

SELECTION

and

APPLICATIONS



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Table of Contents

Forward	iii
1. Introduction & Scope	1
2. The Aluminum Association Alloy and Temper Designation System	2
2.1 Alloy Designation System — Wrought Alloys	2
2.2 Alloy Designation System — Casting Alloys	3
2.3 Tempers Designation System	3
3. A Review of Aluminum Alloy Series, Their Principal Characteristics and Applications	4
3.1 Wrought Alloys	4
1xxx—Pure Al	4
2xxx	5
3xxx	6
4xxx	7
5xxx	8
6xxx	11
7xxx	13
8xxx	14
3.2 Cast Alloys	14
2xx.x	15
3xx.x	16
4xx.x	18
5xx.x	18
7xx.x	19
8xx.x	19
4.0 Summary	20

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Forward

Aluminum Alloy Selection and Applications

This monograph contains an outstanding introductory description of the properties of wrought and cast aluminum alloys and the enormous variety of their applications. From transportation and packing to construction, infrastructure and aerospace, the versatility of aluminum as a practical material is amply documented. The text is richly illustrated with numerous applications which demonstrate the enormous flexibility and the wide range of applications for aluminum alloys.

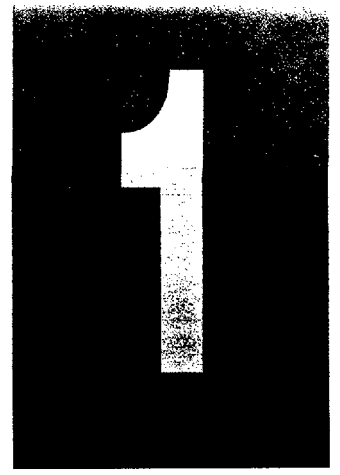
This publication will be invaluable to engineers, designers and students unfamiliar with the variety of aluminum alloys and to those faced with an alloy selection decision. It outlines many of the issues to consider in selecting an alloy for a specific application and environment. Starting with a description of the aluminum alloy designation system, the text describes the major alloy series, outlines their primary chemical constituents, mechanical properties and major characteristics, and provides numerous examples of specific alloys in use.

In summary, this monograph provides a lot of clarity to the process of selecting alloys for various applications.

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Introduction & Scope

Aluminum and its alloys offer an extremely wide range of capability and applicability, with a unique combination of advantages that make it the material of choice for numerous products and markets. It is the purpose of this presentation to (a) provide an overview of the various types of aluminum alloys that are available to engineers, designers, and others considering aluminum for new products or applications, and (b) to describe the properties and characteristics that make aluminum alloys so useful.

The breadth of individual alloys and of applications is so broad that it will be necessary to hit only the highlights and provide representative examples. For more detail on the alloys, their properties, and the applications, I refer you to the new textbook on the subject, *Aluminum: Technology, Applications, and Environment*, by Dr. Dietrich G. Altenpohl.

In what follows, we will look first at the Aluminum Association Alloy and Temper Designation Systems, as these are the systems that make the tracking and recognition of the alloys and their characteristics relatively straightforward. Then we will begin an overview by alloy type, first for wrought alloys and then for cast alloys, covering the characteristics and most important applications of those alloys. By way of background, wrought alloys are those which are cast as ingot or billet and then mechanically worked by some process such as rolling, extrusion, or forgings to final form; cast alloys are those which are cast to final or near final form with out any mechanical working. The wrought and cast alloys, their properties and their applications are somewhat different and so we will discuss them separately.

2

The Aluminum Association Alloy and Temper Designation System

The Aluminum Association Alloy and Temper Designation System is recognized by the American National Standards Institute (ANSI) as the United States national standard, and as such is incorporated into ANSI Standards H35.1. and H35.2. The maintenance of the system is managed by the Aluminum Association, Inc., under ANSI's charter. In addition, there is an International Accord recognizing the Aluminum Association Wrought Alloy Designation System as the de facto international standard; this Accord has been ratified by almost all of the world's aluminum producing countries.

The alloy designation system is briefly described below, first for wrought alloys and then for cast alloys, and these are followed by a brief description of the temper designation system. More detailed information on The Aluminum Association Alloy & Temper Designation System may be gained from study of section 1.0 of Aluminum Association publication "Aluminum Standards & Data."

2.1 Alloy Designation System – Wrought Alloys

- First digit - Principal alloying constituent(s)
- Second digit - Variations of initial alloy
- Third and fourth digits - Individual alloy variations (number has no significance but is unique)
 - 1xxx - Pure Al (99.00% or greater)
 - 2xxx - Al-Cu Alloys
 - 3xxx - Al-Mn Alloys
 - 4xxx - Al-Si Alloys
 - 5xxx - Al-Mg Alloys
 - 6xxx - Al-Mg-Si Alloys
 - 7xxx - Al-Zn Alloys
 - 8xxx - Al+Other Elements
 - 9xxx - Unused series



2.2 Alloy Designation System — Casting Alloys

- First digit - Principal alloying constituent(s)
- Second and third digits - Specific alloy designation (number has no significance but is unique)
- Fourth digit - Casting (0) or ingot (1,2) designation
- Variations indicated by preceding letter (A, B, C)
 - 1xx.x - Pure Al (99.00% or greater)
 - 2xx.x - Al-Cu Alloys
 - 3xx.x - Al-Si + Cu and/or Mg
 - 4xx.x - Al-Si
 - 5xx.x - Al-Mg
 - 7xx.x - Al-Zn
 - 8xx.x - Al-Sn
 - 9xx.x - Al+Other Elements
 - 6xx.x - Unused Series

2.3 Tempers Designation System

- F - As-fabricated
 - O - Annealed
 - H - Strain-hardened (wrought products only)
 - W- Solution heat-treated
 - T - Thermally treated to produce tempers other than F,O,H (usually solution heat-treated, quenched and precipitation hardened)
- Numeric additions indicate specific variations
 e.g., T6 = solution heat treated and artificially aged

3

A Review of Aluminum Alloy Series, Their Principal Characteristics and Applications

3.1 Wrought Alloys

1xxx - Pure Al

- Strain hardenable
- High formability, corrosion resistance and electrical conductivity
- Electrical, chemical applications
- Representative designations: 1100, 1350
- Typical ultimate tensile strength range: 10-27 ksi

The 1xxx series represents the commercially pure aluminum, ranging from the baseline 1100 (99.00% min. Al) to relatively purer 1050/1350 (99.50% min. Al) and 1175 (99.75 % min. Al). Some, like 1350 which is used especially for electrical applications, have relatively tight controls on those impurities that might lower electrical conductivity.

The 1xxx series are strain-hardenable, but would not be used where strength is a prime consideration. Rather the emphasis would be on those applications where extremely high corrosion resistance, formability and/or electrical conductivity are required, e.g., foil and strip for packaging, chemical equipment, tank car or truck bodies, spun hollowware, and elaborate sheet metal work.

Among the specific illustrations provided:

Fig. 1.1 - Aluminum electrical bus bar installation with 1350 bus bar

Fig. 1.2 - Food packaging trays of pure aluminum (1100)

Fig. 1.3 - Decorated foil pouches for food and drink (1060 or 1100)

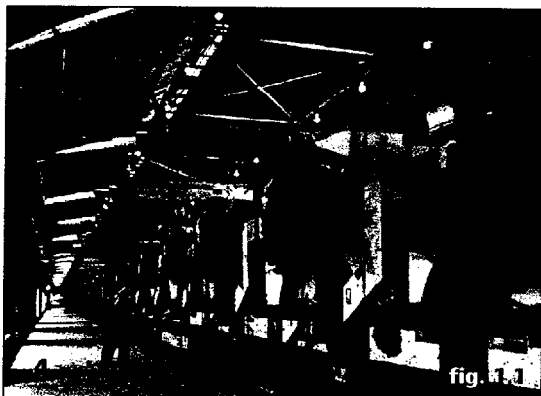


fig. 1.1

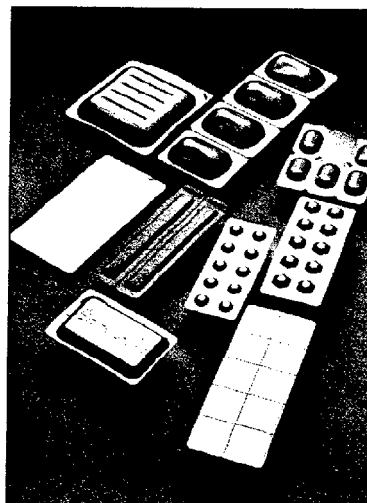


fig. 1.3

2xxx - Al-Cu Alloys

- Heat treatable
- High strength, at room & elevated temperatures
- Aircraft, transportation applications
- Representative alloys: 2014, 2017, 2024, 2219, 2195
- Typical ultimate tensile strength range: 27-62 ksi

The 2xxx series are heat-treatable, and possess in individual alloys good combinations of high strength (especially at elevated temperatures), toughness, and, in specific cases, weldability; they are not resistant to atmospheric corrosion, and so are usually painted or clad in such exposures. The higher strength 2xxx alloys are primarily used for aircraft (2024) and truck body (2014) applications; these are usually used in bolted or riveted construction. Specific members of the series (e.g., 2219 and 2048) are readily welded, and so are used for aerospace applications where that is the preferred joining method.

Alloy 2195 is a new Li-bearing alloy for space applications providing very high modulus of elasticity along with high strength and weldability. There are also high-toughness versions of several of the alloys (e.g., 2124, 2324, 2419), which have tighter control on the impurities that may diminish resistance to unstable fracture, all developed specifically for the aircraft industry. Alloys 2011, 2017, and 2117 are widely used for fasteners and screw-machine stock.

Illustrations of applications for the 2xxxx series alloys include:

Fig. 2.1 - Aircraft internal structure includes extrusions and plate of 2xxx and 7xxx alloys like 2024, 2124 and 2618. External sheet skin may be alclad 2024 or 2618; the higher purity cladding provides corrosion protection to the Al-Cu alloys that will darken with age otherwise.

Fig. 2.2 - Heavy dump and tank trucks and trailer trucks employ 2xxx extrusions for their structural members.

Fig. 2.3 - The fuel tanks and
Fig. 2.4 - booster rockets of the Space Shuttle are 2xxx alloys, originally 2219 and 2419, now sometimes Al-Li "Weldalite" alloy 2195.

