American Welding Society

The Practical Reference Guide for Welding Aluminum

High-Quality Fusion Welding

THE PRACTICAL REFERENCE GUIDE for HIGH-QUALITY FUSION WELDING of ALUMINUM

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Introduction

Aluminum is one of the most underrated and misunderstood metals in welding. It "gets no respect," as a well-known comedian has often said. Aluminum weldments have become commonplace commercially, largely due to their corrosion resistance and light weight. Since aluminum weldments are in abundance, the degree of difficulty when welding aluminum is considered so minimal that basic preparations and precautions are often neglected. Fusion welding of aluminum is similar to welding titanium in the sense that, when the basic rules and preparations are followed, good welds are not difficult to obtain. Cleanliness is most critical.

In this guide we are going to concentrate on obtaining high quality aluminum weldments with the fusion processes, in particular gas tungsten arc welding (GTAW), electron beam welding (EBW), and gas metal arc welding (GMAW). These procedures are more critical when utilizing the GTAW process in the direct current electrode negative mode (GTAW, DCEN) which produces a narrower deeper penetrating weld than the alternating current (AC) mode. The intent is to build in the quality during fabrication rather than inspecting in the quality. Too often when high quality is required the inspection requirements are made more stringent rather than making the fabrication procedures more stringent. If an X-ray quality weld is desired you don't just X-ray the weld. The welding procedure must be planned to obtain X-ray quality weldments.

These guidelines were basically utilized for the following applications:

- *Grumman Aerospace*—for mechanized gas tungsten arc welding (GTAW, DCEN) 2219 aluminum alloy for the Lunar Module for Project Apollo that landed men on the moon. These weldments required X-ray quality, helium leak-tight and pressure testing.
- *General Dynamics Corporation, Quincy Shipbuilding Division*—for gas metal arc welding of 5083 aluminum alloy for the 120-foot diameter Liquid Natural Gas Spheres requiring radiographic quality and pressure tested weldments.
- *General Dynamics, Convair Division*—for Tomahawk Cruise Missile 2219 aluminum alloy weldments utilizing the electron beam welding, gas tungsten arc and gas metal arc welding processes. They were also used for the gas metal arc welding (GMAW) of the 5083 aluminum alloy Aft and Forward Equipment Boxes for the Tomahawk Ground Launches. The electron beam and gas tungsten arc welds were 100% X-rayed.

These guidelines should be followed to produce high quality weldments, even when radiographic or ultrasonic inspection is not required. An example is the GMAW structural plug welds of the Tomahawk Cruise Missile Mid-Body Section. Consistent high-quality was mandatory in this fuel section, although the design was not suitable for X-ray inspection.

Preweld Preparation

Sawing

Band saws, hacksaws, or cut-off saws are normally used for rough cuts followed by machining or draw filing.

Saw-cut edges are not normally suitable for welding, as the jagged edge is a dirt, lubricant, and/or oxide trap that is difficult to clean.

Sharp, circular saw-blade cuts can produce a fine nongalled finish suitable for welding. Power feeding helps to achieve good cuts. However, lubricants should be avoided for final preweld cuts. Alcohol spray mists have proven to be effective when necessary to obtain better surface finishes and minimize the attachment of the aluminum chips to the saw blade.

Machining

Machined surface finishes should not exceed 125 µin. Ra (Root average).

Dry machining (no lubricants) is recommended for surfaces to be consumed by the weld puddle. Alcohol or liquid nitrogen spray mists have proven to be effective when necessary to obtain better surface finishes and minimize the attachment of the aluminum chips to the tool bits. Sharp tools should be used.

Shearing

"As-sheared" edges are not normally suitable for welding. The first portion of the sheared edge surface is cut and tends to smear (gall) while the second portion is a fracture surface. Both conditions