

5. FILLER METAL OF IRON BASED HEAT AND COROSION RESISTANT ALLOYS AND STAINLESS STEELS

5.1 Lancaster Alloys Company can offer the following Heat and Corosion Resistant Alloys and Stainless steel weld wires(1):

Table 5.1. Stock list of LAC for Heat and Corrosion Resistant and Stainless Steel weld

LAC STOCK #	AMS SPECIFICATIONS	ALLOY NAME	AWS SPECIFICATIONS	AWS CLASS	UNS # (2)
5617	AMS 5617	455	N/A	N/A	S45500
5621	AMS 5621	420	N/A	N/A	S42000
5656	AMS 5656	21-6-9	N/A	N/A	S21904
5659	AMS 5659	15-5	N/A	N/A	S15500
5680	AMS 5680	347	AWS A5 .9 (3)	ER347 (3)	S34781
5689	AMS 5689	321	N/A	N/A	S32100
5692	AMS 5692	316	AWS A5 .9	ER316	S31680
5694	AMS 5694	310	AWS A5 .9 (3)	ER310 (3)	S31080
5763	AMS 5763	450	N/A	N/A	S45000
5774	AMS 5774	350	N/A	N/A	S35080
5776	AMS 5776	410	AWS A5 .9 (3)	ER410 (3)	S41000
5780	AMS 5780	355	N/A	N/A	S35500
5782	AMS 5782	19-9W-Mo	N/A	N/A	S63199
5784	AMS 5784	29-9	AWS A5 .9 (3)	ER312 (3)	S64299
5794	AMS 5794	N-155	N/A	N/A	S30155
5803	AMS 5803	17-4	N/A	N/A	S17400
5804	AMS 5804	A286	N/A	N/A	S66286
5813	AMS 5813	15-7Mo	N/A	N/A	S15780
5823	AMS 5823	190	N/A	N/A	S41780
5824	AMS 5824	17-7	N/A	N/A	S17780
5825	AMS 5825	17-4	AWS A5 .9 (3)	ER630	S17480
5826	AMS 5826	15-5VM	N/A	N/A	S15500
5840	AMS 5840	13-8Mo	N/A	N/A	S13889
6466	AMS 6466	502	AWS A5 .9 (3)	RE502 (3)	S50280
S102	N/A	308L	AWS A5 .9	ER308L	S30883
S103	N/A	316L	AWS A5 .9	ER316L	S31683
S104	N/A	316H	AWS A5 .9	ER316H	S31680
S109	N/A	308	AWS A5 .9	ER308	S30880
S115	N/A	309	AWS A5 .9	ER309	S30980
S116	N/A	309L	AWS A5 .9	ER309L	S30983

1. Other alloys and steels are also available upon request
2. SAE/ASTM Unified Numbering System for metals and alloys
3. AWS specification has slightly different chemical composition requirements (see table 5.2)

TABLE 5.2
Chemical composition requirements

LAC STOCK #	Weight percent(a)															
	C	Cr	Ni	Mo	Mn	Si	P	S	N	Cu	Ti	Cb +Ta	Al	Sn	W	Co
5617	0.010 to 0.015	11.00 to 12.50	7.50 to 9.50	0.50	0.50	0.20	0.010	0.010	0.010	1.50 to 2.50	1.00 to 1.35	0.50	-	-	-	-
5621	0.30 to 0.40	12.00 to 14.00	0.50	0.50	1.00	1.00	0.040	0.030	-	0.50	-	-	0.05	0.05	-	-
5656	0.04	19.00 to 21.50	5.50 to 7.50	0.75 to 10.00	8.00 to 10.00	1.00	0.060	0.030	1.50 to 0.40	0.75	-	-	-	-	-	-
5659	0.07	14.00 to 15.50	3.50 to 5.50	0.50	1.00	1.00	0.030	0.015	-	2.50 to 4.50	-	5XC to 0.45	-	-	-	-
5680	0.07	17.00 to 20.00	9.00 to 13.00	0.75	1.00 to 2.00	0.30 to 1.00	0.030	0.030	-	0.75	-	12XC Min	-	-	-	-
5680(b)	0.08	19.00 to 21.50	9.00 to 11.00	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	10XC to 1.00	-	-	-	-
5689	0.08	17.00 to 19.00	9.00 to 12.00	0.75	2.00	0.40 to 1.00	0.040	0.030	0.10	0.75	5X(C+N) to 0.70	-	-	-	-	-
5692	0.08	18.00 to 20.00	11.00 to 14.00	2.00 to 3.00	1.00 to 2.5	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-

TABLE 5.2 (Continued)
Chemical composition requirements

LAC STOCK #	Weight percent(a)															
	C	Cr	Ni	Mo	Mn	Si	P	S	N	Cu	Ti	Cb +Ta	Al	Sn	W	Co
5694	0.15	26.00 to 28	20.50 to 22.50	0.75	1.25 to 2.50	0.25 to 0.60	0.030	0.025	-	0.75	-	-	-	-	-	-
5694(b)	0.08 to 0.15	25.00 to 26.00	20.00 to 22.50	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-
5763	0.05	14.00 to 16.00	6.00 to 7.00	0.50 to 1.00	1.00	1.00	0.030	0.030	-	1.25 to 1.75	-	8XC to 0.75	-	-	-	-
5774	0.08 to 0.12	16.00 to 17.00	4.00 to 5.00	2.50 to 3.25	0.50 to 1.25	0.50	0.040	0.030	0.07 to 0.13	-	-	-	-	-	-	-
5776(c)	0.10 to 0.15	11.50 to 13.50	0.75	0.50	1.00	1.00	0.025	0.015	0.08	0.50	-	-	0.05	0.05	-	-
5776(b)	0.12	11.50 to 13.50	0.60	0.75	0.60	0.50	0.030	0.030	-	0.75	-	-	-	-	-	-
5780	0.10 to 0.15	15.00 to 16.00	4.00 to 5.00	2.50 to 3.25	0.50 to 1.25	0.50	0.030	0.030	0.07 to 0.13	0.50	-	-	-	-	-	-
5782	0.07 to 0.13	19.00 to 22.00	8.00 to 9.50	0.35 to 0.65	1.00 to 2.00	0.30 to 0.65	0.015	0.10	-	0.50	0.10 to 0.30	1.00 to 1.40	-	-	1.25 to 1.75	-

TABLE 5.2 (Continued)
Chemical composition requirements

LAC STOCK #	Weight percent(a)															
	C	Cr	Ni	Mo	Mn	Si	P	S	N	Cu	Ti	Cb +Ta	Al	Sn	W	Co
5784	0.08 to 0.15	27.00 to 31.00	8.50 to 10.50	0.50	1.00 to 2.00	0.75	0.040	0.030	-	0.50	-	-	-	-	-	-
5784(b)	0.15	28.00 to 32.00	8.00 to 10.50	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-
5794	0.10	20.00 to 22.5	19.00 to 21	2.50 to 3.50	1.00 to 2.00	1.00	0.040	0.030	0.10 to 0.20	-	-	0.75 to 1.25	-	-	2.00 to 3.00	18.50 to 21.00
5803(d)	0.05	16.00 to 16.75	4.50 to 5.00	0.75	0.25 to 0.75	0.50	0.015	0.008	0.015	3.25 to 4.00	-	0.15 to 0.30	0.05	0.0050	-	-
5804(e)	0.08	13.50 to 16.00	24.00 to 27.00	1.00 to 1.50	2.00	1.00	0.020	0.015	-	-	2.00 to 2.45	-	0.35	-	-	-
5813	0.09	14.00 to 15.25	6.50 to 7.75	2.00 to 2.75	1.00	0.50	0.025	0.025	-	-	-	-	0.75 to 1.25	-	-	-
5823(f)	0.10 to 0.15	11.00 to 12.50	2.50 to 3.00	1.50 to 2.00	0.40 to 1.30	0.40	0.030	0.030	0.045	0.75	-	-	-	-	-	1.30 to 2.00
5824	0.09	16.00 to 17.25	6.50 to 7.75	-	1.00	0.50	0.025	0.025	-	-	-	-	0.75 to 1.25	-	-	-

TABLE 5.2 (Continued)
Chemical composition requirements

Weight percent(a)

LAC STOCK #	C	Cr	Ni	Mo	Mn	Si	P	S	N	Cu	Ti	Cb +Ta	Al	Sn	W	Co
5825	0.05	16.00 to 16.75	4.50 to 5.00	0.75	0.25 to 0.75	0.75	0.025	0.025	-	3.25 to 4.00	-	0.15 to 0.30	-	-	-	-
5826(g)	0.025 to 0.050	14.40 to 15.30	4.75 to 5.50	0.30	0.25 to 0.75	0.60	0.020	0.010	0.040	3.00 to 3.50	-	5XC to 0.40	0.25	-	-	-
5840(h)	0.05	12.25 to 13.25	7.50 to 8.50	2.00 to 2.50	0.10	0.10	0.008	0.010	0.010	-	-	-	0.90 to 1.35	-	-	-
6466	0.10	4.50 to 6.00	0.60	0.45 to 0.65	0.60 to 0.65	0.25 to 0.60	0.030	0.030	-	0.35	-	-	-	-	-	-
6466(b)	0.10	4.60 to 6.00	0.60	0.45 to 0.65	0.60	0.50	0.030	0.030	-	0.75	-	-	-	-	-	-
S102	0.03	19.50 to 22.00	9.00 to 11.00	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-
S103	0.03	18.00 to 20.00	11.00 to 14.00	2.00 to 3.00	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-
S104	0.04 to 0.08	18.50 to 20.00	11.00 to 14.00	2.00 to 3.00	1.00 to 2.50	0.30 to .065	0.030	0.030	-	0.75	-	-	-	-	-	-
S109	0.08	19.50 to 22.00	9.00 to 11.00	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-
S115	0.12	23.00 to 25.00	12.00 to 14.00	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-
S116	0.03	23.00 to 25.00	12.00 to 14.00	0.75	1.00 to 2.50	0.30 to 0.65	0.030	0.030	-	0.75	-	-	-	-	-	-

coefficient of thermal expansion as the base metal. Such welds can be more completely stress relieved than welds made with austenitic filler metal.

Fabrication problems are considerably lessened with austenitic filler metal. These weld metals possess a high degree of notch toughness and do not harden upon quenching. Both of these properties are favorable to welding, because they lessen the risk of cracking. While preheating is usually desirable, it may often be omitted particularly if the weldment is to receive a postheat treatment. If no postheat treatment is to be administered, preheating is often done for the sole purpose of keeping the residual stresses as low as possible.

A stabilized austenitic filler metal is recommended when the environment is corrosive and unstabilized to sensitized weld deposits. When the welds are to be used in a corrosive environment, consideration should be given to the possibility of electrolytic corrosion resulting from the galvanic current produced by dissimilar metals when exposed to an electrolyte. This problem requires separate consideration for each individual application, since in many environments electrolytic corrosion has not proved to be a problem with these material combinations. Fusion line shearing stresses under cyclic temperature operations and sigma phase formation are factors that should be considered when austenitic filler metal is used in joints intended for elevated temperature operation.

The effect of the heat when welding on the base metal is the same regardless of the filler metal composition. Thus, if the base metal is susceptible to heat affected zone sensitization (Types 429, 430, 446) and if the service environment may cause intergranular attack, the weldment should be post weld heat treated to restore its optimum resistance to corrosion. From the standpoint of mechanical properties in the as-welded condition, the heat affected zone is usually the weakest point in a joint welded with austenitic filler metal.

5.4 Filler metal selection and application.

5680

Alloy 347 (Also known as 18-8) has Cb (Nb) as a stabilizer. This addition of Cb (Nb) reduces the possibility of intergranular chromium carbide precipitation and thus susceptibility to intergranular corrosion. Filler metal of this classification is usually used for welding chromium-nickel stainless steel base metals of similar composition stabilized with either Cb (Nb) or Ti. Although Cb (Nb) is the stabilizing element usually specified in type 347 alloys, it should be recognized that Tantalum (Ta) is also present. Ta and Cb (Nb) are almost equally effective in stabilizing carbon and in providing high-temperature strength. If dilution by base metal produces a low ferrite or fully austenitic weld metal, the crack sensitivity of the weld may increase substantially.

5692

This filler metal is used for welding type 316 and similar alloys. It has been used successfully in certain applications involving special base metal for high-temperature service.

Notes to table 5.2:

- a. Single values shown are maximum percentages; Iron-remainder
- b. Chemical composition per AWS A5. 9 requirements
- c. P+S - 0.030 maximum
- d. Boron - 0.001, Oxygen - 0.0050, Hydrogen - 0.0005, Lead - 0.001 maximum
- e. Boron - 0.003 to 0.010; Vanadium - 0.10 to 0.50
- f. Vanadium - 0.25 to 0.40
- g. Oxygen - 0.010; Hydrogen - 0.0006 maximum
- h. Oxygen - 0.005; Hydrogen - 0.0025 maximum

5.2 Chemical composition

Table 5.2 shows chemical composition for filler metals of heat, corrosion resistant and stainless steels.

5.3 General.

Filler metals belonging to the stainless steel, heat and corrosion resistant iron based groups are the most widely used alloys in the welding of aircraft and other components, because of their large variety and their extensive applications.

There are several groups of these alloys primarily divided by classes: Austenitic, Ferritic, Martensitic. The classes represent the type of microstructure these alloys have after heat treatment, including welding.

The type of microstructure of weldments primarily depends on the chemical composition of the filler metal since cooling rate after welding is high enough, unless post weld heat treatment needs to be applied to get desirable properties.

That's why it is more convenient to divide the most commonly used steel filler metals by their main alloying elements:

- 1) Chromium-molybdenum and straight chromium stainless steel duplicating as closely as possible the base metal composition;
- 2) Austenitic chromium-nickel stainless steel including precipitation hardenable having chromium and nickel contents properly proportioned to allow for dilution (resulting from mixing with the base metal) so that the composition of the final deposit will provide an acceptable amount of austenite to increase weld toughness and ductility.

The as deposited weld metal properties of both hardenable and the non-hardenable straight chromium stainless steels have low toughness and ductility. These alloys are not used for filler metal unless the weldment is to receive a post heat treatment. However, straight chromium stainless steel and chrome-moly filler metal offers the advantage of having the same

5694

Filler metal of this classification is most often used to weld base metals of similar compositions.

5776

This 12 Cr alloy (wt.%) is an air-hardening steel. Preheat and postheat treatments are required to achieve welds of adequate ductility for many engineering purposes. The most common application for filler metal of this type is in welding alloys of similar composition. It is also used for deposition of overlays on carbon steels to resist corrosion, erosion, or abrasion.

5784

Filler metal of this classification was originally designed to weld cast alloys of similar composition. It has also been found to be valuable in welding dissimilar metals such as carbon steel to stainless steel, particularly those grades high in nickel. This alloy gives a two-phase weld deposit with a substantial percentage of ferrite in an austenite matrix. Even with considerable dilution by austenite-forming elements such as nickel, the microstructure remains two-phase and thus highly resistant to weld metal cracks and fissures.

5823

Alloy 190 (M 190), more commonly known as "JETHETE," is widely used for repair of jet engine components with similar compositions. There are only two manufacturers in existence that are currently capable of producing this alloy into weld wire and Lancaster Alloys Co. is one of them.

5825

The composition of this filler metal was designed primarily for welding ASTM A564 Type 630 and other precipitation-hardening stainless steels. The composition was modified to prevent the formation of ferrite networks in the martensitic microstructure which have a deleterious effect on mechanical properties. Depending on the requirements and weld size, the weld metal may be used in either as-welded, welded and precipitation hardened or welded solution treated and precipitation hardened applications.

6466

This filler metal is used for welding material of similar composition, usually in the form of pipe or tubing. This alloy is an air-hardening material and, therefore, when welding with this filler metal, preheating and postweld treatment is required.

S109

Commercial specifications for filler and base metals vary in the minimum alloy requirements; consequently, the names 18-8, 19-9 and 20-10 are often associated with filler metals of this classification. This filler metal is most often used to weld base metal of similar composition, in particular, Type 304.

S102

This classification is the same as S109 except for the carbon content. Low carbon (0.03 percent max) in this filler metal reduces the possibility of intergranular carbide precipitation. This increases the resistance to intergranular corrosion without the use of stabilizers such as columbium (niobium) or titanium. Strength of this low-carbon alloy, however, is less than that of columbium (niobium)-stabilized alloys or Type 308H at elevated temperatures.

S103

This classification is the same as 5692, except for the carbon content. Low carbon (0.03 percent max.) in this filler metal reduces the possibility of intergranular chromium carbide precipitation and thereby increases the resistance to intergranular corrosion without the use of stabilizers such as columbium (niobium) or titanium. This filler metal is primarily used for welding low-carbon molybdenum-bearing austenitic alloys. This low carbon alloy, however, is not as strong at elevated temperature as the columbium (niobium)-stabilized alloys or Type ER316H

S104

This filler metal is the same as 5692 except that the allowable carbon content has been restricted to the higher portion of the 316 range. Carbon content in the range of 0.04 to 0.08 wt.% provides higher strength at elevated temperatures. This filler metal is used for welding 316H base metal.

S115

Filler metals of this classification are commonly used for welding similar alloys in wrought or cast form. Occasionally, they are used to weld Type 304 and similar base metals where severe corrosion conditions exist requiring higher alloy weld metal. They are also used in dissimilar metal welds, such as joining Type 304 to carbon steel, welding the clad side of Type 304 clad steels, and applying stainless steel sheet lining to carbon steel shells.

S116

This classification is the same as S115, except for carbon content. Low carbon (0.03 percent max) in this filler metal reduces the possibility of inter granular carbide precipitation. This increases the resistance to intergranular corrosion with out the use of stabilizers such as columbium (niobium) or titanium. Strength of this low-carbon alloy, however, may not be as great at elevated temperatures as that of the columbium (niobium) stabilized alloys or S115.