	99.00 percent minimum aluminum			..	..	..
1230	..	..	99.30 percent minimum aluminum			..	..	..
1235	..	..	99.35 percent minimum aluminum			..	..	..
1345	..	..	99.45 percent minimum aluminum			..	..	..
1350 ⑥	..	..	99.50 percent minimum aluminum			..	..	..
2011 ①	..	5.5	..	..	..	..	..	..
2014	0.8	4.4	0.8	0.50	..	..	..	..
2017	0.50	4.0	0.7	0.6	..	..	..	..
2018	..	4.0	..	0.7	..	2.0	..	..
2024	..	4.4	0.6	1.5	..	..	..	..
2025	0.8	4.4	0.8	..	..	..	..	..
2036	..	2.6	0.25	0.45	..	..	..	..
2117	..	2.6	..	0.35	..	..	..	..
2124	..	4.4	0.6	1.5	..	..	..	..
2218	..	4.0	..	1.5	..	2.0	..	..
2219 ②	..	6.3	0.30	..	..	..	..	0.06
2319 ②	..	6.3	0.30	..	..	..	..	0.15
2618 ③	0.18	2.3	..	1.6	..	1.0	..	0.07
3003	..	0.12	1.2	..	..	..	..	..
3004	..	..	1.2	1.0	..	..	..	..
3005	..	..	1.2	0.40	..	..	..	..
3105	..	..	0.6	0.50	..	..	..	..
4032	12.2	0.9	..	1.0	..	0.9	..	..
4043	5.2	..	..	..	..	..	..	..
4045	10.0	..	..	..	..	..	..	..
4047	12.0	..	..	..	..	..	..	..
4145	10.0	4.0	..	..	..	..	..	..
4343	7.5	..	..	..	..	..	..	..
4643	4.1	..	..	0.20	..	..	..	..
5005	..	..	..	0.8	..	..	..	..
5050	..	..	..	1.4	..	..	..	..
5052	..	..	..	2.5	0.25	..	..	..
5056	..	..	0.12	5.0	0.12	..	..	..
5083	..	..	0.7	4.4	0.15	..	..	..
5086	..	..	0.45	4.0	0.15	..	..	..
5154	..	..	..	3.5	0.25	..	..	..
5183	..	..	0.8	4.8	0.15	..	..	..
5252	..	..	..	2.5	..	..	..	..
5254	..	..	..	3.5	0.25	..	..	..
5356	..	..	0.12	5.0	0.12	..	..	0.13
5454	..	..	0.8	2.7	0.12	..	..	..
5456	..	..	0.8	5.1	0.12	..	..	..
5457	..	..	0.30	1.0	..	..	..	..
5554	..	..	0.8	2.7	0.12	..	..	0.12
5556	..	..	0.8	5.1	0.12	..	..	0.12
5652	..	..	..	2.5	0.25	..	..	..
5654	..	..	..	3.5	0.25	..	..	0.10
5657	..	..	..	0.8	..	..	..	..

For all numbered footnotes, see page 1-13.

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TABLE 1.1 Nominal Chemical Composition—Wrought Alloys (concluded)

The following values are shown as a basis for general comparison of alloys and are not guaranteed. Refer to Standards Section, Table 6.2, for composition limits.

PERCENT OF ALLOYING ELEMENTS—Aluminum and Normal Impurities Constitute Remainder								
Alloy	**Silicon**	**Copper**	**Manganese**	**Magnesium**	**Chromium**	**Nickel**	**Zinc**	**Titanium**
6003	0.7	..	..	1.2	..	..	..	..
6005	0.8	..	..	0.50	..	..	..	..
6005A ⑪	0.7	..	..	0.55	..	..	..	..
6053	0.7	..	..	1.2	0.25	..	..	..
6061	0.6	0.28	..	1.0	0.20	..	..	..
6063	0.40	..	..	0.7	..	..	..	..
6066	1.4	1.0	0.8	1.1	..	..	..	..
6070	1.4	0.28	0.7	0.8	..	..	..	..
6082	1.0	..	0.7	0.9	..	..	..	..
6101	0.50	..	..	0.6	..	..	..	..
6105	0.8	..	..	0.6	..	..	..	..
6151	0.9	..	..	0.6	0.25	..	..	..
6162	0.6	..	..	0.9	..	..	..	..
6201	0.7	..	..	0.8	..	..	..	..
6262 ⑤	0.6	0.28	..	1.0	0.09	..	..	..
6351	1.0	..	0.6	0.6	..	..	..	..
6463	0.40	..	..	0.7	..	..	..	..
6951	0.35	0.28	..	0.6	..	..	..	..
7005 ④	..	..	0.45	1.4	0.13	..	4.5	0.04
7008	..	..	..	1.0	0.18	..	5.0	..
7049	..	1.6	..	2.4	0.16	..	7.7	..
7050 ⑦	..	2.3	..	2.2	..	..	6.2	..
7072	..	..	..	..	..	..	1.0	..
7075	..	1.6	..	2.5	0.23	..	5.6	..
7108 ⑧	..	..	..	1.0	..	..	5.0	..
7175	..	1.6	..	2.5	0.23	..	5.6	..
7178	..	2.0	..	2.8	0.23	..	6.8	..
7475	..	1.6	..	2.2	0.22	..	5.7	..
8017 ⑨	..	0.15	..	0.03	..	..	..	..
8030 ⑩	..	0.22	..	..	..	..	..	..
8176 ⑨	0.09	..	..	..	..	..	..	..

Note: Listed herein are designations and chemical composition limits for some wrought unalloyed aluminum and for wrought aluminum alloys registered with The Aluminum Association. This does not include all alloys registered with The Aluminum Association. A complete list of registered designations is contained in the "Registration Record of International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys." These lists are maintained by the Technical Committee on Product Standards of The Aluminum Association.

① Lead and Bismuth, 0.40 percent each.
② Vanadium 0.10, Zirconium 0.18.
③ Iron 1.1.
④ Zirconium 0.14.
⑤ Lead and Bismuth, 0.55 percent each.
⑥ Formerly designated EC.
⑦ Zirconium 0.12.
⑧ Zirconium 0.18.
⑨ Iron 0.7.
⑩ Iron 0.55, Boron 0.02.
⑪ Manganese and Chromium 0.12-0.50

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AA Wrought Alloys and Similar Foreign Alloys

The following Table 1.2 lists the AA wrought alloys and the corresponding foreign alloys that are covered by standards as used in Austria, Canada, France, Germany, Great Britain, Italy, Spain and Switzerland and in the Recommendations of the International Organization for Standardization (ISO).

The table includes only those foreign alloys that are essentially equivalent in composition to the corresponding AA alloys, but whose composition limits are not necessarily exactly the same as their AA counterparts. Standards are subject to change, and the actual issue of the specification or standard currently in effect should be consulted for full information.

TABLE 1.2 Foreign Alloy Designations and Similar AA Alloys

Foreign Alloy Designation	Designating Country	Equivalent or Similar AA Alloy
Al99	Austria (Önorm) ①	1200
Al99,5		1050
E-Al		1350
AlCuMg1		2017
AlCuMg2		2024
AlCuMg0,5		2117
AlMg5		5056
AlMgSi0,5		6063
E-AlMgSi		6101
AlZnMgCu1,5		7075
990C	Canada (CSA) ②	1100
CB60		2011
CG30		2117
CG42		2024
CG42 Alclad		Alclad 2024
CM41		2017
CN42		2018
CS41N		2014
CS41N Alclad		Alclad 2014
CS41P		2025
GM31N		5454
GM41		5083
GM50P		5356
GM50R		5056
GR20		5052
GS10		6063
GS11N		6061
GS11P		6053
MC10		3003
S5		4043
SG11P		6151
SG121		4032
ZG62		7075
ZG62 Alclad		Alclad 7075
A5/L	France (NF) ③	1350
A45		1100
A-G1		5050
A-G0.6		5005
A-G4MC		5086
A-GS		6063
A-GS/L		6101
A-M1		3003
A-M1G		3004
A-U4G		2017
A-U2G		2117
A-U2GN		2618
A-U4G1		2024
A-U4N		2218
A-U4SG		2014
A-S12UN		4032
A-Z5GU		7075

Foreign Alloy Designation	Designating Country	Equivalent or Similar AA Alloy
E-A1995 ④ / 3.0257 ⑤	Germany	1350
AlCuBiPb ④ / 3.1655 ⑤		2011
AlCuMg0.5 ④ / 3.1305 ⑤		2117
AlCuMg1 ④ / 3.1325 ⑤		2017
AlCuMg2 ④ / 3.1355 ⑤		2024
AlCuSiMn ④ / 3.1255 ⑤		2014
AlMg4.5Mn ④ / 3.3547 ⑤		5083
AlMgSi0.5 ④ / 3.3206 ⑤		6063
AlSi5 ④ / 3.2245 ⑤		4043
E-AlMgSi0.5 ④ / 3.3207 ⑤		6101
AlZnMgCu1.5 ④ / 3.4365 ⑤		7075
1E	Great Britain (BS) ⑥	1350
91E		6101
H14		2017
H19		6063
H20		6061
L.80, L.81		5052
L.86		2117
L.87		2017
L.93, L.94		2014A
L.95, L.96		7075
L.97, L.98		2024
2L.55, 2L.56		5052
2L.58		5056
3L.44		5050
5L.37		2017
6L.25		2218
N8		5083
N21		4043
150A	Great Britain (DTD) ⑦	2017
324A		4032
372B		6063
717, 724, 731A / 745, 5014, 5084		2618
5090		2024
5100		Alclad 2024

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TABLE 1.2 Foreign Alloy Designations and Similar AA Alloys (concluded)

Foreign Alloy Designation	Designating Country	Equivalent or Similar AA Alloy
P-AlCu4MgMn	Italy (UNI) ⑧	2017
P-AlCu4.5MgMn		2024
P-AlCu4.5MgMnplacc.		Alclad 2024
P-AlCu2.5MgSi		2117
P-AlCu4.4SiMnMg		2014
P-AlCu4.4SiMnMgplacc.		Alclad 2014
P-AlMg0.9		5657
P-AlMg1.5		5050
P-AlMg2.5		5052
P-AlSi0.4Mg		6063
P-AlSi0.5Mg		6101
Al99.5E	Spain (UNE) ⑨	1350
L-313		2014
L-314		2024
L-315		2218
L-371		7075

Foreign Alloy Designation	Designating Country	Equivalent or Similar AA Alloy
Al-Mg-Si	Switzerland (VSM) ⑩	6101
Al1.5Mg		5050
Al-Cu-Ni		2218
Al3.5Cu0.5Mg		2017
Al4Cu1.2Mg		2027
Al-Zn-Mg-Cu		7075
Al-Zn-Mg-Cu-pl		Alclad 7075
Al99.0Cu	ISO ⑪	1100
AlCu2Mg		2117
AlCu4Mg1		2024
AlCu4SiMg		2014
AlCu4MgSi		2017
AlMg1		5005
AlMg1.5		5050
AlMg2.5		5052
AlMg3.5		5154
AlMg4		5086
AlMg5		5056
AlMn1Cu		3003
AlMg3Mn		5454
AlMg4.5Mn		5083
AlMgSi		6063
AlMg1SiCu		6061
AlZn6MgCu		7075

① Austrian Standard M3430.
② Canadian Standards Association.
③ Normes Françaises.
④ Deutsche Industrie-Norm.
⑤ Werkstoff-Nr.
⑥ British Standard.
⑦ Directorate of Technical Development.
⑧ Unificazione Nazionale Italiana.
⑨ Una Norma Espanol.
⑩ Verein Schweizerischer Maschinenindustrieller.
⑪ International Organization for Standardization.

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TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
1060	Sheet and plate	B209	..	..	4000 ⑤	SB-209	..
	Wire, rod, bar, rolled or cold finished	B211	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	
		B345/B345M	..	..	..	..	..
	Tube; drawn	B483/B483M					
	Tube; drawn, seamless	B210	..	..	..	SB-210	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
1100	Sheet and plate	B209	..	..	4001, 4003 AMS-QQ-A-250/1	SB-209	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	..	..	..
					AMS-QQ-A-225/1	..	
	Wire, rod, bar; profiles and tube; extruded	B221	..	..		SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..
	Tube; drawn	B483/B483M	..	..	..	..	..
	Tube; drawn, seamless	B210	..	WW-T-700/1	4062	..	..
	Tube; welded	B313/B313M	..	..	..	..	..
		B547/B547M					
	Rivet wire and rod	B316/B316M	..	QQ-A-430	AS7220	..	..
	Spray gun wire	..	..	..	4180	..	C2.25/C2.25M
	Forgings and forging stock	B247	..	..	..	..	..
	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
	Impacts	B221	..	..	..	..	..
	Foil	B479	..	QQ-A-1876	..	..	..
1145	Foil	B373, B479	..	QQ-A-1876	4011	..	..
1235	Foil	B373, B479	..	QQ-A-1876	..	..	..
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..
1350	ACSR	B232/B232M, B401	..	..	..	..	..
	Bus conductors	B236	..	..	..	..	..
	Rolled redraw rod	B233	..	..	..	..	..
	Stranded conductors	B231/B231M, B400	..	..	..	..	..
	Wire; H19 temper	B230/B230M	..	..	..	..	..
	Wire; H14 temper	B609/B609M	..	..	..	..	..
	Wire; rectangular and square	B324	..	..	..	..	..
	Round solid conductor	B609/B609M	..	..	..	..	..
2011	Tube; drawn, seamless	B210	..	..	..	..	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	AMS-QQ-A-225/3	..	..
2014	Sheet and Plate	B209	..	..	4028, 4029	..	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	4121 AMS-QQ-A-225/4	SB-211	..
	Wire, rod, bar; profiles and tube; extruded	B221	..	..	4153 AMS-QQ-A-200/2	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	..	..
	Tube; drawn, seamless	B210	..	..	..	..	..
	Forgings and forging stock	B247	..	..	4133, 4134 AMS-A-22771	..	..
	Rings; forged and rolled	..	..	..	4314	..	
	Impacts	B221	..	..	..	..	..
Alclad 2014	Sheet and plate	B209	..	..	AMS-QQ-A-250/3	..	..
2017	Wire, rod, bar; rolled or cold finished	B211	..	..	4118 AMS-QQ-A-225/5	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
2018	Forgings and forging stock	B247	..	..	4140	..	
2024	Sheet and plate	B209	..	..	4035, 4037 4193, 4297 AMS-QQ-A-250/4	..	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	4120, 4339 AMS-QQ-A-225/6	SB-211	..
	Wire, rod, bar; profiles and tube; extruded	B221	..		4152, 4164, 4165 AMS-QQ-A-200/3	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	..	..
	Tube; drawn, seamless	B210	..	WW-T-700/3	4087, 4088	..	..
	Tube; hydraulic	..	..	..	4086	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
	Foil	..	..	..	AMS-A-81596	..	..

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TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (continued)

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
Alclad 2024	Plate and Sheet	B209	..	..	4040, 4041 4194, 4195, 4279 AMS-QQ-A-250/5	..	..
Alclad One Side 2024	Sheet and plate	B209	..	..	4036, 4077	..	..
2025	Forgings and forging stock	B247	..	..	4130	..	..
2117	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	AS 7222	..	..
2124	Plate	B209	..	..	4101, 4221 AMS-QQ-A-250/29	..	..
2218	Forgings and forging stock	B247	..	..	4142	..	..
2219	Sheet and plate	B209	..	..	4031, 4295 AMS-QQ-A-250/30	..	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	..	..	..
	Wire, rod, bar, profiles and tubes; extruded	B221	..	..	4162	..	..
	Tube; extruded, seamless	B241/B241M	..	..	4068	..	..
	Tube; drawn, seamless	B210	..	..	4066	..	..
	Forgings and forging stock	B247	..	..	4143, 4144, AMS-A-22771	..	..
	Armor, Extruded	..	MIL-DTL-46083	..	..	..	..
	Armor, Forgings	..	MIL-DTL-46118	..	..	..	..
	Armor plate	..	MIL-DTL-46118	..	..	..	..
	Rings, rolled or forged	..	..	..	4313	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
Alclad 2219	Sheet and plate	B209	..	..	4094, 4095, 4096	..	..
2319	Welding rod and electrodes; bare	..	..	..	4191	..	A5.10/A5.10M
2519	Armor plate	..	MIL-DTL-46192	..	..	..	..
2618	Forgings and forging stock	B247	..	..	4132, AMS-A-22771	..	..
3003	Sheet and plate	B209	..	..	4006, 4008 AMS-QQ-A-250/2	SB-209	..
	Tread Plate	B632/B632M	..	..	..	..	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	AMS-QQ-A-225/2	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/1	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..
	Tube; drawn	B483/B483M	..	..	..	..	..
	Tube, drawn seamless	B210	..	WW-T-700/2	4065, 4067	SB-210	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
	Pipe	B241/B241M	MIL-DTL-25995	..	..	SB-241/SB-241M	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
	Forgings and forging stock	B247	..	..	..	SB-247	..
	Foil	..	..	..	4010 AMS-A-81596	..	..
Alclad 3003	Sheet and plate	B209	..	..	..	SB-209	..
	Brazing Sheet	..	..	..	4063, 4064	..	..
	Tube; drawn, seamless	B210	..	..	..	SB-210	
	Tube; extruded	B221	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fin	B404/B404M	..	..	..	..	..
	Tube; welded	B547/B547M	..	..	..	..	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
3004	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; extruded	B221	..	..	..	..	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
Alclad 3004	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
3005	Sheet	B209	..	..	..	..	..
3102	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
3105	Sheet	B209	..	..	..	..	..
4032	Rods and Bars; Rolled or Cold Finished	..	..	..	4318, 4319	..	..
	Forgings and forging stock	B247	..	..	..	..	..

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TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (continued)

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
4043	Welding rod and electrodes; bare Spray gun wire				4190		A5.10/A5.10M C2.25/C2.25M
4045	Brazing filler metal	..	..	..	AMS-B-20148	..	..
4047	Brazing filler metal	..	..	..	4185 AMS-B-20148		
	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
4145	Brazing filler metal	..	..	..	4184, AMS-B-20148		
	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
4343	Brazing filler metal	..	..	..	AMS-B-20148	..	..
4643	Welding electrode	..	..	..	4189	..	A5.10/A5.10M
5005	Sheet and plate	B209	..	..	..	..	..
	Wire; H19 temper	..	..	..	..	..	..
	Stranded conductor	..	..	..	..	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
	Rod; rolled	..	..	..	..	..	..
	Tube, drawn, seamless	B210	..	..	..	..	..
	Tube, drawn	B483/B483M	..	..	..	..	..
5050	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; drawn, seamless	B210	..	..	..	..	..
	Tube, drawn	B483/B483M	..	..	..	..	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
5052	Sheet and plate	B209	..		4015, 4016, 4017 AMS-QQ-A-250/8	SB-209	..
	Wire, rod and bar; rolled or cold finished	B211	..		4114 AMS-QQ-A-225/7	..	..
	Tube; drawn	B483/B483M	..	..	..	..	..
	Tube; drawn, seamless	B210	..	WW-T-700/4	4069, 4070	SB-210	..
	Tube; hydraulic	..	..	..	4071	..	..
	Tube; extruded	B221	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	SB-234	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
	Foil	..	..	..	4004 AMS-A-81596	..	..
5056	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	..		..
	Wire, rod and bar; rolled or cold finished	B211	..	..	4182	..	..
	Foil	..	..	..	4005 ⑤ AMS-A-81596	..	..
5083	Sheet and plate	B209	..		4056 AMS-QQ-A-250/6	SB-209	..
	Marine Sheet and Plate	B928/B928M	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/4	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; drawn, seamless	B210	..	..	..	..	..
	Tube; welded	B547/B547M	..	..	..	..	..
	Forgings and forging stock	B247	..	..	..	SB-247	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
	Armor plate	..	MIL-DTL-46027	..	..	..	..
	Extruded armor	..	MIL-DTL-46083	..	..	..	..
	Forged armor	..	MIL-DTL-45225	..	..	..	..
5086	Sheet and plate	B209	..	..	AMS-QQ-A-250/7 AMS-QQ-A-250/19	SB-209	..
	Marine Sheet and Plate	B928/B928M	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/5	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; drawn, seamless	B210	..	WW-T-700/5	..	..	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..

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TABLE 1.3 Aluminum Mill Product Specifications ①②③④ (continued)

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
5154	Sheet and plate	B209	..	..	..	SB-209	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
	Tube; drawn, seamless	B210	..	..	..	SB-210	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
5183	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5252	Sheet	B209	..	..	..	..	..
5254	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; extruded, seamless	B241/B241M	..	..	..	..	..
5356	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5454	Sheet and plate	B209	..	..	AMS-QQ-A-250/10	SB-209	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/6	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
	Tube; welded	B547/B547M	..	..	..	..	..
5456	Sheet and plate	B209	..	..	AMS-QQ-A-250/9 AMS-QQ-A-250/20	SB-209	..
	Marine Sheet and Plate	B928/B928M	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/7	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; drawn, seamless	B210	..	..	..	..	..
	Armor plate	..	MIL-DTL-46027	..	..	..	..
	Extruded armor	..	MIL-DTL-46083	..	..	..	..
	Forged armor	..	MIL-DTL-45225	..	..	..	..
5457	Sheet	B209	..	..	..	..	..
5554	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5556	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5654	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5657	Sheet	B209	..	..	..		..
6005	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
6005A	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
6053	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
6060	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
6061	Sheet and plate	B209	..	..	4025, 4026, 4027 AMS-QQ-A-250/11	SB-209	..
	Tread Plate	B632/B632M	..	..	..	..	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	4115, 4116, 4117, 4128 AMS-QQ-A-225/8	SB-211	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	4150, 4160, 4161, AMS-QQ-A-200/8 4172, 4173	SB-221	..
	Structural profiles	B308/B308M	..	..	4113 AMS-QQ-A-200/16	SB-308/SB-308M	..
	Tube, drawn	B483/B483M	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; drawn, seamless	B210	..	WW-T-700/6	4079, 4080, 4082	SB-210	..
	Tube; hydraulic	..	..	..	4081, 4083	..	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
	Pipe	B241/B241M	MIL-DTL-25995	..	..	SB-241/SB-241M	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
	Forgings and forging stock	B247	..	..	4127, 4146⑤, 4248 AMS-A-22771	SB-247	..
	Rings; forged or rolled	..	..	..	4312	..	..
	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	..	..	..
	Impacts	B221	..	..	..	..	..
	Structural pipe and tube; extruded	B429	..	..	..	..	..
	Foil	..	..	..	4009⑤	..	..

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TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (continued)

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
Alclad 6061	Sheet and plate	B209	..	..	4021⑤	SB-209	..
6063	Wire, rod, bar, profiles and tube; extruded	B221	..	..	4156 AMS-QQ-A-200/9	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..
	Tube; drawn	B483/B483M	..	..	..	..	..
	Pipe	B241/B241M	MIL-DTL-25995	..	..	SB-241/SB-241M	..
	Pipe; gas and oil transmission, seamless	B345/B345M	..	..	..	..	..
	Structural pipe and tube; extruded	B429	..	..	..	..	..
6066	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/10	..	..
	Forgings and forging stock	B247	..	..	..	..	..
6070	Rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
	Impacts	B221	..	..	..	..	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
6082	Wire, rod, bar, profiles and tube, extruded	B221	..	..	..	SB-221	..
6101	Bus conductor	B317/B317M	..	..	..	..	..
6105	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
6151	Forgings and forging stock	B247	..	..	4125, AMS-A-22771	..	..
6201	Wire ; T81 temper	B398/B398M	..	..	..	..	..
	Standard conductor; T81 temper	B399/B399M	..	..	..	..	..
6162	Wire, rod, bar, profiles and tube; extruded	B211	..	..	..	..	..
6262	Wire, rod and bar; rolled or cold finished	B211	..	..	AMS-QQ-A-225/10	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
	Tube, drawn seamless	B210 B483/B483M	..	..	..	..	..
6351	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
	Seamless pipe and tube, extruded,	B241/B241M B345/B345M	..	..		..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
6463	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
7005	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
7039	Armor plate	..	MIL-DTL-46063	..	..	..	..
	Armor, Extruded	..	MIL-DTL-46083	..	..	..	..
	Armor, Forgings	..	MIL-DTL-45225	..	..	..	..
7049	Forgings	B247	..	..	4111, AMS-A-22771	..	..
	Extrusions	..	..	..	4157, 4159	..	..
	Hand forgings	..	..	..	4247	..	..
	Forging	..	..	..	4321	..	..
	Plate	..	..	..	4200	..	..
7050	Plate	..	..	..	4050, 4201	..	..
	Wire, rod, bar; extruded	..	..	..	4340, 4341, 4342	..	..
	Forgings	B247	..	..	4107, 4108, AMS-A-22771	..	..
	Die forgings	B247	..	..	4333	..	..
	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	..	..	..
Alclad 7050	Sheet	..	..	..	4243	..	..
7075	Sheet and plate	B209	..	..	4044, 4045, 4078 AMS-QQ-A-250/12 AMS-QQ-A-250/24	..	..
	Sheet; fine grained				4277		
	Wire, rod and bar; rolled or cold finished	B211	..	..	4122, 4123, 4124, 4186, 4187 ⑤	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-225/9 4154, 4166, 4167, 4168, 4169	..	..
	Wire, rod, bar, profiles and tube; extruded (Exfoliation Resistant)	..	..	..	AMS-QQ-A-200/11 AMS-QQ-A-200/15	..	..
	Tube; extruded	B241/B241M	..	..	..	..	..
	Tube; drawn, seamless	B210	..	WW-T-700/7	..	..	..
	Forgings and forging stock	B247	..	..	4126, 4131, 4141, 4147, AMS-A-22771	..	..
	Hand forging	B247			4323		
	Rings, forged or rolled	B247	..	..	4310, 4311	..	..
	Impacts	B221	..	..	..	..	..
	Rivet Wire	B316/B316M	..	QQ-A-430	..	..	

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TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (concluded)

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
Alclad 7075	Sheet and plate	B209	..	..	4048, 4049 AMS-QQ-A-250/13 AMS-QQ-A-250/25 AMS-QQ-A-250/26	..	..
	Sheet; fine grained				4278		
Alclad One Side 7075	Sheet and plate	B209	..	..	4046 AMS-QQ-A-250/18	..	..
7116	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
7129	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
7175	Extruded	..	..	..	4344	..	..
	Forgings and forging stock	B247	..	..	4148, 4149, 4179, AMS-A-22771	..	..
7178	Sheet and plate	B209	..	..	AMS-QQ-A-250/14 AMS-QQ-A-250/21	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/13 AMS-QQ-A-200/14	..	..
	Rivet Wire	B316/B316M	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..		..
Alclad 7178	Sheet and plate	B209	..	..	.. AMS-QQ-A-250/15 AMS-QQ-A-250/22 AMS-QQ-A-250/28	..	..
7475	Sheet and plate	..	..	..	4084, 4085, 4089, 4090, 4202	..	..
Alclad 7475	Sheet	..	..	..	4100, 4207	..	..

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② This cross-reference index lists the basic specification or standard number and no attempt is made to reflect the latest revision or amendment to any particular document. The appropriate specification index published by the specification issuing body should be consulted to determine the latest issue of any particular specification or standard. The aluminum industry generally prefers to use the latest issue of any given specification or standard.

③ Different organizations' specifications for the same alloy and product may contain different requirements.

④ Copies of specifications can be obtained from:

(Aerospace Material Specifications) (AMS)
SAE, Inc.
400 Commonwealth Drive
Warrendale, PA 15096-0001

(Military and Federal)
Standardization Documents Order Desk
Building 4D, 700 Robins Avenue
Philadelphia, PA 19111-5094

(ASME)
American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

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

(AWS)
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

⑤ Noncurrent

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TABLE 1.4 Specifications Covering Aluminum Mill Products ① ②

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED
	FEDERAL SPECIFICATIONS
FED-STD-123	Marking for domestic shipment (civilian agencies)
FED-STD-184	Item identification marking for aluminum products
FED-STD-245	Tolerances for aluminum wrought products finished wire, rod, bar and special shapes
QQ-A-430	1100, 2017, 2024, 2117, 2219, 3003, 5005, 5052, 5056, 6053, 6061, 7050, and 7075 wire and rod for rivets and cold heading
QQ-A-1876	Aluminum Foil; 1100, 1145, 1235
WW-T-700	General specification for drawn tube, seamless
WW-T-700/1	1100 drawn tube, seamless
WW-T-700/2	3003 drawn tube, seamless
WW-T-700/3	2024 drawn tube, seamless
WW-T-700/4	5052 drawn tube, seamless
WW-T-700/5	5086 drawn tube, seamless
WW-T-700/6	6061 drawn tube, seamless
WW-T-700/7	7075 drawn tube, seamless
	MILITARY SPECIFICATIONS
MIL-STD-129	Marking for shipment and storage
MIL-C-5541	Chemical films for aluminum and aluminum alloys
MIL-A-8625	Anodic coatings for aluminum alloys
MIL-DTL-25995	3003, 6061 and 6063 pipe
MIL-DTL-45225	5083, 5456 and 7039 forged armor
MIL-DTL-46027	5083 and 5456 armor plate
MIL-DTL-46063	7039 armor plate
MIL-DTL-46083	5083, 5456, 2219 and 7039 extruded armor
MIL-DTL-46118	2219 armor plate and forgings
MIL-DTL-46192	2519 armor plate
	THE AMERICAN WELDING SOCIETY (AWS)
A5.3/A5.3M	Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Gas Metal Arc Welding
A5.10/A5.10M	Specification for Bare Aluminum and Aluminum Welding Electrodes and Rods, 1100, 2319, 4043, 4047, 4145, 4643, 5183, 5356, 5554, 5556, 5654
C2.25/C2.25M	Thermal Spray - Solid and Composite Wire and Ceramic Rods
	AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
B36.10M	Standard dimensions for welded and seamless (steel) pipe
B36.19M	Standard dimensions for (stainless steel) pipe
SB-209	1060, 1100, 3003, Alclad 3003, 3004, Alclad 3004, 5052, 5083, 5086, 5154, 5254, 5454, 5456, 5652, 6061, and Alclad 6061 sheet and plate
SB-210	1060, 3003, Alclad 3003, 5052, 5154, 6061, and 6063 drawn seamless tube
SB-211	2014, 2024, and 6061 rolled, drawn, or cold finished wire, rod and bar
SB-221	1060, 1100, 2024, 3003, 5083, 5086, 5154, 5454, 5456, 6005A, 6061 and 6063 extruded rod, bar and shapes
SB-234	1060, 3003, Alclad 3003, 5052, 5454, and 6061 drawn, seamless tube for condensers and heat exchangers
SB-241/SB-241M	3003, 6061 and 6063 seamless pipe; 1060, 1100, 3003, Alclad 3003, 5052, 5083, 5086, 5454, 5456, 6061 and 6063 seamless extruded tube
SB-247	5083 and 6061 hand forgings; 2014, 3003, 5083 and 6061 die forgings
SB-308/SB-308M	6061 rolled or extruded standard structural shapes

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED
	AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
B209	1060, 1100, 2014, Alclad 2014, 2024, Alclad 2024, Alclad one side 2024, 2124, 2219, Alclad 2219, 3003, Alclad 3003, 3004, Alclad 3004, 3005, 3105, 5005, 5050, 5052, 5083, 5086, 5154, 5252, 5254, 5454, 5456, 5457, 5652, 5657, 6061, Alclad 6061, 7075, Alclad 7075, Alclad one side 7075, 7178, and Alclad 7178 sheet and plate
B210	1060, 1100, 2011, 2014, 2024, 3003, Alclad 3003, 5005, 5050, 5052,5083, 5086, 5154, 5456, 6061, 6063, 6262 and 7075 drawn seamless tube
B211	1060, 1100, 2011, 2014, 2017, 2024, 2219, 3003, 5052,5056, 5154, 6061, 6063, 6262 and 7075 rolled, drawn or cold finished wire, rod and bar
B221	1060, 1100, 2014, 2024, 2219, 3003, Alclad 3003, 3004, 3102, 5052,5083, 5086, 5154, 5454, 5456, 6005, 6005A, 6060, 6061, 6063, 6066, 6070, 6105, 6162, 6262, 6351, 6463, 7005, 7072, 7075, 7116, 7129 and 7178 extruded wire, rod, bar, shapes and tube
B230/B230M	1350-H19 wire
B231/B231M	Aluminum conductors, concentric-lay-stranded
B232/B232M	1350 Aluminum conductors, steel reinforced, concentric-lay-stranded (ACSR)
B233	1350 drawing stock for electrical purposes
B234	1060, 3003, Alclad 3003, 5052, 5454, and 6061 drawn, seamless tube for condensers and heat exchangers
B236	1350 bus conductor
B241/B241M	3003, 6061, 6063, and 6351 seamless pipe; 1060, 1100, 2014, 2024, 2219, 3003, Alclad 3003, 5052, 5083, 5086, 5254, 5454, 5456, 5652, 6061, 6063, 6351, 7075, and 7178 seamless extruded tube
B247	2014, 2219, 2618, 5083, 6061, 7049, 7050, 7075, and 7175 hand forgings; 1100, 2014, 2018, 2025, 2218, 2219, 2618, 3003, 4032, 5083, 6061, 6066, 6151, 7049, 7050, 7075, 7076 and 7175 die forgings; 2014, 2219, 2618, 6061, 6151, and 7075 rolled ring forgings
B308/B308M	6061 rolled or extruded standard structural shapes
B313/B313M	1100, 3003, 3004, Alclad 3004, 5050, 5052, 5086, 5154, and 6061 round welded tube
B316/B316M	1100, 2017, 2024, 2117, 2219, 3003, 5005, 5052, 5056, 6053, 6061, 7050, 7075 and 7178 rivet and cold heading wire and rod
B317/B317M	6101 extruded rod, bar, structural shapes and pipe for electrical purposes
B324	1350 rectangular and square wire
B345/B345M	3003, 6061, 6063, and 6351 seamless pipe; 1060, 3003, Alclad 3003, 5083, 5086, 6061, 6063, 6070, and 6351 seamless extruded tube
B373	1145 and 1235 foil for capacitors
B398/B398M	6201-T81 wire for electrical purposes
B399/B399M	Concentric-lay-stranded, 6201-T81 conductors
B400	Compact round concentric-lay-stranded, 1350 conductors, hard-drawn
B401	1350 Compact round concentric-lay-stranded aluminum conductors, steel reinforced (ACSR)
B404/B404M	1060, 3003, Alclad 3003, 5052, 5454, and 6061 seamless condenser and heat exchanger tube with integral fins
B429	6061 and 6063 extruded structural pipe and tube
B479	1100, 1145, and 1235 foil for flexible barrier
B483/B483M	1060, 1100, 1435, 3003, 5005, 5050, 5052, 6061, 6063 and 6262 drawn tube
B491/B491M	1050, 1100, 1200, 1235, 3003 and 6063 extruded round coiled tube
B547/B547M	1100, 3003, Alclad 3003, 3004 Alclad 3004, 5050, 5052, 5083, 5086, 5154, 5454 and 6061 formed and arc welded round tube

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TABLE 1.4 Specifications Covering Aluminum Mill Products ① ②

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED
B609/B609M	Aluminum 1350 round wire, annealed and intermediate tempers, for electrical purposes
B632/B632M	Aluminum-alloy 6061 rolled tread plate
B660	Packaging/Packing of Aluminum and Magnesium Products
B666/B666M	Practice for Identification Marking of Aluminum Products
B928/B928M	High Magnesium Aluminum Alloy Sheet and Plate for Marine Service
SAE — AEROSPACE MATERIAL SPECIFICATIONS (AMS)	
2469	Process and Performance Requirement for Hard-Anodic Coating Treatment of Aluminum Alloys
2470	Chromic-Acid Anodizing of Aluminum Alloys
2471	Undyed Coating Sulfuric-Acid Process, Anodizing of Aluminum Alloys
2472	Dyed Coating Sulfuric-Acid Anodizing of Aluminum Alloys
2473	Chemical Film Treatment for Aluminum Alloys, General Purpose Coating
2474	Low Electrical Resistant Coating, Chemical Treatments for Aluminum Alloys
2808	Identification Markings for Forgings
2816	Color Code identification Marking of Welding Wire
4000 ③	1060-O Sheet and Plate
4001	1100-O Sheet and Plate
4003	1100-H14 Sheet and Plate
4004	5052-H191 Foil
4005 ③	5056-H191 Foil
4006	3003-O Sheet and Plate
4008	3003-H14 Sheet and Plate
4009 ③	6061-O Foil
4010	3003-H18 Foil
4011	1145-O Foil
4013	Laminated Shim Stock, Surface Bonded
4015	5052-O Sheet and Plate
4016	5052-H32 Sheet and Plate
4017	5052-H34 Sheet and Plate
4021 ③	Alclad 6061-O Sheet and Plate
4025	6061-O Sheet and Plate
4026	6061-T4 and T451 Sheet and Plate
4027	6061-T6 and T651 Sheet and Plate
4028	2014-O Sheet and Plate
4029	2014-T6 Sheet and 2014-T651 Plate
4031	2219-O Sheet and Plate
4035	2024-O Sheet and Plate
4036	Alclad one side 2024-T3 Sheet and T351 Plate
4037	2024-T3 Sheet and T351 Plate
4040	Alclad 2024-O and 1½% Alclad 2024-O Sheet and Plate
4041	Alclad 2024 and 1½% Alclad 2024-T3 Flat Sheet; Alclad 2024-T351 Plate
4044	7075-O Sheet and Plate
4045	7075-T6 Sheet and T651 Plate
4046	Alclad One Side 7075-T6 Sheet and Alclad One Side, 7075-T651 Plate
4048	Alclad 7075-O Sheet and Plate
4049	Alclad 7075-T6 Sheet and Alclad 7075-T651 Plate
4050	7050-T7451 (formerly T73651) Plate
4056	5083-O Sheet and Plate
4062	1100-H14 Drawn Seamless Tube
4063	Clad One Side 3003 Sheet (Brazing Sheet No. 11-O)
4064	Clad Two Sides 3003 Sheet (Brazing Sheet No. 12-O)
4065	3003-O Drawn Tube, Seamless
4066	2219-T851 Drawn Tube, Seamless
4067	3003-H14 Drawn Tube, Seamless
4068	2219-T351 Drawn Tube, Seamless
4069	5052-O Drawn Tube, Special Tolerances, Seamless
4070	5052-O Drawn Tube, Seamless
4071	5052-O Drawn, Hydraulic Tube, Seamless
4077	Alclad one side 2024-O Sheet and Plate
4078	7075-T7351 Plate
4079	6061-O Drawn Seamless Tube, Special Tolerances
4080	6061-O Drawn Seamless Tube
4081	6061-T4 Drawn, Seamless Hydraulic Tube
4082	6061-T6 Seamless Drawn Tube
4083	6061-T6 Drawn, Seamless Hydraulic Tube
4084	7475-T61 Sheet
4085	7475-T761 Sheet
4086	2024-T3 Drawn, Seamless Hydraulic Tube
4087	2024-O Drawn Seamless Tube
4088	2024-T3 Drawn Seamless Tube
4089	7475-T7651 Plate
4090	7475-T651 Plate
4094	Alclad 2219-T81 Sheet and T851 Plate
4095	Alclad 2219-T31 Sheet and T351 Plate
4096	Alclad 2219-O Sheet and Plate
4100	Alclad 7475-T761 Sheet
4101	2124-T851 Plate
4107	7050-T74 (formerly T736) Die Forgings
4108	7050-T7452 (formerly T73652) Hand Forgings
4111	7049-T73 Forgings and Forging Stock
4113	6061-T6 Extruded Profiles
4114	5052-F Rolled or Cold Finished, Rods and Bars
4115	6061-O Rolled, Drawn or Cold Finished Wire, Rod, Bar and Flash Welded Rings
4116	6061-T4 Cold Finished Wire, Rod and Bar
4117	6061-T6 and T651 Rolled or Cold Finished Wire, Rod, Bar and Flash Welded Rings
4118	2017-T4 and T451 Rolled Cold Finished Wire, Rod and Bar
4120	2024-T4 and T351 Rolled or Cold Finished Wire, Rod and Bar
4121	2014-T6 Rolled or Cold Finished Wire, Rod and Bar
4122	7075-T6 Rolled or Cold Finished Wire, Rod, Bar and Rings
4123	7075-T651 Rolled or Cold Finished Rod and Bar
4124	7075-T7351 Rolled or Cold Finished Bars, Rods and Wire
4125	6151-T6 Die Forgings and Rolled or Forged Rings
4126	7075-T6 Die and Hand Forgings and Rolled Rings
4127	6061-T6 Forgings and Rolled or Forged Rings
4128	6061-T451 Bars, Rolled or Cold Finished
4130	2025-T6 Die Forgings
4131	7075-T74 Die and Hand Forgings
4132	2618-T61 Die and Hand Forgings, Rolled Rings and Forging Stock
4133	2014-T6 Forgings and Rolled Rings
4134	2014-T4 Die Forgings
4140	2018-T61 Die Forgings
4141	7075-T73 Die Forgings
4143	2219-T6 Forgings and Rolled or Forged Rings
4144	2219-T852 and -T851 Hand Forgings and Rings
4146 ③	6061-T4 Forgings and Rolled or Forged Rings
4147	7075-T7352 Forgings
4148	7175-T66 Die Forgings
4149	7175-T74 Die and Hand Forgings
4150	6061-T6 Extrusions and Rings
4152	2024-T3 Extrusions
4153	2014-T6 Extrusions
4154	7075-T6 Extrusions
4156	6063-T6 Extrusions
4157	7049-T73511 Extrusions
4159	7049-T76511 Extrusions
4160	6061-O Extrusions
4161	6061-T4 Extrusions
4162	2219-T8511 Extrusions
4163	2219-T3511 Extrusions
4164	2024-T3510 Extrusions
4165	2024-T3511 Extrusions
4166	7075-T73 Extrusions
4167	7075-T73511 Extrusions
4168	7075-T6510 Extrusions
4169	7075-T6511 Extrusions
4172	6061-T4511 Extrusions
4173	6061-T6511 Extrusions
4179	7175-T7452 Forgings
4180	1100-H18 Wire for Metal Spraying
4184	4145 Brazing Filler Metal
4185	4047 Brazing Filler Metal
4186	7075-F Wire, Rod and Bar ; Rolled or Cold Finished
4187 ③	7075-O Wire, Rod and Bar ; Rolled, Drawn or Cold Finished
4189	4643 Welding Wire

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TABLE 1.4 Specifications Covering Aluminum Mill Products ① ②

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED
4190	4043 Welding Wire
4191	2319 Welding Wire
4193	2024-T861 Sheet and Plate
4194 ③	Alclad 2024-T361 Sheet and Plate
4195	Alclad 2024-T861 Sheet and Plate
4200	7049-T7351 Plate
4201	7050-T7651 Plate
4202	7475-T7351 Plate
4203	7010-T7351 Plate
4204	7010-T7651 Plate
4205	7010-T7451 (formerly T73651) Plate
4206	7055-T7751 Plate
4207	Alclad 7475-T61 Sheet
4208	2004-F Sheet
4209	Alclad 2004-F Sheet
4221	2124-T8151 Plate
4232	2090-T86 Extrusions
4243	Alclad 7050-T76 Sheet
4247	7049-T7352 Hand Forgings
4248	6061-T652 Hand Forgings and Rolled Rings
4251	2090-T83 Sheet
4252	7150-T7751 Plate
4255	Clad One Side 6951 Sheet (No. 21 Brazing Sheet) As Fabricated
4256	Clad Two Sides 6951 Sheet (No. 22 Brazing Sheet) As Fabricated
4259 ③	8090-T6 Sheet (Unrecrystallized)
4270	Alclad 2424-T3 Sheet
4273	2424-T3 Sheet and Plate
4274	Alclad 2424-O Sheet, Fine Grained
4276	2424-O Sheet, Fine Grained
4277	7075-O Sheet, Fine Grained
4278	Alclad 7075-O Sheet, Fine Grained
4279	Alclad 2024-T4 Sheet
4295	2219 Sheet and Plate
4296	Alclad 2524-T3 Sheet and Plate
4297	2024-T4 Sheet
4303	2090-T81 Plate
4306	7150-T6151 Plate
4307 ③	7150-T61511 Extrusions
4308 ③	8009-H112 Sheet
4309 ③	8009-H112 Extrusions
4310	7075-T651 and T652 Rings, Forged or Rolled
4311	7075-T7351 and T7352 Rings, Forged or Rolled
4312	6061-T651 and T652 Rings, Rolled or Forged
4313	2219-T351 and T352 Rings, Forged or Rolled
4314	2014-T651 and T652 Rings, Forged or Rolled
4319	4032-T651 Rolled or Cold Finished Bars and Rods
4320	7149-T73 Forgings
4321	7049-O1 Forgings
4323	7075-T7452 Hand Forgings
4333	7050-T7452 Die Forgings
4334 ③	7249-T74 and T7452 Forgings
4337	7055-T77511 Extruded Profiles
4339	2024-T851 Rolled or Cold Finished Bars and Rods
4340	7050-T76511 Extrusions
4341	7050-T73511 Extrusions
4342	7050-T74511 (formerly T736511) Extrusions
4343	7149-T73511 Extrusions
4344	7175-T73511 Extrusions
4345	7150-T77511 Extrusions
4347	6013-T4 Sheet
AMS-QQ-A-200	Aluminum Alloy, Bar, Rod, Shapes, Structural Shapes, Tube and Wire, Extruded, General Specification for
AMS-QQ-A-200/1	3003, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/2	2014, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/3	2024, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/4	5083, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/5	5086, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/6	5454, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/7	5456, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/8	6061, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/9	6063, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/10	6066, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/11	7075, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/13	7178, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-200/14	7178-T76, Bar, Rod, Shapes and Wire, Extruded (Exfoliation Resistant)
AMS-QQ-A-200/15	7075-T76, Bar, Rod and Shapes, Extruded (Exfoliation Resistant)
AMS-QQ-A-200/16	6061, Structural Shapes, Extruded
AMS-QQ-A-200/17	6162, Bar, Rod, Shapes, Tube and Wire, Extruded
AMS-QQ-A-225	Aluminum and Aluminum Alloy, Bar, Rod, Wire, or Special Shapes; Rolled, Drawn or Cold Finished; General Specification for
AMS-QQ-A-225/1	1100 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/2	3003 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/3	2011 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/4	2014 Aluminum Alloy, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/5	2017 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/6	2024 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/7	5052 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/8	6061 Aluminum Alloy, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/9	7075 Aluminum Alloy, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn or Cold Finished
AMS-QQ-A-225/10	6262 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
AMS-QQ-A-250	Aluminum and Aluminum Alloy, Plate and Sheet, General Specification for
AMS-QQ-A-250/1	1100 Aluminum Sheet and Plate
AMS-QQ-A-250/2	3003 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/3	Alclad 2014 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/4	2024 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/5	Alclad 2024 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/6	5083 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/7	5086 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/8	5052 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/9	5456 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/10	5454 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/11	6061 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/12	7075 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/13	Alclad 7075 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/14	7178 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/15	Alclad 7178 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/18	Alclad One Side 7075 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/19	5086 Aluminum Alloy Plate and Sheet for Seawater Applications
AMS-QQ-A-250/20	5456 Aluminum Alloy Plate and Sheet for Seawater Applications
AMS-QQ-A-250/21	7178-T76 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
AMS-QQ-A-250/22	Alclad 7178-T76 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
AMS-QQ-A-250/24	7075 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
AMS-QQ-A-250/25	Alclad 7075 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
AMS-QQ-A-250/26	7075, Alclad 7011 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/28	7178, Alclad 7011 Aluminum Alloy Plate and Sheet
AMS-QQ-A-250/29	2124 Aluminum Alloy Plate
AMS-QQ-A-250/30	2219 Aluminum Alloy Plate and Sheet
AMS-H-6088	Heat Treatment of Wrought Aluminum Alloys
AMS-B-20148	4045 and 4343 Brazing Sheet
AMS-A-22771	Aluminum Alloy Forgings, Heat Treated
AMS-A-81596	2024, 3003, 5052 and 5056 Foil

SAE — AEROSPACE STANDARDS (AS)

7220	1100-H14 Rivets
7222	2117-T4 Rivets

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

C80.5	Aluminum Alloy Rigid Conduit
H35.1	Alloy and Temper Designation Systems for Wrought Aluminum
H35.2	Dimensional Tolerances for Aluminum Mill Products

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2. Typical Properties

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

TABLE 2.1 Typical Mechanical Properties ① ②

ALLOY AND TEMPER	TENSION				HARDNESS	SHEAR	FATIGUE	MODULUS
	STRENGTH MPa		ELONGATION percent		BRINNELL NUMBER	ULTIMATE SHEARING STRENGTH	ENDURANCE ③ LIMIT	MODULUS ④ OF ELASTICITY MPa × 10^3
			in 50 mm	in 5D				
	ULTIMATE	YIELD	1.60 mm Thick Specimen	12.5 mm Diameter Specimen	500 kgf load 10 mm ball	MPa	MPa	
1060-O	70	30	43	..	19	50	20	69
1060-H12	85	75	16	..	23	55	30	69
1060-H14	100	90	12	..	26	60	35	69
1060-H16	115	105	8	..	30	70	45	69
1060-H18	130	125	6	..	35	75	45	69
1100-O	90	35	35	42	23	60	35	69
1100-H12	110	105	12	22	28	70	40	69
1100-H14	125	115	9	18	32	75	50	69
1100-H16	145	140	6	15	38	85	60	69
1100-H18	165	150	5	13	44	90	60	69
1350-O	85	30	..	..⑤	..	55	..	69
1350-H12	95	85	..	..	..	60	..	69
1350-H14	110	95	..	..	..	70	..	69
1350-H16	125	110	..	..	..	75	..	69
1350-H19	185	165	..	..⑥	..	105	50	69
2011-T3	380	295	..	13	95	220	125	70
2011-T8	405	310	..	10	100	240	125	70
2014-O	185	95	..	16	45	125	90	73
2014-T4, T451	425	290	..	18	105	260	140	73
2014-T6, T651	485	415	..	11	135	290	125	73
Alclad 2014-O	170	70	21	..	..	125	..	73
Alclad 2014-T3	435	275	20	..	..	255	..	73
Alclad 2014-T4, T451	421	255	22	..	..	255	..	73
Alclad 2014-T6, T651	470	415	10	..	..	285	..	73
2017-O	180	70	..	20	45	125	90	73
2017-T4, T451	425	275	..	20	105	260	125	73
2018-T61	420	315	..	10	120	270	115	74
2024-O	185	75	20	20	47	125	90	73
2024-T3	485	345	18	..	120	285	140	73
2024-T4, T351	472	325	20	17	120	285	140	73
2024-T361 ⑦	495	395	13	..	130	290	125	73
Alclad 2024-O	180	75	20	..	..	125	..	73
Alclad 2024-T3	450	310	18	..	..	275	..	73
Alclad 2024-T4, T351	440	290	19	..	..	275	..	73
Alclad 2024-T361 ⑦	460	365	11	..	..	285	..	73
Alclad 2024-T81, T851	450	415	6	..	..	275	..	73
Alclad 2024-T861 ⑦	485	455	6	..	..	290	..	73
2025-T6	400	255	..	17	110	240	125	72
2036-T4	340	195	24	..	..	205	125 ⑨	71
2117-T4	295	165	..	24	70	195	95	71
2124-T851	485	440	..	8	..	..	..	73
2218-T72	330	255	..	9	95	205	..	74
2219-O	170	75	18	..	..	..	..	73
2219-T42	360	185	20	..	..	..	..	73
2219-T31, T351	360	250	17	..	..	..	..	73
2219-T37	395	315	11	..	..	..	..	73
2219-T62	415	290	10	..	..	..	105	73
2219-T81, T851	455	350	10	..	..	..	105	73
2219-T87	475	395	10	..	..	..	105	73
2618-T61	440	370	..	10	115	260	90	73
3003-O	110	40	30	37	28	75	50	69
3003-H12	130	125	10	18	35	85	55	69
3003-H14	150	145	8	14	40	95	60	69
3003-H16	175	170	5	12	47	105	70	69
3003-H18	200	185	4	9	55	110	70	69

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TABLE 2.1 Typical Mechanical Properties ① ② (continued)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TENSION				HARDNESS	SHEAR	FATIGUE	MODULUS
	STRENGTH MPa		ELONGATION percent		BRINNELL NUMBER	ULTIMATE SHEARING STRENGTH	ENDURANCE ③ LIMIT	MODULUS ④ OF ELASTICITY MPa × 10^3
			in 50 mm	in 5D				
	ULTIMATE	YIELD	1.60 mm Thick Specimen	12.5 mm Diameter Specimen	500 kgf load 10 mm ball	MPa	MPa	
Alclad 3003-O	110	40	30	37	..	75	..	69
Alclad 3003-H12	130	125	10	18	..	85	..	69
Alclad 3003-H14	150	145	8	14	..	95	..	69
Alclad 3003-H16	175	170	5	12	..	105	..	69
Alclad 3003-H18	200	185	4	9	..	110	..	69
3004-O	180	70	20	22	45	110	95	69
3004-H32	215	170	10	15	52	115	105	69
3004-H34	240	200	9	10	63	125	105	69
3004-H36	260	230	5	8	70	140	110	69
3004-H38	285	250	5	5	77	145	110	69
Alclad 3004-O	180	70	20	22	..	110	..	69
Alclad 3004-H32	215	170	10	15	..	115	..	69
Alclad 3004-H34	240	200	9	10	..	125	..	69
Alclad 3004-H36	260	230	5	8	..	140	..	69
Alclad 3004-H38	285	250	5	5	..	145	..	69
3105-O	115	55	24	..	..	85	..	69
3105-H12	150	130	7	..	..	95	..	69
3105-H14	170	150	5	..	..	105	..	69
3105-H16	195	170	4	..	..	110	..	69
3105-H18	215	195	3	..	..	115	..	69
3105-H22	165	140	11	..	..	95	..	69
3105-H24	180	150	10	..	..	105	..	69
3105-H25	185	160	9	..	..	105	..	69
3105-H26	195	165	9	..	..	110	..	69
3105-H28	205	180	8	..	..	115	..	69
4032-T6	380	315	..	9	120	260	110	79
5005-O	125	40	25	..	28	75	..	69
5005-H12	140	130	10	..	..	95	..	69
5005-H14	160	150	6	..	..	95	..	69
5005-H16	180	170	5	..	..	105	..	69
5005-H18	200	195	4	..	..	110	..	69
5005-H32	140	115	11	..	36	95	..	69
5005-H34	160	140	8	..	41	95	..	69
5005-H36	180	165	6	..	46	105	..	69
5005-H38	200	185	5	..	51	110	..	69
5050-O	145	55	24	..	36	105	85	69
5050-H32	170	145	9	..	46	115	90	69
5050-H34	190	165	8	..	53	125	90	69
5050-H36	205	180	7	..	58	130	95	69
5050-H38	220	200	6	..	63	140	95	69
5052-O	195	90	25	27	47	125	110	70
5052-H32	230	195	12	16	60	140	115	70
5052-H34	260	215	10	12	68	145	125	70
5052-H36	275	240	8	9	73	160	130	70
5052-H38	290	255	7	7	77	165	140	70
5056-O	290	150	..	32	65	180	140	71
5056-H18	435	405	..	9	105	235	150	71
5056-H38	415	345	..	13	100	220	150	71
5083-O	290	145	..	20	..	170	..	71
5083-H32 ⑪	315	230	..	14	..	..	160	71
5083-H116 ⑪	315	230	..	14	..	..	160	71
5083-H321 ⑪	315	230	..	14	..	..	160	71
5086-O	260	115	22	..	..	165	..	71
5086-H32	290	205	12	..	..	..	..	71
5086-H116 ⑪	290	205	12	..	..	..	..	71
5086-H34	325	255	10	..	..	185	..	71
5086-H112	270	130	14	..	..	..	..	71

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TABLE 2.1 Typical Mechanical Properties ① ② (continued)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TENSION				HARDNESS	SHEAR	FATIGUE	MODULUS
	STRENGTH MPa		ELONGATION percent in 2 in.		BRINNELL NUMBER	ULTIMATE SHEARING STRENGTH	ENDURANCE ③ LIMIT	MODULUS ④ OF ELASTICITY MPa × 10^3
			in 50 mm	in 5D				
	ULTIMATE	YIELD	1.60 mm Thick Specimen	12.5 mm Diameter Specimen	500 kgf load 10 mm ball	MPa	MPa	
5154-O	240	115	27	..	58	150	115	70
5154-H32	270	205	15	..	67	150	125	70
5154-H34	290	230	13	..	73	165	130	70
5154-H36	310	250	12	..	78	180	140	70
5154-H38	330	270	10	..	80	195	145	70
5154-H112	240	115	25	..	63	..	115	70
5252-H25	235	170	11	..	68	145	..	69
5252-H38, H28	285	240	5	..	75	160	..	69
5254-O	240	115	27	..	58	150	115	70
5254-H32	270	205	15	..	67	150	125	70
5254-H34	290	230	13	..	73	165	130	70
5254-H36	310	250	12	..	78	180	140	70
5254-H38	330	270	10	..	80	195	145	70
5254-H112	240	115	25	..	63	..	115	70
5454-O	250	115	22	..	62	160	..	70
5454-H32	275	205	10	..	73	165	..	70
5454-H34	305	240	10	..	81	180	..	70
5454-H111	260	180	14	..	70	160	..	70
5454-H112	250	125	18	..	62	160	..	70
5456-O	310	160	..	22	..	..	..	71
5456-H32 ⑪	350	255	..	14	90	205	..	71
5456-H25	310	165	..	20	..	..	..	71
5456-H116 ⑪	350	255	..	14	90	205	..	71
5456-H321 ⑪	350	255	..	14	90	205	..	71
5457-O	130	50	22	..	32	85	..	69
5457-H25	180	160	12	..	48	110	..	69
5457-H38, H28	205	185	6	..	55	125	..	69
5652-O	195	90	25	27	47	125	110	70
5652-H32	230	195	12	16	60	140	115	70
5652-H34	260	215	10	12	68	145	125	70
5652-H36	275	240	8	9	73	160	130	70
5652-H38	290	255	7	7	77	165	140	70
5657-H25	160	140	12	..	40	95	..	69
5657-H38, H28	195	165	7	..	50	105	..	69
6005A-T1	..	..	..	..	..	..	..	..
6005A-T5	290	260	10	..	90	..	95	69
6005-T61	310	275	12	..	95	205	95	69
6061-O	125	55	25	27	30	85	60	69
6061-T4, T451	240	145	22	22	65	165	95	69
6061-T6, T651	310	275	12	15	95	205	95	69
Alclad 6061-O	115	50	25	..	..	75	..	69
Alclad 6061-T4, T451	230	130	22	..	..	150	..	69
Alclad 6061-T6, T651	290	255	12	..	..	185	..	69
6063-O	90	50	..	..	25	70	55	69
6063-T1	150	90	20	..	42	95	60	69
6063-T4	170	90	22	..	..	..	..	69
6063-T5	185	145	12	..	60	115	70	69
6063-T6	240	215	12	..	73	150	70	69
6063-T83	255	240	9	..	82	150	..	69
6063-T831	205	185	10	..	70	125	..	69
6063-T832	290	270	12	..	95	185	..	69
6066-O	150	85	..	16	43	95	..	69
6066-T4, T451	360	205	..	16	90	200	..	69
6066-T6. T651	395	360	..	10	120	235	110	69
6070-T6	380	350	10	..	..	235	95	69
6082-T6, T6511	340	315	12	14	95	215	95	69
6101-H111	95	75	..	..	..	..	..	69
6101-T6	220	195	15 ⑧	..	71	140	..	69
6262-T9	400	380	..	9	120	240	90	69
6351-T4	250	150	20	..	..	..	..	69
6351-T6	310	285	14	..	95	200	90	69

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TABLE 2.1 Typical Mechanical Properties ① ② (concluded)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TENSION				HARDNESS	SHEAR	FATIGUE	MODULUS
	STRENGTH MPa		ELONGATION percent		BRINNELL NUMBER	ULTIMATE SHEARING STRENGTH	ENDURANCE ③ LIMIT	MODULUS ④ OF ELASTICITY MPa · 10^3
	ULTIMATE	YIELD	in 50 mm	in 5D	500 kgf load 10 mm ball	MPa	MPa	
			1.60 mm	12.5 mm				
6463-T1	150	90	20	..	42	95	70	69
6463-T5	185	145	12	..	60	115	70	69
6463-T6	240	215	12	..	74	150	70	69
7049-T73	515	450	..	10	135	305	..	72
7049-T7352	515	435	..	9	135	295	..	72
7050-T73510, T73511	495	435	..	11	..	..	..	72
7050-T7451 ⑩	525	470	..	10	..	305	..	72
7050-T7651	550	490	..	10	..	325	..	72
7075-O	230	105	17	14	60	150	..	72
7075-T6, T651	570	505	11	9	150	330	160	72
Alclad 7075-O	220	95	17	..	..	150	..	72
Alclad 7075-T6, T651	525	460	11	..	..	315	..	72
7175-T74	525	455	..	10	135	290	160	72
7178-O	230	105	15	14	..	..	..	72
7178-T6, T651	605	540	10	9	..	..	..	72
7178-T76, T7651	570	505	..	9	..	..	..	71
Alclad 7178-O	220	95	16	..	..	..	..	72
Alclad 7178-T6, T651	560	460	10	..	..	..	..	72
7475-T61	565	490	11	..	..	..	..	70
7475-T651	585	510	..	13	..	..	..	72
7475-T7351	495	420	..	13	..	..	..	72
7475-T761	515	450	12	..	..	..	..	70
7475-T7651	530	460	..	12	..	..	..	72
Alclad 7475-T61	515	455	11	..	..	..	..	70
Alclad 7475-T761	490	420	12	..	..	..	..	70
8176-H24	160	95	15	..	..	70	..	69

① The mechanical property limits are listed by major product in the "Standards Section" of this manual.
② The indicated typical mechanical properties for all except 0 temper material are higher than the specified minimum properties. For 0 temper products typical ultimate and yield values are slightly lower than specified (maximum) values.
③ Based on 500,000,000 cycles of completely reversed stress using the R.R. Moore type of machine and specimen.
④ Average of tension and compression moduli. Compression modulus is about 2% greater than tension modulus.
⑤ 1350-O wire will have an elongation of approximately 23% in 250 mm.
⑥ 1350-H19 wire will have an elongation of approximately 1½% in 250 mm.
⑦ Tempers T361 and T861 were formerly designated T36 and T86, respectively.
⑧ Based on 6.3 mm. thick specimen.
⑨ Based on 10^7 cycles using flexural type testing of sheet specimens.
⑩ T7451, although not previously registered, has appeared in literature and in some specifications as T73651.
⑪ 5xxx products in the -H116 and -H321 tempers have similar properties and have the same testing requirements, but are produced by different practices. The -H116 and -H321 tempers are typically used in marine and other applications requiring demonstration of intergranular and exfoliation corrosion resistance. Products in the -H32 temper have similar tensile properties and while production methods may be similar, corrosion testing requirements are different; therefore -H32 temper products shall not be substituted for -H116 or -H321 products.

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TABLE 2.2 Typical Tensile Properties at Various Temperatures ①

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
1100-O	–195	170	41	50
	–80	105	38	43
	–30	95	34	40
	25	90	34	40
	100	70	32	45
	150	55	29	55
	205	41	24	65
	260	28	18	75
	315	20	14	80
	370	14	11	85
1100-H14	–195	205	140	45
	–80	140	125	24
	–30	130	115	20
	25	125	115	20
	100	110	105	20
	150	95	85	23
	205	70	50	26
	260	28	18	75
	315	20	14	80
	370	14	11	85
1100-H18	–195	235	180	30
	–80	180	160	16
	–30	170	160	15
	25	165	150	15
	100	145	130	15
	150	125	95	20
	205	41	24	65
	260	28	18	75
	315	20	14	80
	370	14	11	85
2011-T3	25	380	295	15
	100	325	235	16
	150	195	130	25
	205	110	75	35
	260	45	26	45
	315	21	12	90
	370	16	10	125
2014-T6, T651	–195	580	495	14
	–80	510	450	13
	–30	495	425	13
	25	485	415	13
	100	435	395	15
	150	275	240	20
	205	110	90	38
	260	65	50	52
	315	45	34	65
	370	30	24	72
2017-T4, T451	–195	550	365	28
	–80	450	290	24
	–30	440	285	23
	25	425	275	22
	100	395	270	18
	150	275	205	15
	205	110	90	35
	260	60	50	45
	315	41	34	65
	370	30	24	70

For all numbered footnotes, see page 2-9.

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
2024-T3 (Sheet)	–195	585	425	18
	–80	505	360	17
	–30	495	350	17
	25	485	345	17
	100	455	330	16
	150	380	310	11
	205	185	140	23
	260	75	60	55
	315	50	41	75
	370	34	28	100
2024-T4, T351 (plate)	–195	580	420	19
	–80	490	340	19
	–30	475	325	19
	25	470	325	19
	100	435	310	19
	150	310	250	17
	205	180	130	27
	260	75	60	55
	315	50	41	75
	370	34	28	100
2024-T6, T651	–195	580	470	11
	–80	495	405	10
	–30	485	400	10
	25	475	395	10
	100	450	370	10
	150	310	250	17
	205	180	130	27
	260	75	60	55
	315	50	41	75
	370	34	28	100
2024-T81, T851	–195	585	540	8
	–80	510	475	7
	–30	505	470	7
	25	485	450	7
	100	455	425	8
	150	380	340	11
	205	185	140	23
	260	75	60	55
	315	50	41	75
	370	34	28	100
2024-T861	–195	635	585	5
	–80	560	530	5
	–30	540	510	5
	25	515	490	5
	100	485	460	6
	150	370	330	11
	205	145	115	28
	260	75	60	55
	315	50	41	75
	370	34	28	100
2117-T4	–195	385	230	30
	–80	310	170	29
	–30	305	165	28
	25	295	165	27
	100	250	145	16
	150	205	115	20
	205	110	85	35
	260	50	38	55
	315	32	23	80
	370	20	14	110

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TABLE 2.2 Typical Tensile Properties at Various Temperatures ① (continued)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
2124-T851	–268	705	620	10
	–195	595	545	9
	–80	525	490	8
	–30	505	470	8
	25	485	440	9
	100	455	420	9
	150	370	340	13
	205	185	140	28
	260	75	55	60
	315	50	41	75
	370	38	28	100
2218-T61	–195	495	360	15
	–80	420	310	14
	–30	405	305	13
	25	405	305	13
	100	385	290	15
	150	285	240	17
	205	150	110	30
	260	70	41	70
	315	38	21	85
	370	28	17	100
2219-T62	–195	505	340	16
	–80	435	305	13
	–30	415	290	12
	25	400	275	12
	100	370	255	14
	150	310	230	17
	205	235	170	20
	260	185	140	21
	315	70	55	40
	370	30	26	75
2219-T81, T851	–195	570	420	15
	–80	490	370	13
	–30	475	360	12
	25	455	345	12
	100	415	325	15
	150	340	275	17
	205	250	200	20
	160	200	160	21
	315	48	41	55
	370	30	26	75
2618-T61	–195	540	420	12
	–80	460	380	11
	–30	440	370	10
	25	440	370	10
	100	425	370	10
	150	345	305	14
	205	220	180	24
	260	90	60	50
	315	50	31	80
	370	34	24	120
3003-O	–195	230	60	46
	–80	140	50	42
	–30	115	45	41
	25	110	41	40
	100	90	38	43
	150	75	34	47
	205	60	30	60
	260	41	23	65
	315	28	17	70
	370	19	12	70

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
3003-H14	–195	240	170	30
	–80	165	150	18
	–30	150	145	16
	25	150	145	16
	100	145	130	16
	150	125	110	16
	205	95	60	20
	260	50	28	60
	315	28	17	70
	370	19	12	70
3003-H18	–195	285	230	23
	–80	220	200	11
	–30	205	195	10
	25	200	185	10
	100	180	145	10
	150	160	110	11
	205	95	60	18
	260	50	28	60
	315	28	17	70
	370	19	12	70
3004-O	–195	290	90	38
	–80	195	75	30
	–30	180	70	26
	25	180	70	25
	100	180	70	25
	150	150	70	35
	205	95	65	55
	260	70	50	70
	315	50	34	80
	370	34	21	90
3004-H34	–195	360	235	26
	–80	260	205	16
	–30	250	200	13
	25	240	200	12
	100	235	200	13
	150	195	170	22
	205	145	105	35
	260	95	50	55
	315	50	34	80
	370	34	21	90
3004-H38	–195	400	295	20
	–80	305	260	10
	–30	290	250	7
	25	285	250	6
	100	275	250	7
	150	215	185	15
	205	150	105	30
	260	85	50	50
	315	50	34	80
	370	34	21	90
4032-T6	–195	455	330	11
	–80	400	315	10
	–30	385	315	9
	25	380	315	9
	100	345	305	9
	150	255	230	9
	205	90	60	30
	260	55	38	50
	315	34	22	70
	370	23	14	90

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TABLE 2.2 Typical Tensile Properties at Various Temperatures ① (continued)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
5050-O	–195	255	70	..
	–80	150	60	..
	–30	145	55	..
	25	145	55	..
	100	145	55	..
	150	130	55	..
	205	95	50	..
	260	60	41	..
	315	41	29	..
	370	27	18	..
5050-H34	–195	305	205	..
	–80	205	170	..
	–30	195	165	..
	25	195	165	..
	100	195	165	..
	150	170	150	..
	205	95	50	..
	260	60	41	..
	315	41	29	..
	370	27	18	..
5050-H38	–195	315	250	..
	–80	235	205	..
	–30	220	200	..
	25	220	200	..
	100	215	200	..
	150	185	170	..
	205	95	50	..
	260	60	41	..
	315	41	29	..
	370	27	18	..
5052-O	–195	305	110	46
	–80	200	90	35
	–30	195	90	32
	25	195	90	30
	100	195	90	36
	150	160	90	50
	205	115	75	60
	260	85	50	80
	315	50	38	110
	370	34	21	130
5052-H34	–195	380	250	28
	–80	275	220	21
	–30	260	215	18
	25	260	215	16
	100	260	215	18
	150	205	185	27
	205	165	105	45
	260	85	50	80
	315	50	38	110
	370	34	21	130
5052-H38	–195	415	305	25
	–80	305	260	18
	–30	290	255	15
	25	290	255	14
	100	275	250	16
	150	235	195	24
	205	170	105	45
	260	85	50	80
	315	50	38	110
	370	34	21	130

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
5083-O	–195	405	165	36
	–80	295	145	30
	–30	290	145	27
	25	290	145	25
	100	275	145	36
	150	215	130	50
	205	150	115	60
	260	115	75	80
	315	75	50	110
	370	41	29	130
5083-H32	25	315	230	14
5086-O	–195	380	130	46
	–80	270	115	35
	–30	260	115	32
	25	260	115	30
	100	260	115	36
	150	200	110	50
	205	150	105	60
	260	115	75	80
	315	75	50	110
	370	41	29	130
5154-O	–195	360	130	46
	–80	250	115	35
	–30	240	115	32
	25	240	115	30
	100	240	115	36
	150	200	110	50
	205	150	105	60
	260	115	75	80
	315	75	50	110
	370	41	29	130
5254-O	–195	360	130	46
	–80	250	115	35
	–30	240	115	32
	25	240	115	30
	100	240	115	36
	150	200	110	50
	205	150	105	60
	260	115	75	80
	315	75	50	110
	370	41	29	130
5454-O	–195	370	130	39
	–80	255	115	30
	–30	250	115	27
	25	250	115	25
	100	250	115	31
	150	200	110	50
	205	150	105	60
	260	115	75	80
	315	75	50	110
	370	41	29	130
5454-H32	–195	405	250	32
	–80	290	215	23
	–30	285	205	20
	25	275	205	18
	100	270	200	20
	150	220	180	37
	205	170	130	45
	260	115	75	80
	315	75	50	110
	370	41	29	130

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TABLE 2.2 Typical Tensile Properties at Various Temperatures ① (continued)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
5454-H34	–195	435	285	30
	–80	315	250	21
	–30	305	240	18
	25	305	240	16
	100	295	235	18
	150	235	195	32
	205	180	130	45
	260	115	75	80
	315	75	50	110
	370	41	29	130
5456-O	–195	425	180	32
	–80	315	160	25
	–30	310	160	22
	25	310	160	20
	100	290	150	31
	150	215	140	50
	205	150	115	60
	260	115	75	80
	315	75	50	110
	370	41	29	130
5456-H32	25	350	255	14
5652-O	–195	305	110	46
	–80	200	90	35
	–30	195	90	32
	25	195	90	30
	100	195	90	30
	150	160	90	50
	205	115	75	60
	260	85	50	80
	315	50	38	110
	370	34	21	130
5652-H34	–195	380	250	28
	–80	275	220	21
	–30	260	215	18
	25	260	215	16
	100	260	215	18
	150	205	185	27
	205	165	105	45
	260	85	50	80
	315	50	38	110
	370	34	21	130
5652-H38	–195	415	305	25
	–80	305	260	18
	–30	290	255	15
	25	290	255	14
	100	275	250	16
	150	235	195	24
	205	170	105	45
	260	85	50	80
	315	50	38	110
	370	34	21	130
6005A-T5	25	290	260	10
6005A-T61	25	310	275	12
6053-T6, T651	25	255	220	13
	100	220	195	13
	150	170	165	13
	205	90	85	25
	260	38	28	70
	315	28	19	80
	370	20	14	90

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
6061-T6, T651	–195	415	325	22
	–80	340	290	18
	–30	325	285	17
	25	310	275	17
	100	290	260	18
	150	235	215	20
	205	130	105	28
	260	50	34	60
	315	32	19	85
	370	21	12	95
6063-T1	–195	235	110	44
	–80	180	105	36
	–30	165	95	34
	25	150	90	33
	100	150	95	18
	150	145	105	20
	205	60	45	40
	260	31	24	75
	315	22	17	80
	370	16	14	105
6063-T5	–195	255	165	28
	–80	200	150	24
	–30	195	150	23
	25	185	145	22
	100	165	140	18
	150	140	125	20
	205	60	45	40
	260	31	24	75
	315	22	17	80
	370	16	14	105
6063-T6	–195	325	250	24
	–80	260	230	20
	–30	250	220	19
	25	240	215	18
	100	215	195	15
	150	145	140	20
	205	60	45	40
	260	31	24	75
	315	23	17	80
	370	16	14	105
6082-T6, T6511	–195	525	425	17
	–80	420	360	13
	–30	350	340	..
	25	340	315	14
	100	330	310	..
	150	330	310	..
	205	105	75	..
	260	..	..	..
	315	..	..	..
	370	..	..	..
6101-T6	–195	295	230	24
	–80	250	205	20
	–30	235	200	19
	25	220	195	19
	100	195	170	20
	150	145	130	20
	205	70	48	40
	260	33	23	80
	315	21	16	100
	370	17	12	105

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TABLE 2.2 Typical Tensile Properties at Various Temperatures ① (concluded)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY AND TEMPER	TEMP.	TENSILE STRENGTH, MPa		ELONGATION IN 50 mm PERCENT
	°C	ULTIMATE	YIELD ②	
6151-T6	–195	395	345	20
	–80	345	315	17
	–30	340	310	17
	25	330	295	17
	100	295	275	17
	150	195	185	20
	205	95	85	30
	260	45	34	50
	315	34	27	43
	370	28	22	35
6262-T651	–195	415	325	22
	–80	340	290	18
	–30	325	285	17
	25	310	275	17
	100	290	260	18
	150	235	215	20
6262-T9	–195	510	460	14
	–80	425	400	10
	–30	415	385	10
	25	400	380	10
	100	365	360	10
	150	260	255	14
	205	105	90	34
	260	60	41	48
	315	32	19	85
	370	21	12	95
7075-T6, T651	–195	705	635	9
	–80	620	545	11
	–30	595	515	11
	25	570	505	11
	100	485	450	14
	150	215	185	30
	205	110	90	55
	260	75	60	65
	315	55	45	70
	370	41	32	70
7075-T73, T7351	–195	635	495	14
	–80	545	460	14
	–30	525	450	13
	25	505	435	13
	100	435	400	15
	150	215	185	30
	205	110	90	55
	260	75	60	65
	315	55	45	70
	370	41	32	70
7175-T74	–195	730	675	13
	–80	620	570	14
	–30	600	550	16
	25	550	505	14
	100	495	475	17
	150	240	215	30
	205	125	90	65
7178-T6, T651	–195	730	650	5
	–80	650	580	8
	–30	625	560	9
	25	605	540	11
	100	505	470	14
	150	215	185	40
	205	105	85	70
	260	75	60	76
	315	60	48	80
	370	45	38	80
7178-T76, T7651	–195	730	615	10
	–80	625	540	10
	–30	605	525	10
	25	570	505	11
	100	475	440	17
	150	215	185	40
	205	105	85	70
	260	75	60	76
	315	60	48	80
	370	45	38	80
7475-T61 Sheet	–195	685	600	10
	–80	605	545	12
	–30	580	515	12
	25	550	495	12
	100	485	450	14
	150	205	180	28
	205	95	75	55
	260	65	50	70
	315	45	38	80
	370	34	26	85
7475-T651	25	585	510	13
7475-T761 Sheet	–195	655	565	11
	–80	580	505	12
	–30	550	485	12
	25	525	460	12
	100	440	420	14
	150	205	180	38
	205	95	75	55
	260	65	50	70
	315	45	38	80
	370	34	26	85

① These data are based on a limited amount of testing and represent the lowest strength during 10,000 hours of exposure at testing temperature under no load; stress applied at approximately 0.58 MPa/s in to yield strength and then at strain rate of approximately 0.001mm/mm/s in to failure. Under some conditions of temperature and time, the application of heat will adversely affect certain other properties of some alloys.

② Offset equals 0.2 percent.

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TABLE 2.3 Typical Physical Properties

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY	AVERAGE ① COEFFICIENT OF THERMAL EXPANSION	MELTING RANGE ②③ APPROX.	TEMPER	THERMAL CONDUCTIVITY AT 25°C	ELECTRICAL CONDUCTIVITY AT 20°C MS/m ⑧		ELECTRICAL RESISTIVITY AT 20°C
	20° TO 100°C per °C	°C		W/mK	Equal Volume	Equal Mass	Ohmmm²/m
1060	23.6	645–655	O	234	36	118	0.028
			H18	230	35	117	0.029
1100	23.6	640–655	O	222	34	113	0.029
			H18	218	33	108	0.030
1350	23.6	645–655	All	234	36	118	0.028
2011	22.9	540–645 ⑤	T3	151	23	71	0.043
			T8	172	26	82	0.038
2014	23.0	505–635 ④	O	193	29	92	0.034
			T4	134	20	63	0.050
			T6	155	23	74	0.043
2017	23.6	510–640 ④	O	193	29	92	0.034
			T4	134	20	63	0.050
2018	22.3	505–640 ⑤	T61	155	23	74	0.043
2024	23.2	500–635 ④	O	193	29	93	0.034
			T3, T4, T361	121	17	56	0.059
			T6, T81, T861	151	22	71	0.045
2025	22.7	520–640 ④	T6	155	23	74	0.043
2036	23.4	555–650 ⑤	T4	159	24	78	0.042
2117	23.8	550–650 ⑤	T4	155	23	75	0.043
2124	22.9	500–635 ④	T851	152	22	71	0.045
2218	22.3	505–635 ④	T72	155	23	73	0.043
2219	22.3	545–645 ④	O	172	26	80	0.038
			T31, T37	113	16	57	0.062
			T6, T81, T87	121	17	58	0.059
2618	22.3	550–640	T6	146	21	70	0.048
3003	23.2	640–655	O	193	29	92	0.034
			H12	163	24	78	0.042
			H14	159	24	78	0.042
			H18	155	23	74	0.043
3004	23.9	630–655	All	163	24	79	0.042
3105	23.6	635–655	All	172	26	86	0.038
4032	19.4	530–570 ④	O	155	23	77	0.043
			T6	138	20	67	0.050
4043	22.0	575–630	O	163	24	81	0.041
4045	21.1	575–600	All	171	26	88	0.038
4343	21.6	575–615	All	180	27	92	0.037
5005	23.8	630–655	All	201	30	100	0.033
5050	23.8	625–650	All	193	29	96	0.034
5052	23.8	605–650	All	138	20	67	0.050
5056	24.1	565–640	O	117	17	57	0.059
			H38	109	16	53	0.062
5083	23.8	580–640	O	117	17	57	0.059
5086	23.8	585–640	All	126	18	60	0.056
5154	23.9	590–645	All	126	19	62	0.053
5252	23.8	605–650	All	138	20	67	0.050
5254	23.9	590–645	All	126	19	62	0.053
5356	24.1	575–635	O	117	17	57	0.059
5454	23.6	600–645	O	134	20	66	0.050
			H38	134	20	66	0.050
5456	23.9	570–640	O	117	17	57	0.059
5457	23.8	630–655	All	176	27	89	0.037
5652	23.8	605–650	All	138	20	69	0.050
5657	23.8	635–655	All	205	31	104	0.032
6005	23.6	605–655 ⑤	T1	180	27	90	0.037
			T5	188	28	93	0.036
6005A	23.6	600–650	T1	176	27	90	0.037
6005A	23.6	600–650	T5	193	29	96	0.034
6005A	23.6	600–650	T61	188	28	93	0.036

For all numbered footnotes, see page 2-11.

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TABLE 2.3 Typical Physical Properties (concluded)

The following typical properties are not guaranteed, since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes.

ALLOY	AVERAGE ① COEFFICIENT OF THERMAL EXPANSION	MELTING RANGE ② ③ APPROX.	TEMPER	THERMAL CONDUCTIVITY AT 25°C	ELECTRICAL CONDUCTIVITY AT 20°C MS/m ⑧		ELECTRICAL RESISTIVITY AT 20°C
	20° TO 100°C per °C	°C		W/mK	Equal Volume	Equal Mass	Ohmmm²/m
6053	23.0	575–650 ⑤	O	172	26	86	0.038
			T4	155	23	77	0.042
			T6	167	24	81	0.041
6061	23.6	580–650 ⑤	O	180	27	90	0.037
			T4	155	23	77	0.043
			T6	167	25	82	0.040
6063	23.4	615–655	O	218	34	111	0.029
			T1	193	29	96	0.034
			T5	209	32	105	0.031
			T6, T83	201	31	102	0.032
6066	23.2	560–645 ④	O	155	23	77	0.043
			T6	146	21	71	0.048
6070	. .	565–650 ④	T6	172	26	84	0.038
6082	23.0	575-650	T6, T76511	172	26	84	.040
6101	23.4	620–655	T6	218	33	109	0.030
			T61	222	34	113	0.029
			T63	218	34	111	0.029
			T64	226	35	115	0.029
			T65	218	34	111	0.029
6105	23.4	600–650 ⑤	T1	176	27	88	0.037
			T5	193	29	96	0.034
6151	23.2	590–650 ⑤	O	205	31	103	0.032
			T4	163	24	80	0.042
			T6	172	26	86	0.038
6201	23.4	610–655 ⑤	T81	205	31	104	0.032
6262	23.4	580–650 ⑤	T9	172	26	84	0.038
6351	23.4	555–650	T6	176	27	88	0.038
6463	23.4	615–655 ⑤	T1	193	29	96	0.034
			T5	209	32	105	0.031
			T6	201	31	102	0.032
6951	23.4	615–655	O	213	32	108	0.031
			T6	197	30	100	0.033
7049	23.4	475–635	T73	155	23	77	0.043
7050	23.0	490–630	T74 ⑦	157	24	78	0.042
7072	23.6	640–655	O	222	34	112	0.029
7075	23.6	475–635 ⑥	T6	130	19	61	0.053
7175	23.4	475–635 ⑥	T74	157	23	72	0.043
7178	23.4	475–630 ⑥	T6	126	18	57	0.056
7475	23.2	475–635	T61, T651	138	20	69	0.050
			T76, T761	146	23	77	0.043
			T7351	163	24	81	0.041
8017	23.6	645–655	H12, H22	. .	34	113	0.029
			H212	. .	35	117	0.029
8030	23.6	645–655	H221	230	35	117	0.029
8176	23.6	645–655	H24	230	35	117	0.029

① Coefficient to be multiplied by 10^{-6}. Example: $23.6 \cdot 10^{-6} = 0.0000236$.
② Melting ranges shown apply to wrought products of 6 mm thickness or greater.
③ Based on typical composition of the indicated alloys.
④ Eutectic melting is not eliminated by homogenization.
⑤ Eutectic melting can be completely eliminated by homogenization.
⑥ Homogenization may raise eutectic melting temperature 10–20°C but usually does not eliminate eutectic melting.
⑦ Although not formerly registered, the literature and some specifications have used T736 as the designation for this temper.
⑧ MS/m = 0.58 · % IACS.

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Aluminum and Aluminum Alloy Density Calculation Procedure

The following describes the procedures used to calculate nominal densities of aluminum and aluminum alloys. The densities are determined by computation rather than by a weighing method.

A. For each alloying element, the arithmetic mean of its registered limits is determined. The mean is rounded① to the number of places indicated in Table I.

B. For each impurity element or combination of impurity elements for which a maximum limit is registered, an arithmetic mean is determined using zero as the minimum limit. The mean is rounded to the number of places indicated in Table I.

C. For impurity elements having a combined limit (e.g., Si + Fe), each of the elements is considered to have an equal concentration. The concentrations are calculated by dividing the mean determined for the combined limit in Step B by the number of elements in the combined limit. Each element's concentration is rounded to the number of places indicated in Table I. (See the example calculation for alloy 5254.)

D. The element concentrations in steps A, B and C are totaled and then subtracted from 100 to obtain the concentration of aluminum to be used in the calculation.② The aluminum concentration is rounded to two decimal places.

E. Each element concentration determined in steps A, B, C and D is multiplied by its respective factor given in Table II. Each answer is rounded to three decimal places.

F. The values determined in step E are added together and the number 100 is divided by the total. The answer is rounded to five decimal places.

G. The density in customary units (lbs/cu. in.) is calculated by multiplying the answer obtained in step F by $3.612729 \cdot 10^{-2}$ and rounding the answer as follows:

1. For aluminum having a specified minimum aluminum content on 99.35 percent or greater the value obtained is rounded to the nearest multiple of 0.0005 and expressed as 0.XXX0 or 0.XXX5.
2. For aluminum having a specified minimum aluminum content of less than 99.35 percent and aluminum alloys the value obtained is rounded to the nearest multiple of 0.001 and expressed as 0.XXX.

H. The final expression of density in metric units ($kg/m^3 \cdot 10^3$) is obtained by rounding the value determined in step F as follows:

1. For aluminum having a specified minimum aluminum content less than 99.35 percent or greater, the value obtained is rounded to the nearest multiple of 0.005 and expressed as $X.XX0 \cdot 10^3$ or $X.XX5 \cdot 10^3$.
2. For aluminum having a specified minimum aluminum content of less than 99.35 percent and for aluminum alloys, the value obtained is rounded to the nearest multiple of 0.01 and expressed as $X.XX \cdot 10^3$.

NOTE: Limiting the expression of density to the number of decimal places indicated above is based on the fact that composition variations are discernible from one cast to another for most alloys. The expression of density values to more decimal places than are outlined above implies a higher precision than is justified and should not be used. The values derived by this method are nominal values and as such should not be specified as engineering requirements but, rather, should be used in calculating nominal values for such things as covering area, weight per unit length, weight per unit area, and so on. A density value obtained by this procedure and expressed to the final number of decimal places obtained above should not then be converted to the other system of units.

① Rounding, except when specified otherwise, shall be in accordance with the rounding-off method of ASTM Recommended Practice E29 (see Table I).

② For 1xxx aluminum the calculated aluminum content may be less than the specified minimum aluminum content. Nevertheless, the calculated aluminum content should be used for purposes of this calculation procedure.

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Table I

Less than 0.001 percent	0.000X
0.001 but less than 0.01 percent	0.00X
0.01 but less than 0.10 percent	
Unalloyed aluminum made by a refining process	0.0XX
Alloys and unalloyed aluminum not made by a refining process	0.0X
0.10 through 0.55 percent	0.XX
Over 0.55 percent	0.X, X.X, etc.

Rules for Rounding Off:

Rounding-off method of ASTM Recommended Practices E29, for indicating which places of figures are to be considered significant in specified limiting values:

When the figure next beyond the last place to be retained is less than 5, retain unchanged the figure in the last place retained.

When the figure next beyond the last place to be retained is greater than 5, increase by 1 the figure in the last place retained.

When the figure next beyond the last place to be retained is 5, and there are no figures beyond this 5, or only zeros, increase by 1 the figure in the last place retained if it is odd; leave the figure unchanged if it is even. Increase by 1 the figure in the last place retained, if there are figures beyond this 5.

Table II

Element	Factor
Ag	0.0953
Al	0.3705
B	0.4274
Be	0.5411
Bi	0.1020
Cd	0.1156
Ce	0.1499
Co	0.1130
Cr	0.1391
Cu	0.1116
Fe	0.1271
Ga	0.1693
Li	1.4410
Mg	0.5522
Mn	0.1346
Na	1.0309
Ni	0.1123
O	0.5378
Pb	0.0882
Sc	0.3344
Si	0.4292
Sn	0.1371
Ti	0.2219
V	0.1639
Zn	0.1401
Zr	0.1541

Example (Alloy 5254)

Element	Registered Limits	Calculated Element Concentration	Factor	Element conc. × Factor
Si + Fe	0.45	0.11*	0.4292	0.047
Fe		0.11*	0.1271	0.014
Cu	0.05	0.02	0.1116	0.002
Mn	0.01	0.005	0.1346	0.001
Mg	3.1–3.9	3.5	0.5522	1.933
Cr	0.15–0.35	0.25	0.1391	0.035
Zn	0.20	0.10	0.1401	0.014
Ti	0.05	0.02	0.2219	0.004
		4.115		
Al	Remainder (100 – 4.115 = 95.88)		0.3705	35.524
				37.574

$$\frac{100}{37.574} = 2.6614148\text{.....rounded to } 2.66141$$

Density: $2.66 \cdot 10^3\ kg/m^3$

*For Si and Fe: $\frac{0.45 - 0}{2} = 0.225$, rounded to 0.22

$$\frac{0.22}{2} = 0.11 \text{ each for Si and Fe}$$

Example (Alloy 6061)

Element	Registered Limits	Calculated Element Concentration	Factor	Element conc. × Factor
Si	0.40–0.8	0.6	0.4292	0.258
Fe	0.7	0.35	0.1271	0.044
Cu	0.14–0.40	0.28	0.1116	0.031
Mn	0.15	0.08	0.1346	0.011
Mg	0.8–1.2	1.0	0.5522	0.552
Cr	0.04–0.35	0.20	0.1391	0.028
Zn	0.25	0.12	0.1401	0.017
Ti	0.15	0.08	0.2219	0.018
		2.71		
Al	Remainder (100 – 2.71 = 97.29)		0.3705	36.046
				37.005

$$\frac{100}{37.005} = 2.7023375\text{.....rounded to } 2.70234$$

Density: $2.70 \cdot 10^3\ kg/m^3$

Example (Aluminum 1145)

Element	Registered Limits	Calculated Element Concentration	Factor	Element conc. × Factor
Si + Fe	0.55	0.14*	0.4292	0.060
Fe		0.14*	0.1271	0.018
Cu	0.05	0.02	0.1116	0.002
Mn	0.05	0.02	0.1346	0.003
Mg	0.05	0.02	0.5522	0.011
Zn	0.05	0.02	0.1401	0.003
V	0.05	0.02	0.1639	0.003
Ti	0.03	0.02	0.2219	0.004
		0.40		
Al		99.60	0.3705	36.902
				37.006

* (0.55–0)/2 = 0.275, rounded to 0.28; or 0.14 each.
100/37.006 = 2.7022644, rounded to 2.70226

Density: 2.70226, rounded to $2.700 \cdot 10^3 kg/m^3$

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TABLE 2.4 Nominal Specific Gravities of Aluminum and Aluminum Alloys

Specific gravity is dependent upon composition, and variations are discernible from one cast to another for most alloys. The nominal values shown below should not be specified as engineering requirements but are used in calculating typical values for mass per unit length, mass per unit area, covering area, etc. X.XX0 and X.XX5 specific gravity values are limited to 99.35 percent or higher purity aluminum.

Alloy	Specific Gravity
1050	2.705
1060	2.705
1100	2.71
1145	2.700
1200	2.70
1230	2.70
1235	2.705
1345	2.705
1350	2.705
2011	2.83
2014	2.80
2017	2.79
2018	2.82
2024	2.78
2025	2.81
2036	2.75
2117	2.75
2124	2.78
2218	2.81
2219	2.84
2618	2.76
3003	2.73
3004	2.72
3005	2.73
3105	2.72
4032	2.68
4043	2.69
4045	2.67
4047	2.66
4145	2.74
4343	2.68
4643	2.69
5005	2.70
5050	2.69
5052	2.68
5056	2.64
5083	2.66
5086	2.66
5154	2.66
5183	2.66

Alloy	Specific Gravity
5252	2.67
5254	2.66
5356	2.64
5454	2.69
5456	2.66
5457	2.69
5554	2.69
5556	2.66
5652	2.67
5654	2.66
5657	2.69
6003	2.70
6005	2.70
6005A	2.70
6053	2.69
6061	2.70
6063	2.70
6066	2.72
6070	2.71
6082	2.70
6101	2.70
6105	2.69
6151	2.71
6162	2.70
6201	2.69
6262	2.72
6351	2.71
6463	2.69
6951	2.70
7005	2.78
7008	2.78
7049	2.84
7050	2.83
7072	2.72
7075	2.81
7175	2.80
7178	2.83
7475	2.81
8017	2.71
8030	2.71
8176	2.71

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3. Application and Fabrication

TABLE 3.1 Wrought Alloy Products and Tempers ③

ALLOY	SHEET	PLATE	TUBE		PIPE	STRUC-TURAL PROFILES ①	EXTRUDED WIRE, ROD, BAR AND PROFILES	ROLLED OR COLD-FINISHED			RIVETS	FORGINGS & FORGING STOCK	FOIL	FIN STOCK
			DRAWN	EXTRUDED				ROD	BAR	WIRE				
1050				H112										
1060	O H12 H14 H16 H18	O H12 H14 H112	O H12 H14 H18 H113	O H112				H14						
1100	O H12 H14 H16 H18	O H12 H14 H112	O H12 H14 H16 H18 H113	O H112			O H112	O H112 F	O H112 F	O H112 H12 H14 H16 H18	O H14	H112 F	O H19	O H14 H18 H19 H25 H111 H113 H211
1145													O H19	O H14 H19 H25 H111 H113 H211
1200				H112										
1235				H112									O H19	
1345										O H12 H14 H16 H18 H19				
1350 ②	O H12 H14 H16 H18	O H12 H14 H112		H111	H111	H111	H111	O H12 H14 H16 H22 H24 H26	H12 H111	O H12 H14 H16 H19 H22 H24 H26				
2011			T3 T4511 T8					T3 T4 T451 T8	T3 T4 T451 T8	T3 T8				
2014	O T3 T4 T6	O T451 T651	O T4 T6	O T4 T4510 T4511 T6 T6510 T6511			O T4 T4510 T4511 T6 T6510 T6511	O T4 T451 T6 T651	O T4 T451 T6 T651	O T4 T6		F T4 T6 T652		
Alclad 2014	O T3 T4 T6	O T451 T651												
2017								O H13 T4 T451	O T4 T451	O H13 T4	T4			
2018												F T61		

For all numbered footnotes, see page 3-6.

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TABLE 3.1 Wrought Alloy Products and Tempers ③ (continued)

ALLOY	SHEET	PLATE	TUBE		PIPE	STRUC-TURAL PROFILES ①	EXTRUDED WIRE, ROD, BAR AND PROFILES	ROLLED OR COLD-FINISHED			RIVETS	FORGINGS & FORGING STOCK	FOIL	FIN STOCK
			DRAWN	EXTRUDED				ROD	BAR	WIRE				
2024	O T3 T361 T4 T72 T81 T861	O T351 T361 T851 T861	O T3	O T3 T3510 T3511 T81 T8510 T8511			O T3 T3510 T3511 T81 T8510 T8511	O H13 T351 T4 T6 T851	O T351 T4 T6 T851	O H13 T36 T4 T6	T4			
Alclad 2024	O T3 T361 T4 T81 T861	O T351 T361 T851 T861												
Alclad One Side 2024	O T3 T361 T81 T861	O T351 T361 T851 T861												
1½% Alclad 2024	O T3 T361 T81 T861	O T351 T361 T851 T761												
1½% Alclad One Side 2024	O T3 T361 T81 T861	O T351 T361 T851 T861												
2025												F T6		
2036	T4													
2117								O H13 H15		O H13 H15	T4			
2124		T351												
2218												F T61 T72		
2219	O T31 T37 T81 T87	O T351 T37 T851 T87		O T31 T3510 T3511 T81 T8510 T8511			O T31 T3510 T3511 T81 T8510 T8511	T851	T851		T6	F T6 T852		
Alclad 2219	O T31 T37 T81 T87	O T351 T37 T851 T87												
2618												F T61		
3003	O H12 H14 H16 H18	O H12 H14 H112	O H12 H14 H16 H18 H25 H113	O H112	H18 H112		O H112	O H112 F	O H112 F	O H112 H12 H14 H16 H18	O H14	H112 F	O H19	O H14 H18 H19 H25 H111 H113 H211
Alclad 3003	O H12 H14 H16 H18	O H12 H14 H112	O H14 H18 H25 H113	O H112										

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TABLE 3.1 Wrought Alloy Products and Tempers ③ (continued)

ALLOY	SHEET	PLATE	TUBE		PIPE	STRUC-TURAL PROFILES ①	EXTRUDED WIRE, ROD, BAR AND PROFILES	ROLLED OR COLD-FINISHED			RIVETS	FORGINGS & FORGING STOCK	FOIL	FIN STOCK
			DRAWN	EXTRUDED				ROD	BAR	WIRE				
3004	O H32 H34 H36 H38	O H32 H34 H112	O H34 H36 H38	O										
Alclad 3004	O H32 H34 H36 H38	O H32 H34 H112												
3005	O H12 H14 H16 H18 H19 H26 H28													
3105	O H12 H14 H16 H18 H25													
4032												F T6		
5005	O H12 H14 H16 H18 H32 H34 H36 H38	O H12 H14 H32 H34 H112						O H12 H14 H16 H22 H24 H26 H32		O H19 H32	O H32			
5050	O H32 H34 H36 H38	O H112	O H32 H34 H36 H38					O F	O F	O H32 H34 H36 H38				
5052	O H32 H34 H36 H38	O H32 H34 H112	O H32 H34 H36 H38					O F H32	O F	O H32 H34 H36 H38	O H32		O H19	
5056								O F H32	O F	O H111 H12 H14 H18 H32 H34 H38 H192 H392	O H32		H19	
5083	O H32 H116 H321	O H32 H112 H116 H321		O H111 H112			O H111 H112					H111 H112 F		

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TABLE 3.1 Wrought Alloy Products and Tempers ③ (continued)

ALLOY	SHEET	PLATE	TUBE		PIPE	STRUCTURAL PROFILES ①	EXTRUDED WIRE, ROD, BAR AND PROFILES	ROLLED OR COLD-FINISHED			RIVETS	FORGINGS & FORGING STOCK	FOIL	FIN STOCK
			DRAWN	EXTRUDED				ROD	BAR	WIRE				
5086	O H112 H116 H32 H34 H36 H38	O H112 H116 H32 H34	O H32 H34 H36	O H111 H112			O H111 H112							
5154	O H32 H34 H36 H38	O H32 H34 H112	O H34 H38	O H112			O H112	O H112 F	O H112 F	O H112 H32 H34 H36 H38				
5252	H24 H25 H28													
5254	O H32 H34 H36 H38	O H32 H34 H112												
5454	O H32 H34	O H32 H34 H112	H32 H34	O H111 H112			O H111 H112							
5456	O H32 H116 H321	O H32 H112 H116 H321										H112 F		
5457	O													
5652	O H32 H34 H36 H38	O H32 H34 H112												
5657	H241 H25 H26 H28													
6005				T1 T5			T1 T5							
6005A				T1 T5 T61			T1 T5 T61							
6053								O H13		O H13	T61	F T6		
6061	O T4 T6	O T451 T651	O T4 T6	O T1 T4 T4510 T4511 T51 T6 T6510 T6511	T6	T6	O T1 T4 T4510 T4511 T51 T6 T6510 T6511	O H13 T4 T451 T6 T651	O T4 T451 T6 T651	O H13 T4 T6 T89 T913 T94	T6	F T6 T652		
Alclad 6061	O T4 T6	O T451 T651												
6063			O T4 T6 T83 T831 T832	O T1 T4 T5 T52 T6	T6		O T1 T4 T5 T52 T6							

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