







The Aluminum Association

Aluminum and Its Alloys







Technical Report: Aluminum and Its Alloys

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TECHNICAL REPORT:

ALUMINUM AND ITS ALLOYS

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ABSTRACT

Aluminum, especially when alloyed with one or more of several common elements, has been increasingly specified and used in packaging, architectural, transportation, chemical, electrical and many general applications. Today, aluminum is surpassed only by steel in its use as a structural material. The properties of aluminum and its alloys which give rise to their widespread usage, with particular emphasis on manufacturability, recyclability, and corrosion resistance, are briefly described in this report. The designation system by which alloys are classified is also described, and references are provided for the reader who may desire more detailed information.

PREFACE

The first edition of this report was prepared for, and first presented at, The Annual Liberty Bell Corrosion Course, sponsored by The National Association of Corrosion Engineers in Philadelphia, Pennsylvania in September 1978. The original was updated for the Second Edition in 1994.

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INTRODUCTION

THE MANY ADVANTAGES OF ALUMINUM & ITS ALLOYS

Aluminum and its alloys possess a number of advantageous characteristics that make it ideal for applications in the electrical, automotive, aerospace, transportation, packaging, petrochemical, and building & construction industries, most notably:

- Low density, about one-third that of steel
- High strength-to-density ratio
- High strength, ductility & toughness at subzero & cryogenic temperatures
- Superior corrosion resistance
- Very high electrical conductivity
- Exceptional toughness in specific alloys
- Fabricability, including by rolling, extrusion, drawing, forging, and casting
- Weldability by most commercial processes
- Recyclability, back into the same high-quality products
- Ability to be used as a composite with a range of other materials

Aluminum also has a relatively low melting point, around 1000 degF, which requires special consideration for applications involving high temperature exposure. Where structural strength is required, aluminum alloys are not recommended for use above about 400 degF.

Aluminum & its alloys have a modulus of elasticity about one-third that of steels, so aluminum structural members will have greater deflections than steel structural members.

HOW ALLOYS ARE DESIGNATED

The principal alloying additions to aluminum are copper, manganese, silicon, magnesium and zinc; other elements are also added in smaller amounts for grain refinement and to develop special properties. More recently elements such as silver, lithium and scandium have been used in small quantities for aerospace applications. Since there is a wide variety of aluminum alloys, special designation systems were developed by The Aluminum Association to distinguish the alloys in a meaningful manner and, further, to indicate what metallurgical condition, or temper has been imparted to the alloy.

Aluminum and its alloys are divided into two classes according to how they are formed: wrought and cast. The "wrought" category is indeed a broad one, since aluminum can be formed by virtually every known process; wrought forms include sheet and plate, foil, extrusions, bar and rod, wire, forgings and impacts, drawn and extruded tubing, and others. Cast alloys are those specially formulated to flow into

sand or permanent molds, to be die cast, or to be cast by any other process where the casting is the final form.

Each wrought or cast aluminum alloy is designated by a number to distinguish it as a wrought or cast alloy and to broadly describe the alloy. A wrought alloy is given a four- digit number. The first digit classifies the alloy series or principal alloying modification in the basic element. The second digit, if different than 0 (zero), denotes a modification in the basic alloy. The third and fourth digits form an arbitrary number which identifies the specific alloy in the series.* Variations are identified by a serial letter after the numerical designation e.g. 6005 A. A cast alloy is assigned a three digit number followed by a decimal. Here again the first digit signifies the alloy series or principal addition; the second and third digits identify the specific alloy; the decimal indicates whether the alloy composition is for finished castings (.0) or for ingot (.1 or .2). A capital letter prefix (A,B, C, etc.) indicates a modification of the basic alloy.

The designation systems for aluminum wrought and cast alloys are shown in Tables 1 and 2, respectively.

*Note: An exception is for the 1xxx series alloys, where the last two digits indicate the minimum aluminum percentage. For example, alloy 1060 contains a minimum of 99.60% aluminum.