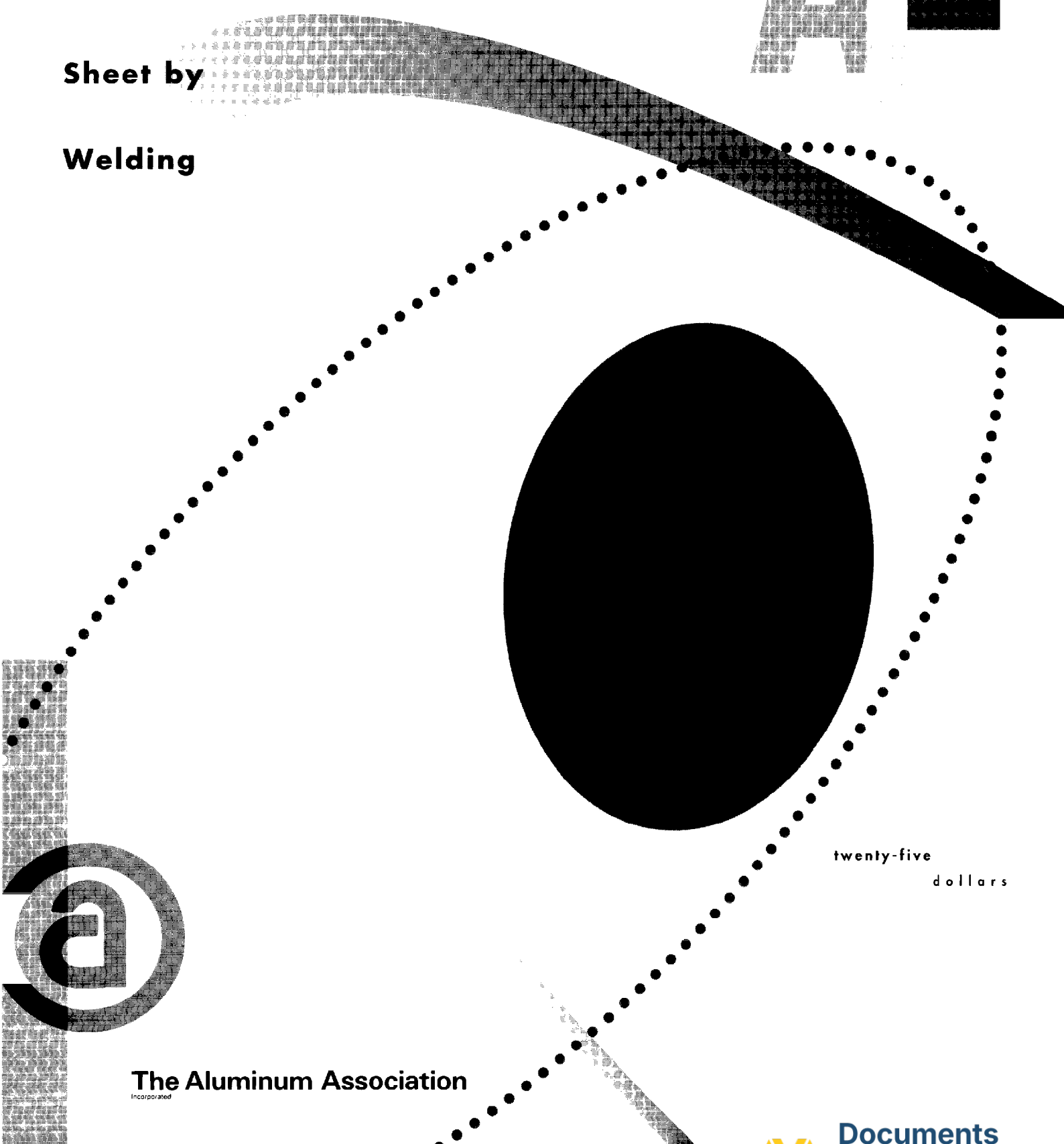


Repair of
Aluminum
Automotive
Sheet by
Welding



twenty-five
dollars

The Aluminum Association
Incorporated

Repair of Aluminum Automotive Sheet by Welding

THE ALUMINUM ASSOCIATION

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Introduction

The rapid growth of the use of aluminum in automobiles in recent years brings with it the inevitable need to repair damage that occurs in service. This manual addresses welding and its role in repair activity. The principal focus is on sheet products but the techniques and processes described are applicable to other wrought aluminum product forms. There are two principal welding processes in use today: gas metal-arc (GMA) welding and gas tungsten-arc (GTA) welding. These processes are popularly known as MIG and TIG, respectively. These two processes, coupled with a variety of joint configurations, provide the capability to complete essentially all anticipated repair requirements.

GTA (TIG) welding is widely used for welding relatively thin aluminum sections ranging from 0.015 to 3/16 in. In this process, an arc is established between a nonconsumable tungsten electrode and the aluminum parts to be welded, with a shield of inert gas enveloping the arc and weld pool.

The types of equipment and operating parameters used in GTA welding are noted, as are the functioning of the equipment and precautions that must be observed to ensure proper usage and safety. This publication also covers arc shielding gases and filler metal used with various parent metal alloys.

The choice of filler alloy in the welding of aluminum is an important factor in eliminating weld cracking, and the nominal compositions of some filler alloys are listed and analyzed for appropriate applications. Proper GTA welding techniques are examined, accompanied by a table of typical practices. It is noted that some training is needed to weld aluminum body sheet but this can usually be accomplished in a few days.

GMA (MIG) welding is more suitable for heavier gauges but can be used on metal as thin as 0.030 in., especially when welding to a heavier sheet, a heavier extrusion or with backing. The GMA process is generally a higher speed welding method than GTA and can be more difficult to control on light sheet.

Power sources and the equipment to be used for GMA welding are discussed, as are types of wire feeders and a table listing typical practices for the process. Proper GMA welding techniques are explained and a table on typical practices is included.

Resistance spot welding, commonly used in automobile construction, is not practical for repair activity because equipment is costly relative to the limited amount it can be used.

Also examined are machine welding, weld finishing and performance; and safe welding practices are cited. The overall topic of welding

aluminum is covered in greater detail in The Aluminum Association Publication 23, entitled "Welding Aluminum: Theory and Practice," from which much of the material in this publication has been drawn. This publication also deals with issues of preparation for welding and for postweld finishing.

Finally, it should be noted that oftentimes the welding of light gauge sheet as used in automobiles is considered to be "difficult." This is a normal reaction to undertaking new procedures, especially when they bear a similarity to the procedures for welding of steel. We suggest that the repairer simply think of welding aluminum sheet as "different." With this approach and by following the recommendations in this publication, the welding of aluminum will quickly become a regular part of the repairer's wide range of skills.

2.0 Automotive Wrought Alloys

In the years since the energy crisis of the 1970s there has been continuous progress made by automobile producers to make their products more fuel efficient. Increased fuel efficiency benefits both in the lessened use of a nonrenewable natural resource and in reduced emissions by the vehicle in service.

Government regulations have been put into place setting overall fleet fuel economy requirements. Initially, downsizing was the most obvious approach to improving fuel economy and was coupled with

reduced rolling and wind resistance, more efficient engines, and the use of lightweight materials. Much of the gain realized from these steps has occurred, while at the same time, more electronics and increased emphasis on vehicle safety are today tending to add weight to the car. The result is that lightweight materials are being specified more and more, and aluminum applications are multiplying.

Under the hood, extensive use is made of aluminum castings. Exterior panels, especially hoods and deck

lids, are appearing in aluminum sheet. Other product forms such as forgings and extrusions are being used in underbody and suspension parts and in vehicle structures.

Table 1 gives the compositions of a number of widely used sheet alloys around the globe over the past twenty years. There are three broad alloy groupings shown in the table—the 2XXX, 5XXX, and 6XXX series. Welding procedures are the same, but the different filler alloys must be used for the different alloy series being welded; as will be discussed in the Filler Metal section of this publication.

TABLE 1. CHEMICAL COMPOSITION LIMITS OF SELECTED AUTO BODY SHEET ALLOYS (% by weight) [1]

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
2XXX TYPE								
2008	0.5-0.8	0.4	0.7-1.1	0.3	0.25-0.5	0.1	0.25	0.1
2010	0.5	0.5	0.7-1.3	0.10-0.40	0.40-1.0	0.15	0.3	—
2036	0.5	0.5	2.2-3.0	0.1-0.4	0.3-0.6	0.1	0.25	0.15
2037	0.5	0.5	1.4-2.2	0.1-0.4	0.3-0.8	0.1	0.25	—
2038	0.5-1.3	0.6	0.8-1.8	0.1-0.4	0.4-1.0	0.2	0.5	0.15
5XXX TYPE								
5030	0.25	0.4	0.5	0.2	3.5-5.0	0.2	0.1	0.1
5043	0.4	0.7	0.05-0.35	0.7-1.2	0.7-1.3	0.05	0.25	0.1
5052	0.25	0.4	0.1	0.1	2.2-2.8	0.15-0.35	0.1	—
5182	0.2	0.35	0.15	0.2-0.5	4.0-5.0	0.1	0.25	0.1
5454	0.25	0.4	0.1	0.5-1.0	2.4-3.0	0.05-0.2	0.25	0.2
5754	0.4	0.4	0.1	0.5	2.6-3.6	0.3	0.2	0.15
6XXX TYPE								
6009	0.6-1.0	0.5	0.15-0.6	0.2-0.8	0.4-0.8	0.1	0.25	0.1
6010	0.8-1.2	0.5	0.15-0.6	0.2-0.8	0.6-1.0	0.1	0.25	0.1
6013	0.6-1.0	0.5	0.6-1.1	0.2-0.8	0.8-1.2	0.1	0.25	0.1
6016	1.0-1.5	0.5	0.2	0.2	0.25-0.6	0.1	0.2	0.15
6061	0.4-0.8	0.7	0.15-0.4	0.15	0.8-1.2	0.04-0.35	0.25	0.15
6111	0.7-1.1	0.4	0.5-0.9	0.15-0.45	0.5-1.0	0.1	0.15	0.1

[1] - maximum unless a range is shown.

Casting, extrusion, and forging alloys are given in Table 2 for informational purposes. As noted, this publication deals with sheet alloys, but the procedures are applicable to other products of comparable thicknesses.

TABLE 2. NOMINAL CHEMICAL COMPOSITIONS OF EXTRUSION, FORGING, AND CASTING ALLOYS (% BY WEIGHT)

	Si	Cu	Mg	Mn	Zn	Cr	Al
WROUGHT							
6061	0.6	0.27	1.0	—	—	0.2	Remainder
6063	0.4	—	0.7	—	—	—	Remainder
6151	0.9	—	0.6	—	—	0.25	Remainder
7005	—	—	1.4	0.45	4.5	0.13	Remainder (1)
CAST (2)							
319.0	6.0	3.5	—	—	—	—	Remainder
356.0	7.0	—	0.32	—	—	—	Remainder
443.0	5.2	—	—	—	—	—	Remainder

1. Contains 0.14% Zr

2. Many automotive parts are made of die castings which are not welded except in special cases, and are not shown here

3.0 Filler Metal

Due to the nature of the GMA welding process, a filler metal is always used. When GTA welding, a filler metal may or may not be used. However, as discussed below, a filler metal is usually desirable when welding the heat-treatable aluminum alloys (i.e., the 2XXX and 6XXX alloys) to prevent weld cracking.

When a filler metal is used, the weld deposit is an alloy of the filler metal and base metal. The chemistry of this deposit will largely determine the cracking sensitivity and the mechanical properties of the welded joint. Joint strength, cracking sensitivity, ductility, and corrosion resistance can also be significantly influenced by the dilution in the weld deposit (e.g., the amount of filler

metal and the amount of base metal melted into the weld). Thus the combination of filler alloy and the amount of base metal dilution provide the means for controlling these factors, especially weld cracking. Table 3 lists nominal compositions of filler metals for aluminum automotive alloys.

Table 4 lists recommended filler alloys for various combinations of aluminum automotive body sheet alloys. It should be noted that there is no "universal" aluminum filler alloy. The automotive repair shop dealing with aluminum will need to have most of the filler alloys in Table 4 on hand. The repair technician should determine the alloy of the part being welded from the manufacturer's

information and choose the filler alloy according to the recommendations in Table 4. The consequences of using the wrong filler alloy can be severe and include weld cracking, preferential corrosion of the weld, and greatly reduced mechanical properties.

The heat-treatable alloys (i.e., 2XXX and 6XXX alloys) usually require the addition of filler metal to eliminate weld cracking. For example, alloy 6061 will almost always crack if it is welded without filler metal. However, it is readily welded using 4043 filler metal, which melts and solidifies at temperatures lower than the base metals on which it is used. For this reason, it remains ductile after the base metal has cooled somewhat and the stresses which could cause cracking are relieved by the ductility of the filler metal. Heat-treatable 2XXX and 6XXX alloys having any appreciable copper content, such as 2008, 2036, 6009, or 6111, should never be welded using high-magnesium 5XXX filler alloys, since weld cracking often results. For this reason, the 2XXX and 6XXX alloys are most often welded using a 4XXX filler metal such as 4043.

TABLE 3. NOMINAL COMPOSITIONS OF COMMON ALUMINUM FILLER ALLOYS (% BY WEIGHT)

Alloy	Si	Cu	Mn	Mg	Cr	Ti	Al
4043	5.2	—	—	—	—	—	Remainder
4047	12.0	—	—	—	—	—	Remainder
4145	10.0	4.0	—	—	—	—	Remainder
5183	—	—	0.75	4.7	0.15	—	Remainder
5356	—	—	0.12	5.0	0.12	0.13	Remainder
5554	—	—	0.75	2.7	0.12	0.13	Remainder