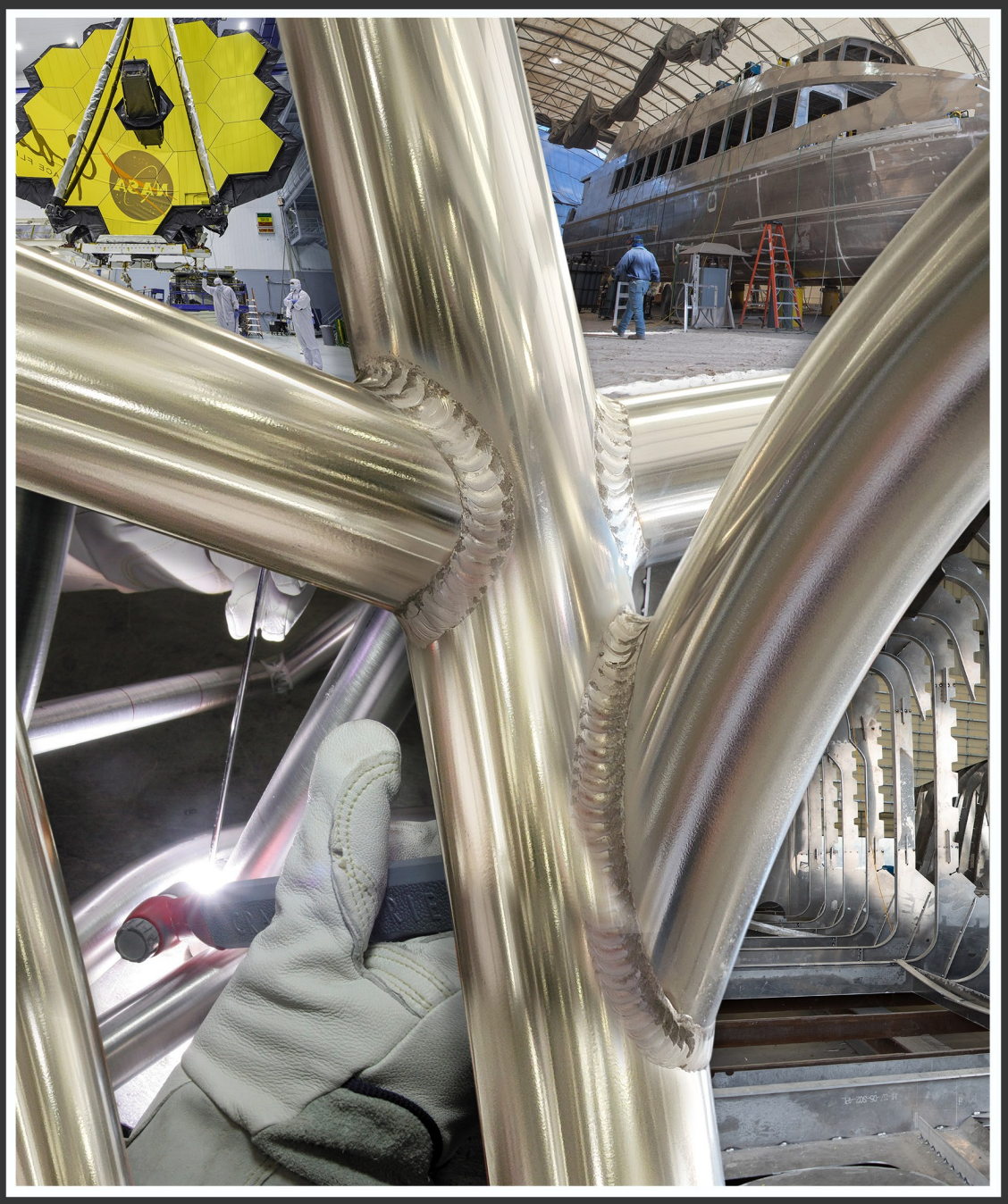
Welding Aluminum: Theory and Practice

The Aluminum Association



Acknowledgement

About the Aluminum Association

The Aluminum Association represents aluminum production and jobs in the United States, ranging from primary production to value added products to recycling, as well as suppliers to the industry. The association is the industry's leading voice, representing companies that make around 70 percent of the aluminum and aluminum products shipped in North America. The association develops global standards, business intelligence, sustainability research and industry expertise for member companies, policymakers, and the general public. The aluminum industry helps manufacturers produce sustainable and innovative products, including more fuel-efficient vehicles, recyclable packaging, greener buildings, and modern electronics. In the U.S., the aluminum industry supports $176 billion in economic activity and nearly 634,000 direct and indirect jobs. For more information visit *https://www.aluminum.org*, on Twitter *@AluminumNews* or at *Facebook.com/AluminumAssociation*.

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Tony Anderson – ITW Welding North America (Task Group Chair)
William Avery – Superior Flux and Manufacturing
Tyler Borcher – Arconic Corporation
Pat Berube – Arconic Corporation
Thomas Pfaller – AlcoTec
Donald J. Spinella – Arconic Corporation
John Weritz – The Aluminum Association
Sam Muhamed - The Aluminum Association

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Devan DePauw – Corus Industries
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Erik Miller – Miller Electric
Kodi Welch – Miller Electric
Galen White – Hobart Brothers
Carson Williams – Hobart Brothers

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Chapter 1: Introduction to Aluminum Welding

Superb strength-to-weight ratio, resistance to corrosion, formability, and intrinsic recyclability render aluminum and its alloys desirable for many applications. But to be competitive in the modern industrial world, a structural metal must be readily weldable.

The earliest welding techniques suitable for aluminum included oxy-fuel gas welding, which was limited in application and created corrosion problems when the flux was inadequately removed after welding, and resistance welding, which has inherent joint design limitations, but was very successful and is still used today. Initially arc welding of aluminum was restricted to shielded metal arc welding (SMAW) with a flux-coated electrode. The SMAW process is very limited in application, and the flux used causes similar corrosion issues to oxy-fuel gas welding.

The breakthrough for aluminum welding occurred in the 1940s with the introduction of the inert gas welding processes: first the Gas Tungsten Arc Welding process (GTAW, also referred to as Tungsten Inert Gas or TIG welding), followed shortly after by the Gas Metal Arc Welding process (GMAW, also referred to as Metal Inert Gas or MIG welding). With the introduction of these welding processes it became possible to make high strength welds without corrosive fluxes at high speeds and in all positions.

Today, aluminum and its alloys are readily weldable using a variety of techniques. This book will thoroughly explain the traditional joining methods for aluminum, such as GMAW and GTAW, and introduce the latest technologies, such as laser welding and friction stir welding. This book provides up-to-date knowledge of aluminum welding so that full advantage may be taken of the unique and beneficial properties of this useful metal.

Welded Aluminum Applications

Aluminum and its alloys are suitable for many applications. Aluminum alloys have dominated the aerospace industry since its inception. Aluminum is used for a wide range of aerospace applications from rocket casings to space station modules.

The automotive industry, faced with increasing demands for fuel economy, is incorporating aluminum into vehicles. Integration of aluminum alloys in closures, body structure, and frames provides desired light-weighting while improving performance and safety. Highway truck bodies, trailers, and some cabs are fabricated of welded aluminum, providing larger capacities without adding to gross weight. Fire engines and truck ladders are also built of aluminum to reduce weight and improve performance.

Overhead highway signs, traffic signal supports, lighting poles, and protective railings are common on our highways. Aluminum for these applications offers good appearance, durability, and ease of handling during installation.

A growing number of corrosion-resistant gondola rail cars is being built for service in the transportation of coal and other bulk commodities. Welded aluminum passenger vehicles for inter-city rail service, rapid transit, subway systems, and for specialized people movers are common.

The marine industry uses of aluminum include all types of work and pleasure craft as well as specialized military craft. In addition, there are many unusual applications such as helicopter recovery systems for marine vessels.

Welded aluminum pipelines are used where the corrosion resistance, weldability, and other unique properties of aluminum are beneficial for transporting oil, gas, water, and other chemical products.

Welded aluminum is also prevalent in other industries such as electronics and architecture. There are numerous examples of the advantages of aluminum fabricated by welding, including temporary buildings, greenhouses, pedestrian bridges, gangways, handrails, specialized architectural components, and petrochemical storage tanks. Aluminum is particularly useful in low temperature (cryogenic) applications, such as liquefied natural gas storage, where advantage can be taken from its ability to retain its strength and toughness at very low temperatures.

Aluminum's Properties

Contrary to popular belief, aluminum alloys are not difficult to weld. However, aluminum al-