3. FILLER METAL OF MAGNESIUM BASED ALLOYS

3.1 Lancaster Alloys Company can offer the following Magnesium based alloys welding rods and bare electrodes:

Table 3.1. Stock List of LAC for Magnesium Weld Wire

LAC STOCK #	AMS SPECIFICATIONS	ALLOY NAME	AWS SPECIFICATIONS	AWS CLASS	UNS # *
4350	AMS 4350	AZ61A	AWS A5.19	ER AZ61A	M11610
4395	AMS 4395	AZ92A	AWS A5. 19	ER AZ92A	M11922
4396	AMS 4396	AZ33A	AWS A5. 19	ER EZ33A	M12331
M107	N/A	AZ101A	AWS A5. 19	ER AZ101A	M11101

* SAE/ASTM Unified Numbering System for metals and alloys.

3.2 Chemical composition of Magnesium weld rods.

Table 3.2 gives chemical compositions for filler metals of Magnesium alloys.

3.3 Filler metal selection.

3.3.1 General welding considerations

Magnesium is well known for its extreme lightness, excellent machineability and weldability and the high strength-to-weight ratio of its alloys. Its specific gravity is 1.74. On an equal value basis, it weighs roughly one-forth as much as steel, and two-thirds as much as aluminum.

When heated in air to its melting point, magnesium tends to oxidize rapidly. For this reason, welding with magnesium requires the use of a protective shield, such as an inert gas or flux.

Because of its comparatively low melting point, latent heat of fusion and specific heat per unit volume, magnesium requires a relatively small amount of heat to melt. The total heat of fusion is approximately two-thirds that for aluminum and one-fifth that for steel. The high coefficients of thermal expansion (from 65 to 750 °F about 0.000016 per ° F) and conductivity tend to cause considerable distortion during welding. In this respect, the welding of magnesium is more critical than the welding of steel and similar to the welding of aluminum.

TABLE 3.2
Chemical Composition Requirements for Magnesium electrodes

LAC STOCK #	Mg %	AL %	Be %	Mn min, %	Zn %	Zr %	RARE EARTH %	Cu max, %	Fe max, %	Ni max, %	Si max, %	OTHER ELEMENTS TOTAL max, %
4350	Remainder	5.8 to 7.2	0.0002 to 0.0008	0.15	0.40 to 1.5	-	-	0.05	0.005	0.005	0.05	0.30
4395	Remainder	9.5 to 10.5	0.0002 to 0.0008	0.13	0.75 to 1.25	-	-	0.05	0.005	0.005	0.05	0.30
4396	Remainder	8.3 to 9.7	0.0002 to 0.0008	0.15	1.7 to 2.3	-	-	0.05	0.005	0.005	0.05	0.30
M107	Remainder	-	-	-	2.0 to 3.1	0.45 to 1.0	2.5 to 4.0	-	-	-	-	0.30

Note: Analysis shall regularly be made only for the elements specified in this table. If, however, the presence of other elements is suspected or indicated in amounts greater than the specified limits, further analysis shall be made to determine that these elements are not present in amounts in excess of the specified limits.

3.3.2 Weldability and filler metal selection.

The weldability of most magnesim alloys can be considered good to excellent if proper filler metal is employed. The use of a filler metal with a lower melting point and a wider freezing range than the base metal is advantageous as it improves weldability and minimizes weld cracking. A list of recommended filler metal used with the variuos base metal is given in table 3.4.

Some typical mechanical properties of all-weld metal of various magnesium alloys are shown in table 3.3.

TABLE 3.3

All-weld metal properties of various Magnesium alloys

FILLER ALLOY	ULTIMATE TENSILE STRENGTH (X 10^3 PSI)	TENSILE YIELD STRENGTH (X 10^3 PSI)	% ELONGATION IN 2 INCHES	WROUGHT BASE ALLOY
AZ61A	34.3	14.5	10.0	AZ31B
AZ61A	36.2	14.5	16.2	ZE10A
AZ92A	36.8	18.9	8.0	AZ31B
EZ33A	27.8	18.9	4.5	ZE10A
EZ33A	32.0	17.8	9.0	HK31A
EZ33A	26.8	19.8	3.5	HM31A
EZ33A	30.0	21.2	6.3	HM21A

3.4 Storage and care of filler metal.

Filler metal cleanliness and freedom from surface oxidation are important in gas shielding arc welding. Oil or other organic material as well as heavy oxide coatings on the surface of the filler metal, will interfere with coalescence of the molten weld pool and cause porosity or other weld defects, or both. For this reason, filler metal is manufactured and packaged in order to prevent contamination.

Proper storage of welding rods and electrodes in the user's plant is essential if the filler metal is to remain free of contamination until used. Packages of filler metal should not be left outdoors or in unheated buildings because the greater variation in temperature and humidity increase the possibility of moisture condensation. Properly protected filler metal can be stored for long periods of time without adverse affect on its performance.

Packages of filler metal should remain sealed until ready for use. Once removed from the container, spooled electrodes should be kept covered, even during use, to prevent surface contamination by dust, moisture, or other airborne foreign material. After welding is completed, the electrode should be returned to its original container for storage. Welding rods should also be kept covered until ready for use. Storage conditions here need not be as rigorous as for spooled electrodes because good welding practice always includes a stainless steel wool rub of the rod just prior to use to remove surface oxidation or other contamination.

TABLE 3.4
Guide to the choice of filler metal for gas shielded arc welding.

BASE ALLOY	AM100A	AZ10A	AZ31B &C	AZ61A	AZ63A	AZ80A	AZ81A	AZ91C	AZ92A	EK41A	EZ33A	HK31A
	Filler alloy											
AM100A	**M107(a)** **4395**											
AZ10A	4395	4350 4395										
AZ31B & C	4395	4350 4395	4350 4395									
AZ61A	4395	4350 4395	4350 4395	4350 4395								
AZ63A	b	b	b	b	M107(a) 4395							
AZ80A	4395	4350 4395	4350 4395	4350 4395	b	4350 4395						
AZ81A	4395	4395	4395	4395	b	4395	M107(a) 4395					
AZ91C	4395	4395	4395	4395	b	4395	4385	M107(a) 4395				
AZ92A	4395	4395	4395	4395	b	4395	4395	4395	M107(a)			
EK41A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396(a)		
EZ33A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396	4396	
HK31A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396	4396	4396(a)
HM21A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396	4396	4396
HM31A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396	4396	4396
HZ32A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396	4396	4396
K1A	4395	4395	4395	4395	b	4395	4395	4395	4395	4396	4396	4396
M1A MG1	4395	4350 4395	4350 4395	4350 4395	b	4350 4395	4395	4395	4395	4395	4395	4395
ZE41A	c	c	c	c	b	c	c	c	c	4396	4396	4396
ZK21A	4395	4350 4395	4350 4395	4350 4395	b	4350 4395	4395	4395	4395	4395	4395	4395
ZH62A ZK51A ZK60A ZK61A	b	b	b	b	b	b	b	b	b	b	b	b

TABLE 3.4
Guide to the choice of filler metal for gas shielded arc welding (continued)

BASE ALLOY	HM21A	HM31A	HZ32A	K1A	LA141A	M1A MG1	QE22A	ZE10A	ZE41A	ZK21A	ZH62A ZK51A ZK60A ZK61A
	Filler alloy										
HM21A	**4396**										
HM31A	4396	4396									
HZ32A	4396	4396	4396(a)								
K1A	4396	4396	4396	4396(a)							
M1A MG1	4395	4395	4395	4395	c	4350 4395					
ZE41A	4396	4396	4396	4396	c	c	4396	c	4396(a)		
ZK21A	4395	4395	4395	4395	c	4350 4395	4396	4350 4395	4395	4350 4395	
ZH62A ZK51A ZK60A ZK61A	b	b	b	b	b	b	b	b	b	b	4396(a)

a. Cast alloys are generally welded with filler metal having the same or similar composition as the base metal in order to achieve maximum strength and proper response to post weld heat treatment schedules. Lacking the availability of suitable rods of such alloys, the commercially available filler metal listed will provide equivalent weldability but with the possibility of some reduction in strength.

b. Welding not recommended

c. No data available for welding this combination.

Note: When more than one filler metal is listed, they are listed in order of preference.