1. FILLER METAL OF ALUMINUM BASED ALLOYS

1.1 Lancaster Alloys Company can offer the following Aluminum Welding Wires* :

Table 1.1. Stock List of LAC for Aluminum Weld Wire

LAC STOCK #	AMS SPECIFICATIONS	ALLOY NAME	AWS SPECIFICATIONS	AWS CLASS	UNS # **
4180	AMS 4180	1100	AWS A5.10	ER1100 R1100	A91100
4181	AMS 4181	4008	N/A	N/A	A9400B
4184	AMS 4184	4145	AWS A5. 10	ER4145 R4145	A94145
4185	AMS 4185	4047	AWS A5. 10	ER4047 R4047	A94047
4189	AMS 4189	4643	AWS A5. 10	ER4643 R4643	A94643
4190	AMS 4190	4043	AWS A5. 10	ER4043 R4043	A94043
4191	AMS 4191	2319	AWS A5. 10	ER2319 R2319	A92319
4245	AMS 4245	355	AWS A5. 10	R-C355.0	A33550
4246	AMS 4246	357	AWS A5. 10	R-A357.0	A03570
A105	N/A	N/A	AWS A5.10	ER5183 R5183	A95183
A106	N/A	N/A	AWS A5. 10	ER5356 R5356	A95356

* *Other aluminum alloys are also available upon request*

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

TABLE 1.2
Chemical Composition Requirements for Aluminum Filler Metals

	Weight Percent (a)(b)									Other Elements		
LAC STOCK #	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	EACH	Total	Al
4180	(c)	(c)	0.05-0.20	0.05	-	-	-	0.10	-	0.05(d)	0.15	99.0 Min (e)
4181	6.5-7.5	0.09	0.05	0.05	0.30-0.45	-	-	0.05	0.04-0.15	0.05(d)	0.15	REMAINDER
4184	9.3-10.7	0.8	3.3-4.7	0.15	0.15	0.15	-	0.20	-	0.05(d)	0.15	REMAINDER
4185	11.0-13.0	0.8	0.30	0.15	0.10	-	-	0.20	-	0.05(d)	0.15	REMAINDER
4189	3.6-4.6	0.8	0.10	0.05	0.10-0.30	-	-	0.10	0.15	0.05(d)	0.15	REMAINDER
4190	4.5-6.0	0.8	0.30	0.05	0.05	-	-	0.10	0.20	0.05(d)	0.15	REMAINDER
4191(f)	0.20	0.30	5.6-6.8	0.20-0.40	0.02	-	-	0.10	0.10-0.20	0.05(d)	0.15	REMAINDER
4245	4.5-5.5	0.20	1.0-1.5	0.10	0.40-0.6	-	-	0.10	0.20	0.05	0.15	REMAINDER
4246	6.5-7.5	0.15	0.05	0.03	0.45-0.6	-	-	0.05	0.20	0.05	0.15	REMAINDER
A105	0.40	0.40	0.10	0.50-1.0	4.3-5.2	0.05-0.25	-	0.25	0.15	0.05(d)	0.15	REMAINDER
A106	0.25	0.40	0.10	0.05-.20	4.5-5.5	0.05-0.20	-	0.10	0.06-0.20	0.05(d)	0.15	REMAINDER

Notes:

a. The filler metal shall be analyzed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of these elements shall be determined to ensure that they do not exceed the limits specified for "Other Elements".

b. Single values are maximum, except where otherwise specified.

c. Silicon plus Iron shall not exceed 0.95 percent.

d. Beryllium shall not exceed 0.0008 percent.

e. The Aluminum content for unalloyed Aluminum is the difference between 100.00 percent and the sum of the other metallic elements present in amounts of 0.010 percent or more each, expressed to the second decimal before determining the sum.

f. Vanadium content shall be 0.05-0.15 percent. Zirconium content shall be 0.10-0.25 percent.

1.3 Filler Metal selection.

The proper choice of aluminum filler metal mainly depends on the base metal properties needed to be achieved and welding technique. Post weld cracking, corrosion resistance and behavior under elevated temperatures also need to be taken into consideration.

1.3.1 Cracking

Cracking usually can be minimized by choosing a filler alloy of higher alloy content than the base metal. For example, alloy 6061 is extremely crack sensitive when welded with 6061 filler; but is readily welded with 4043 filler metal (LAC Stock # 4190), which contains approximately 5% Silicon. Alloy 4043 has the advantage of both melting and solidifying at a temperature lower than the usual base metal on which it is used. For this reason, it remains plastic after the base metal has cooled somewhat, and the contraction stresses which might cause cracking are relieved by the plasticity of the filler metal. Under other conditions a higher magnesium alloy filler- such as 5356 (Stk. # A106) and 5183 (Stk # A105) - increases weld strength and decreases crack sensitivity. Filler alloy 4043 should not be used on higher magnesium alloys 5083, 5086 or 5456, since excessive magnesium-silicide eutectics can develop in the weld structure to decrease ductility and increase crack sensitivity.

To control hot cracking of aluminum weldments, it is desirable to avoid weld metal compositions (the result of the filler metal plus dilution) that are known to be crack sensitive. Severe cracking is known to occur in weld metal when the geometry of the joints, coupled with weld metal chemistry and welding techniques, causes the dilution of the elements to fall within a critical composition range. Cracking problems decrease when the weld metal composition range is below or above this critical range. For silicon this critical range is from approximately 0.5% to approximately 2%. for example, a 4043 filler diluted 80% with alloy 1100 base material (as in a square butt weld) would result in a silicon content in the crack sensitive range.

1.3.2 Corrosion resistance.

Assemblies, vessels and drums for use in certain corrosive environments or with certain chemicals may require special filler alloys. These alloys may be of higher purity or may have closer composition limits on some of the alloying constituents. Aluminum-magnesium filler alloys are highly resistant to corrosion, but tend to be anodic to many other nonheat-treatable alloys, particularly in joints with low dilution. For this reason, they should be used with base alloys possessing a similar solution potential whenever the weld and base metal are to be continuously or cyclically exposed to an electrolyte. A good example is the use of 1100 (stk. # 4180) with 1100 parent metal in some salt water or corrosive applications.

1.3.3 Elevated temperature service

The choice of both base metal and filler metal is important when selecting aluminum alloys for elevated temperature service. Aluminum alloys of over 3.5% magnesium are not ordinarily recommended for continuous service at temperatures of 150°F and above.

1.3.4 Selection of filler metal

Metallurgically, the selection of the correct filler alloy greatly influences the service life of an aluminum weldment. Recommended filler alloys for general purpose welding of various aluminum alloy combination, including casting, are given in tables 1.3 and 1.4. In the repair of castings, the filler alloy is usually chosen to match the composition of the casting.

Table 1.3 - Suggested fillers for commonly welded aluminum alloys

MATERIAL WELDED	STRENGTH	DUCTILITY	SALT WATER CORROSION RESISTANCE	LEAST CRACKING TENDENCY
1100	4190	4180	4180	4190
2219	4191	4191	4191	4191
6061	A106	A106	4190	4190
6063	A106	A106	4190	4190
3003	4190	4180	4180	4190
5052	A106	A106	A105	A106
5086	A106	A106	A106	A106
5083	A105	A106	A105	A106
5454	A106	A106	A106	A106
5456	A105	A106	A105	A106

1.3.5 Storage and use of aluminum filler metal.

A major step towards producing good aluminum welds is the use of high quality filler metal. It should be free of gas and non metalic impurities, with a clean, smooth surface free of moisture, lubricant or other contaminants. Certain care must be taken during storage and use to prevent contamination that could result in poor welds.

To avoid contamination, filler metal supplies should be kept covered, and stored in a dry place at a relatively uniform temperature. Spooled wire temporarily left unused on the welding machine, in between work shifts, should be covered with a clean cloth or plastic bag if the feed unit does not have its own cover. If a spool of wire will not be used for a considerable length of time, it should be returned to its carton and tightly sealed. Original electrode or wire containers should not be opened until the contents are to be used.

Finally, it is very important in the Gas Metal-Arc process since a relatively small diameter filler wire feeds through the welding gun at a high rate of speed, that the electrode wire be uniform in diameter, of a suitable temper, free from slivers, continuous scratches, inclusions, kinks, waves or sharp bends, and spooled so that it is free to unwind without restrictions.

Lancaster Alloys Company is a reliable source for aluminum filler metal of the highest quality. Our customers can be absolutely sure of uniformity, absence of any surface defects and containment free products which do not require additional work that is readily available for welding in the condition received. Lancaster Alloys Company can offer a wide variety of re-sealable packing bags covered by requirements of AMS, AWS, and other commercial practices to keep the filler metal containment free as long as it stays in the original packaging.

1.4 Typical procedures for welding Aluminum

There are several welding techniques and procedures used in joining Aluminum alloys. In this catalog we have outlined the two most widely use practices of groove welding for Gas Metal-Arc (GMAW) and Gas Tungsten-Arc (GTAW) welding.

Table 1.4
Guide to the choice of filler metal for general purpose welding

Base Metal	201.0 206.0 224.0	319.0, 333.0 354.0, 355.0 C355.0	356.0, A356.0 357.0, A357.0 413.0, 443.0 A444.0	511.0, 512.0 513.0, 514.0 535.0	7004, 7005. 7039, 710.0 712.0	6009 6010 6070	6005,6061. 6063,6101. 6151,6201. 6351,6951	5456	5454
1060, 1070,1080, 1350	4184	4184	4190(a)(b)	A106(c)(d)	A106(c)(d)	4190(a)(b)	4190(a)(b)	A106(d)	4190(b)(d)
1100, 3003, Alc3003	4184	4184	4190(a)(b)	A106(c)(d)	A106(c)(d)	A106(c)(d)	4190(a)(b)	4190(a)(b)	A106(d)
2014, 2036	4184(e)	4184(e)	4184	-	-	4184	4184	-	-
2219	4191(a)	4184(e)	4184(b)(c)	4190	4190	4190(a)(b)	4190(a)(b)	-	4190(a)(b)
3004, Alc 3004	-	4190(b)	4190(b)	A106(d)	A106(d)	4190(b)	4190(b)(d)	A106(d)	A106(d)
5005, 5050	-	4190(b)	4190(b)	A106(d)	A106(d)	4190(b)	4190(b)(d)	A106(d)	A106(d)
5052, 5652	-	4190(b)	4190(f)	A106(d)	A106(d)	4190(b)	A106(c)(d)	A106(d)	A106(d)
5083	-	-	A106(c)(d)	A106(d)	A105(d)	-	A106(d)	A105(d)	A106(d)
5086	-	-	A106(c)(d)	A106(d)	A106(d)	-	A106(d)	A106(d)	A106(d)
5154, 5254	-	-	4190(d)	A106(d)	A106(d)	-	A106(d)	A106(d)	A106(d)
5454	-	4190(b)	4190(d)	A106(d)	A106(d)	4190(b)	A106(c)(d)	A106(d)	4190(d)
5456	-	-	A106(c)(d)	A106(d)	A106(d)	-	A106(d)	A105(d)	A105(d)
6005, 6061,6063,6101 6151,6201,6351, 6951	4184	4184(b)(c	4190(b)(d)	A106(d)	A106(c)(d)	4190(a)(b)	4190(b)(d)		
6009, 6010, 6070	4184	4184(b)(c)	4190(a)(b)	4190	4190	4190(a)(b)			
7004, 7005, 7039 710.0, 712.0	-	4190(b)	4190(b)(d)	A106(d)	A106(d)				
511.0, 512.0, 513.0 514.0, 535.0	-	-	4190(d)	A106(d)					
356.0, A356.0, 357.0 A357.0, 413.0, 443.0 A444.0	4184	4184(b)(c)	4190(b)						
319.0, 333.0, 354.0 355.0, C355.0	4184(e)	4184(b)(c)							
201.0, 206.0, 224.0	4191(a)								

Table 1.4
Guide to the choice of filler metal for general purpose welding (continued)

Base Metal	5154 5254	5086	5083	5052 5652	5005 5050	3004 Alc. 3004	2219	2014 2036	1100 3003 Alc. 3003	1060 1070 1080 1350
1060, 1070,1080, 1350	A106 (b)(c)(d)	A106(d)	A106(d)	4190(b)(d)	4180(b)(c)	4190(b)(d)	4184(b)(c)	4184	4180(b)(c)	4180(b)(c)
1100, 3003, Alc3003	A105(b)(c)(d)	A106(d)	A106(d)	4190(b)(d)	4180(b)(c)	4190(b)(d)	4184(b)(c)	4184	4180(b)(c)	-
2014, 2036	-	-	-	-	4184	4184	4184(e)	4184(e)	-	-
2219	4190(b)	-	-	4190(b)	4190(a)(b)	4190(a)(b)	4191(a)	-	-	-
3004, Alc 3004	A106(d)	A106(d)	A106(d)	A106 (b)(c)(d)	A106(c)(d)	A106(c)(d)	-	-	-	-
5005, 5050	A106(d)	A106(d)	A106(d)	A106 (b)(c)(d)	A106(c)(d)	-	-	-	-	-
5052, 5652	A106(d)	A106(d)	A106(d)	A106 (c)(d)	-	-	-	-	-	-
5083	A106(d)	A106(d)	A105(d)	-	-	-	-	-	-	-
5086	A106(d)	A106(d)	-	-	-	-	-	-	-	-
5154, 5254	A106(d)	-	-	-	-	-	-	-	-	-

Notes:

1. Service conditions such as immersion in fresh or salt water, exposure to specific chemicals, or a sustained high temperature(over 150°F (66°C) may limit the choice of filler metals. Filler metals A105 and A106 are not recommended for sustained elevated temperature service.
2.Recommendations in this table apply to gas shielded arc welding processes. For oxyfuel gas welding, only 4180, 4184, 4185 and 4190 filler metals are ordinarily used.
3.Where no filler metal is listed, the base metal combination is not recommended for welding.
   a. 4184 may be used for some applications.
   b. 4185 may be used for some applications.
   c. 4190 may be used for some applications.
   d. A105 and A106 may be used. In some cases ,they provide : (1) improved color match after anodizing treatment, (2) highest welding ductility, and (3) higher weld strength.
   e. 4191 may be used for some applications. It can supply high strength when the weldment is post-weld solution heat threaded and aged.

1.4.1 GMAW

For the GMAW process spooled filler metal is used in smaller wire diameters ranging from .030" to .1/16" (very seldom in 3/32").

Table 1.5 shows the typical groove weld procedure on GMAW.
Lancaster Alloys Company can suppply aluminum weld wire on layer wound spools in 2", 8", and 12" OD in accordance with requirements of AMS and AWS specifications. The inner end of each spool is easily accesible for alloy verification. Filler metal on each spool is one continuous length of wire free of splices.

TABLE 1.5

Approximate groove welding procedures for the gas metal-arc welding of aluminum

Metal Thickness in.	Weld Position (1)	Root Opening, in.	Weld Passes	Electrode Diameter, in.	DC, Amps	Arc Voltage	Argon Gas Flow, cfh	Arc travel speed, ipm	Approximate Electrode Consumption, Lb/100 ft
1/16		None	1	.030	70-110	15-20	25	25-45	1.5
	F	3/32	1	.030	70-110	15-20		25-45	2
3/32	F	NONE	1	.030-3/64	90-150	18-22	30	25-45	1.8
	F,V,H,O	1/8	1	.030	110-130	18-23	30	23-30	2
1/8	F,V,H	0-3/32	1	.030-3/64	120-150	20-24	30	24-30	2
	F,V,H,O	3/16	1	.030-3/64	110-135	19-23	30	18-28	3
3/16	F,V,H	0-1/6	1F,1R	.030-3/64	130-175	22-26	35	24-30	4
	F,V,H	0-1/16	1	3/34	140-180	23-27	35	24-30	5
	O	0-1/16	2F	3/64	140-175	23-27	60	24-30	5
	F,V	3/32-3/16	2	3/64-1/16	140-185	23-27	35	24-30	8
	O,H	3/16	3	3/64	130-175	23-27	60	25-35	10
1/4	F	0-3/32	1F,1R	3/64-1/16	175-200	24-28	40	24-30	6
	F	0-3/32	2	3/64-1/16	185-225	24-29	40	24-30	8
	V,H	0-3/32	3F,1R	3/64	165-190	25-29	45	25-35	10
	O	0-3/32	3F,1R	3/64-1/16	180-200	25-29	60	25-35	10
	F,V	1/8-1/4	2-3	3/64-1/16	175-225	25-29	40	24-30	12
	O,H	1/4	4-6	3/64-1/16	170-200	25-29	60	25-40	12
3/8	F	0-3/32	1F,1R	1/16	225-290	26-29	50	20-30	16
	F	0-3/32	2F,1R	1/16	210-275	26-29	50	24-35	18
	V,H	0-3/32	3F,1R	1/16	190-220	26-29	55	24-30	20
	O	0-3/32	5F,1R	1/16	200-250	26-29	80	25-40	20
	F,V	1/4-3/8	4	1/16	210-290	26-29	50	24-30	35
	O,H	3/8	8-10	1/16	190-260	26-29	80	25-40	50
3/4	F	0-3/32	3F,1R	1/16-3/32	340-400	26-31	60	14-20	50
	F	0-1/8	4F,1R	3/32	325-375	26-31	60	16-20	70
	V,H,O	0-1/16	8F,1R	1/16	240-300	26-30	80	24-30	75
	F	0-1/16	3F,3R	1/16	270-330	26-30	60	16-24	70
	V,H,O	0-1/16	6F,6R	1/16	230-280	26-30	80	16-24	75

1. F=Flat; V=Vertical; H=Horizontal; O=Overhead

1.4.2 GTAW

For the manual GTAW process, straight length (rods) are used and may be cut to lengths specified by the customer, usually in diameters ranging from 3/64" to 1/4".

Table 1.6 shows the typical procedure for manual GTAW of groove joints in aluminum alloys.

TABLE 1.6

Typical procedure for manual welding of groove joints in aluminum and its alloys by using the gas tungsten-arc welding process (electrode negative)

Metal Thickness in.	Joint	Filler rod Diameter, in.	Thoriated Tungsten electrode diameter in	Arc Travel, ipm	Current, Amps	Arc Voltage	Helium Flow, cfh
0.030	Square groove 1 pass	3/64	040	17	20	21	20
0.040	Square groove 1 pass	1/16	040	16	26	20	20
0.060	Square groove 1 pass	1/16	040	20	44	20	20
0.090	Square groove 1 pass	3/32	1/16	11	80	17	30
0.125	Square groove 1 pass	1/8	1/16	16	118	15	20
0.250	Square groove 1 pass	5/32	1/8	7	250	14	30
0.500	Single vee groove 90° incl. angle. 1/4" root face. 2 passes	5/32	1/8	5 1/2	310	14	40
0.750	90° groove angle. 3 1/16 root face. 2 passes	5/32	1/8	4	300	17	50
1.000	Double vee 90° groove angle. No root face. 5 passes	1/4	1/8	1 1/2	360	19	50

Notes

1. Helium is recommended for gas tungsten-arc welding of aluminum and its alloys with straight polarity direct current.
2. Helium arc voltage is 40% greater then argon arc voltage per unit of arc length, resulting in a hotter arc, deeper penetration, greater travel speeds, and in some instances, minimum of heat effects on work.
3. For a given change in arc length the helium arc voltage changes more then the argon arc voltage. This makes possible more sensitive control of automatic welding with helium shielding gas.
4. Aluminum, because of its high thermal conductivity, requires the high rate of heat which helium gas produces.

Lancaster Alloys Company can supply aluminum welding rods in 18", 27", 36", and other lengths may be available upon request. All rods can be flag tagged one end or two ends in accordance with AMS 2816 requirements. Rods can be packaged in 1, 5 or 10 lb bags.

1.5 Properties and performance of weldments

Development of GTAW and GMAW has made practical the use of high-strength filler metals, and permitted the welding of alloys not joinable by other fusion processes that resulted in achieving welds with increased strength and ductility.

The properties and performance of weldments may be influenced by many factors, including the composition, form and temper of the base metals, the filler metal used, the welding process, travel speed, rate of cooling, joint design and service environment. The effect of these and other variables should be considered. In many instances, weldments are designed so that the welds are in non-critical areas and in case of overload, the assembly will be stressed to failure at some other location. Most of the information given here applies to situations where the weld and adjacent metal are critical from the standpoint of strength and performance.

Tables 1.7 through 1.8 gives examples of some properties of welded joints in non-heat treated and heat treatable aluminum alloys.

TABLE 1.7

Tensile strength and elongation of gas-shielded arc welded groove joints in some nonheat-threated aluminum alloys (1)

Aluminum Association Designation	Filler Alloy	Average Tensile Strength, psi x10³	Minimum Annealed Tensile Strength, psi x10³	Average yield Strength (psi x10³) 0.2% Offset in 2 in.	Minimum yield Strength (psi x10³) 0.2% Offset in 2 in.	Free Bend Elongation (%)	Tensile Elongation in 2 in. (%)
1100	4180	13	11	6	6	54	29
3003	4180	16	14	7	7	58	24
5005	A106	16	14	9	8	32	15
5050	A106	23	16	12	10	36	18
5052	A106	28	25	14	13	39	19
5083	A105	43	40	22	18	34	16
5086	A106	39	35	19	17	38	17

1. Reduced section tensile

TABLE 1.8

Typical strength and elongation of gas-shielded arc welded groove joints in some heat treatable aluminum alloys

	Base Alloy Properties				As Welded				Postweld Heat Treated and			
			Elongation				Elongation				Elongation	
Alloy and Temper	Tensile Strength[1] psi x10³	Yield Strength[2] psi x10³	% in 2 in.	Filler Alloy	Tensile Strength[1] psi x10³	Yield Strength[2] psi x10³	% in 2 in.	Free Bend %	Tensile Strength[1] psi x10³	Yield Strength[2] psi x10³	% in 2 in.	Free Bend %
2014-T6, T651	70	60	13	4190	34	28	4	9	50	-	2	5
2219-T81	66	50	10	4191	35	26	3	20	43[3]	37[3]	2[3]	-
2219-T87	69	57	10	4191	35	26	3	20	43[3]	37[3]	2[3]	-
2219-T6, T62	60	42	10	4191	35	26	3	20	50	38	7	-
6061-T4, T451	35	21	22	4190	27	18	8	16	35[3]	-	8[3]	-
6061-T6, T651	45	40	12	4190	27	18	8	16	44	40	5	11
6061-T6,T651	45	40	12	A106	30	19	11	25	-	-	-	-
6063-T4	25	13	22	4190	20	10	12	16	30	-	13	-
6063-T6	35	31	12	4190	20	12	8	16	30	-	13	-
6063-T6	35	31	12	A106	20	12	12	25	-	-	-	-
7039-T61	60	50	14	A105	47	32	10	-	-	-	-	-
7039-T61	60	50	15	A106	45	31	11	-	-	-	-	-
7039-T64	65	55	13	A105	45	26	12	21	-	-	-	-
7039-T64	65	55	13	A106	44	25	13	19	-	-	-	

1. Reduced section tensile
2. 0.2% offset in 2 inch gage.
3. Postweld aged only.

Table 1.9 Effect of welding conditions on strength of groove joints in alloy 6061 with filler metal 4190

Base Alloy and Temper	Thickness in.	As Welded				Aged After Welding			Solution Heat Treated and Aged After Welding		
		Welding Process and conditions	Tensile Strength, psi x10³	Yield Strength 0.2% offset in 2 in. Gauge psi x10³	% Elongation in 2 in. Gauge	Tensile Strength, psi x10³	Yield Strength 0.2% offset in 2 in. Gauge psi x10³	% Elongation in 2 in. Gauge	Tensile Strength psi x10³	Yield Strength 0.2% offset in 2 in. Gauge psi x10³	% Elongation in 2 in. Gauge
6061-T4	1/32	AC-GTA 96 ipm	33	21	6		28	4	-	-	-
6061-T6	1/32	AC-GTA 96 ipm	33	26	2		26	3	-	-	-
6061-T4	1/8	SP-DC GTA 20 ipm	34	21	8	41	26	3	44	40	5
6061-T6	1/8	SP-DC GTA 35 ipm Single Pass	36	24	6	-	26	3	44	40	5
6061-T6	1/4	Auto-GMA One Pass Each Side 40 ipm	37	20	6	-	18	8	43	40	5
6061-T4	3	Auto-GMA Multypass V Groove	25	13	10	-	18	8	34	-	4

Table 1.10 Minimum Tensile strengths at various temperatures across arc-welded butt joints in alluminum alloys

Base Alloy Aluminum Association designation	Filler Alloy Metal	Ultimate Tensile Strength (Psi)[1]					
		-300°F	-200°F	-100°F	100°F	300°F	500°F
2219-T37[2]	4191	**48 ,500**	40 ,000	36 ,000	35 ,000	31 ,000	19 ,000
2219-T62[3]	4191	**64 ,500**	59 ,500	55 ,000	50 ,000	38 ,000	22 ,000
3003	4180	**27 ,500**	21 ,500	17 ,500	14 ,000	9 ,500	5 ,000
5052	A106	**38 ,000**	31 ,000	26 ,500	25 ,000	21 ,000	10 ,500
5083	A105	**54 ,500**	46 ,000	40 ,500	40 ,000	-	-
5086	A106	**48 ,000**	40 ,500	35 ,500	35 ,000	-	-
6061-T6	4190	**34 ,500**	30 ,000	26 ,500	24 ,000	20 ,000	6 ,000
6061-T6	4190	**55 ,000**	49 ,500	46 ,000	42 ,000	31 ,500	7 ,000

1. Alloys not listed at 300°F and 500°F are not recommended for use at sustained operating temperatures of over 150°F
2. As welded
3. Heat treated and aged after welding