American Welding Society

The Practical Reference Guide to Welding Aluminum

Commercial Applications

THE PRACTICAL REFERENCE GUIDE to WELDING ALUMINUM in COMMERCIAL APPLICATIONS

Compiled/Edited/Written by

Frank G. Armao

Group Leader, Nonferrous Applications
The Lincoln Electric Company

American Welding Society
550 N.W. LeJeune Road, Miami, Florida 33126

AUTHOR NOTES

Ultimately, I would like to thank Bob Schneider, who is an old friend of mine, for making this book happen. A couple of years ago, I was asked by Debrah Weir of AWS to review a similar book that Bob had written titled "The Practical Guide for Welding Aluminum: High Quality Fusion Welding." My review concluded that, while Bob's book captured his long and varied experience in the aerospace industry, it didn't include practices common in other, higher production volume industries. The next thing I knew, Bob and Debrah suggested that I cover those industries in a separate volume, which became this book. With additional encouragement and support from Debrah, who is Corporate Director of New Product Development for AWS, and Lee Kvidahl, an AWS past president and the current chair of the AWS Product Development Committee, this book has become a reality. Thank you both for your patience and help.

I would also like to thank Dr. Toby Pearlstein of Bain & Co., Mr. Paul Sullivan, formerly of the Massachusetts Highway Department, and Mr. Randy Kissell of the TGB Group for their help in reviewing and suggesting constructive changes to this guide. Although neither had direct involvement with this guide, I would be remiss if I didn't acknowledge the long-time contributions of two other people: Paul Dickerson, formerly of Alcoa, and Paul Miller, formerly of MK Industries. Paul Dickerson was my mentor for many years and taught me most of what I know about welding aluminum. Paul Miller has been a friend for a long time, has been tireless in promoting the use of proper techniques and proper equipment in the welding of aluminum alloys, and has been a great help to me on many occasions.

Frank G. Armao
Cleveland, Ohio

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Introduction

The use of aluminum as a structural material is a fairly recent development. Originally, aluminum was considered to be a precious metal. In fact, when the Washington Monument was completed in December, 1884, it was capped with a 100-ounce pyramid of pure aluminum. The problem that initially impeded the use of aluminum as a structural material was the fact that aluminum is a reactive metal. It is never found in its elemental state in nature, but is always tightly bound with oxygen as aluminum oxide, Al_2O_3.

Aluminum oxide, found as bauxite ore, was always plentiful; however, no direct reduction method, such as that used to make steel, was found to produce aluminum from bauxite until 1886, when the American, Charles M. Hall, and the Frenchman, Paul Heroult, almost simultaneously, yet independently, discovered electrolytic processes for obtaining pure aluminum from aluminum oxide. As a result, aluminum became available in commercial quantities. These processes, with some modifications, are still used today.

Since that time, aluminum has found wide use in numerous applications:

- It conducts electricity and heat almost as well as copper.
- It is widely used in electrical bus bars and other conductors, heat exchangers, and cookware.
- It does not become brittle with decreasing temperature, but instead becomes stronger, so it has found wide application in cryogenic equipment at temperatures as low as –452°F.
- It is very corrosion resistant in most environments, so it has found wide applications in marine and chemical environments.

The characteristics of aluminum alloys, which make them attractive as structural materials for many applications, are their light weight (one third the weight of steel for equal volumes) and their relatively high strength (equal in many cases to that of construction steel grades). This combination has resulted in increased use of aluminum alloys in applications such as automobiles, trucks, over-the-road trailers, and railroad cars. Additionally, the structure of most aircraft is fabricated mainly from aluminum alloys, although in this application, pieces are most often joined by riveting.

Welding Aluminum vs. Welding Steel

Most industrial welders start out by learning how to weld steel; a minority later move on to welding aluminum. Since most welding equipment is designed to weld steel, the welding of aluminum alloys is frequently just an afterthought. However, this attitude is changing.

The welding of aluminum is often approached as though aluminum were just shiny steel. However, there are definite differences between the welding of steel and aluminum. This guide will discuss these differences and how to overcome the problems that arise when the welding of aluminum is considered to be the same as the welding of steel. Three common fallacies are as follows:

(1) *If you take enough care almost all steels are weldable.*

Fabricators regularly fall into this trap. There are some aluminum alloys—especially the stronger ones—that are just not arc weldable.

(2) *All steels are heat treatable.*

Some aluminum alloys are heat treatable, but some aren't. Even for the heat-treatable aluminum alloys, the heat treatments are totally different from those used for steel. In fact, if you heat some alloys and then quench them, they become softer, not harder. Be aware of the differences and act accordingly.

(3) *When welding steels, you can almost always make a weld that is as strong as the parent material.*

In aluminum alloys, the weld will rarely be as strong as the parent material. This is usually true for welds in both heat-treatable and nonheat-treatable alloys. The strength difference between the weld or heat-affected zone (HAZ) and the parent is significant, often 30% or more.

Aluminum Alloy and Temper Designations

Much in the same manner that the American Iron and Steel Institute (AISI) registers steel chemistries and grades, the Aluminum Association (AA) registers alloy designations, chemistries, and mechanical properties for aluminum alloys. However, the alloy designation system is totally different than that used for steels. Additionally, different systems are used for wrought and cast alloys.