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Silver and Phos Copper Silver Brazing Alloys

HIGH SILVER BRAZING ALLOYS

Washington Alloy offers approximately 14 different high silver brazing alloys for joining most ferrous and nonferrous metals, except aluminum and magnesium. These High Silver Brazing Alloys are manufactured from only the highest purity raw materials, thereby elim¬inating undesirable trace elements which might otherwise interfere with brazing operations. All Washington Alloy High Silver Brazing Alloys are carefully formulated to provide maximum strength and corrosion resistance when joining stainless steel, copper alloys, nickel alloys, precious metals and just about any combination of these metals.

CADMIUM VS. CADMIUM-FREE

Washington Alloy offers both cadmium-free as well as cadmium-bearing alloys. The presence of cadmium gives the alloy a lower melting range and excellent fluidity. These alloys are mostly used in electrical components, petrochemical applications, brazing and joining of mild steel, tool steel, tungsten carbide tool tips and copper or nickel alloys.

Although the cadmium-bearing alloys provide some advantages, they are potentially dangerous due to the toxicity of the fumes and are considered carcinogenic. For this reason Washington Alloy offers several cadmium-free alloys such as USA 35CF, USA 45CF, USA 56CF and USA 54CF. The cadmium-free alloys are primarily used in the fabrication of

REEL DATA

WASHINGTON ALLOY PRODUCT	APPLICABLE SPECIFICATIONS			CHEMICAL COMPOSITION						
	AMS A5.8	Federal QQ-B-654A	AMS	Ag	Cu	Zn	Cd	Ni	Sn	P
SILVER BRAZING ALLOYS										
USA 45%	BAg-1	VII	AMS4769B	45	15	16	24			
USA 50%	BAg-1 a	IV	AMS4770G	50	15.5	16.5	18			
USA 35%	BAg-2	VIII	AMS4768D	35	26	21	18			
USA 35 CF	—			35	32	33	—			
USA 30%	BAg-2a			30	27	23	20			
USA 50N	BAg-3	V	AMS4771E	50	15.5	15.5	16	3		
USA 40 NCF	BAg-4	BAg-4		40	30	28		2		
USA 45 CF	BAg-5	BAg-5		45	30	25				
USA 50 CF	BAg-6			50	34	16				
USA 56 CF	BAg-7	BAg-7		56	22	17			5	
USA 72 CF	BAg-8			72	Bal.					
USA 54 CF	BAg-13		AMS4772	54	Bal.	5		1		
USA 30 CF	BAg-20	BAg-20		30	38	32				
USA 40 CF	BAg-28			40	30	28			2	
PHOS-COPPER SILVER ALLOYS										
USA 0	BCUP-2			0	Bal.					7.2
USA 5%	BCUP-3			5	Bal.					6
USA 6F	BCUP-4			6	Bal.					7.25
USA 15%	BCUP-5			15	Bal.					5
USA 2%	BCUP-6			2	Bal.					7

PHOS-COPPER-SILVER BRAZING ALLOYS

Washington Alloy Phos-Copper-Silver Brazing Alloys (USA 0, USA 2%, USA 5%, USA 6F and USA 15%) are all manufactured to offer economy as well as consistently high standards of quality and performance. These alloys are excellent for joining copper to copper where the phosphorus content of the phos-copper-silver brazing alloy reacts with the copper of the base metal in such a way that the filler metal becomes “self-fluxing”. For this reason these alloys are used quite extensively for joining closed copper tubing in the refrigeration and air conditioning industries where flux removal after brazing is difficult to impossible. Washington Alloy Phos-Copper-Silver Brazing Alloys are also used to join copper to brass and brass to brass, however, when joining these combinations a paste flux is recom-mended. Please keep in mind that these alloys

Silver and Phos Copper Silver Brazing Alloys

dairy or food handling equipment where the use of cadmium-bearing filler metals is prohibited.

BARE OR FLUX COATED

In any brazing application, capillary action is of primary importance. To promote capillary action the joint surfaces must be cleaned of contaminants. In most cases this is done by dipping the filler metal into a jar of paste flux before applying to the joint and heat-source.

In many cases the use of paste flux can be avoided by using one of Washington Alloy flux-coated silver brazing rods such as USA 35% flux-coated, USA 45% or USA 45CF flux-coated and USA 56CF flux-coated. The extruded coating on these filler metals provides excellent cleansing action which promotes "wetting-in" and capillary flow. The coating is flexible, low-fuming and has good shelf life.

STANDARD FORMS

1/32", 3/64", 1/16", 3/32" and 1/8" bare wire diameters
18", 20" or 36" straightened and cut lengths
50 troy ounce coils (1, 3 and 5 troy ounce coils also available)
Flux-coated rods available in 1/16" and 3/32"

REEL DATA

MELTING RANGE	BRAZING TEMP. RANGE	TYPICAL APPLICATION	
Solidus	Liquidus		
1125°F	1145°F	1145°F-1400°F	Joining ferrous and non-ferrous close fitting joints, electrical components, refrigeration, petrochemical
1160°F	1175°F	1175°F-1400°F	Brazing of mild steel, tool steel and stainless steel, copper, nickel and dissimilar combinations.
1125°F	1295°F	1295°F-1550°F	Joining dissimilar combinations where joint clearances are larger or where fillets are required.
1150°F	1350°F	1350°F-1550°F	Same as USA 35% but cadmium-free.
1125°F	1310°F	1310°F-1550°F	Economical version of USA 35%. A popular general purpose brazing alloy.
1170°F	1270°F	1270°F-1500°F	Brazing tungsten carbide tool tips and stainless steel. Excellent for poor fit-ups and fillets.
1240°F	1435°F	1435°F-1650°F	Tungsten carbides, stainless steel, nickel alloys, food handling equipment since cadmium-free.
1225°F	1370°F	1370°F-1550°F	Commonly used in electrical industry, food and dairy industries since cadmium-free.
1270°F	1425°F	1425°F-1600°F	Good for bridging gaps in ferrous and non-ferrous metals. Used to braze galvanized steel.
1145°F	1205°F	1205°F-1400°F	Brazing stainless steel in food processing equipment and plants, electrical components, copper, nickel
1435°F	1435°F	1435°F-1650°F	Atmosphere or vacuum brazing of copper and steel.
1325°F	1575°F	1575°F-1775°F	For high temperature service applications up to 700°F. For brazing aircraft parts.
1250°F	1410°F	1410°F-1600°F	High brazing temperature range. For ferrous and non-ferrous base metals.
1200°F	1310°F	1310°F-1550°F	Excellent general purpose uses. Joining copper, nickel, carbon and stainless steel. Cadmium-free.
1310°F	1460°F	1350°F-1550°F	For joint clearances from .002" to .005" in plumbing, heating, air conditioning, electrical connections. Where close-fitting joints cannot be maintained. For joint clearances of .003" to .006".
1190°F	1495°F	1325°F-1500°F	For close fit-up work. Low melting point. For joint clearances of .001" to .005".
1190°F	1325°F	1275°F-1450°F	Where close fitting joints cannot be maintained but where joint ductility is critical .003" to .006". For joint clearance of .003" to .005" where lower brazing temperatures are required.
1190°F	1475°F	1300°F-1500°F	
1190°F	1450°F	1350°F-1500°F	

are not to be used on iron or steel, nickel based alloys or any alloy containing more than 10% nickel due to the possibility of phosphorus embrittlement". Basically the phosphorus of the filler metal reacts with iron or steel or nickel to create a weakening condition known as phosphorus embrittlement.

Washington Alloy Phos-Copper-Silver Brazing Alloys offer excellent corrosion resistance except when exposed to sulfurous atmospheres. Commonly used in the plumbing, heating and electrical industries.

STANDARD FORMS

Round 1/16", 3/32", 1/8", 3/16", 1/4" Square 3/32", 1/8", 3/16", 1/4". Flat 1/16" x.050 and 1/8" x.050 Lengths 18", 20" and 36"

ALUMINUM WELDING & BRAZING ALLOYS

WASHINGTON ALLOY 4043
AWS/SFA5.10ER4043
UNS A94043

DESCRIPTION AND APPLICATION
Washington Alloy 4043 (commonly referred to as AlSi5) is a 5% silicon aluminum filler metal that is available in spools or cut lengths for MIG or TIG processes. This alloy is recommended for welding 3003, 3004, 5052, 6061, 6063 and casting alloys 43, 355, 356 and 214. Washington Alloy 4043 has a melting range of 1065-1170°F and a density of .097 lbs./cu. in. The post-anodizing color tint is gray. Tensile strength average is 29,000 psi.

TYPICAL WELD METAL CHEMISTRY (%)

Si	4.5-6.0
Fe	0.80 max.
Cu	0.30 max.
Mn	0.05 max.
Mg	0.05 max.
Zn	0.10 max.
Ti	0.20 max.
Al	Balance
Others*	0.15 total max.

*Be shall not exceed 0.0008 percent.

WASHINGTON ALLOY 5356
AWS/SFA 5.10ER5356
UNSA95356

DESCRIPTION AND APPLICATION
Washington Alloy 5356 (commonly referred to as AlMg5) is a 5% magnesium aluminum filler metal that is available for MIG or TIG welding processes. The weld deposit of Washington Alloy 5356 offers much better corrosion resistance when exposed to salt water. Common applications would be base metals 5050, 5052, 5083, 5356. 5454 and 5456. The post-anodizing color tint is white. Tensile strength average is 38,000 psi.

TYPICAL WELD METAL CHEMISTRY (%)

Si	0.25 max.
Fe	0.40 max.
Cu	0.10 max.
Mn	.05-.20
Mg	4.5-5.5
Cr	.05-.20
Zn	.10 max.
Ti	.06-.20
Al	Balance
Others*	0.15 total max.

*Be shall not exceed 0.0008 percent.

WASHINGTON ALLOY 1100
AWS/SFA 5.10 ER1100
UNS A91100

DESCRIPTION AND APPLICATION
Washington Alloy 1100 (commonly referred to as Al 99.5) is a 99% aluminum filler metal that is available in spools or cut lengths for MIG or TIG welding processes. Washington Alloy 1100 is commonly used for architectural and decorative applications, furniture, piping, deep drawing applications and spun hollow ware. Common applications would include base metals 1100, 3003, and 3003 to similar base metals or to 1060,1070, 1080 and 1350. Slight golden color after anodizing. Average tensile strength as welded is 13,500 psi.

TYPICAL WELD METAL CHEMISTRY (%)

Si & Fe	0.95 max.
Cu	0.05-0.20
Mn	0.05 max.
Zn	0.10 max.
Al	99.0 min.
Others*	0.15 total max.

*Be shall not exceed 0.0008 percent.

WASHINGTON ALLOY 5556
AWS/SFA5.10ER5556
UNS A95556

DESCRIPTION AND APPLICATION
Washington Alloy 5556 is an aluminum filler metal that contains more manganese and zinc with slightly more magnesium than Washington Alloy 5356. This gives Washington Alloy 5556 good ductility and improved crack resistance. This alloy may be used for MIG or TIG welding processes. Commonly used on base metals 5154, 5254, 5454 and 5456. The approximate melting range is 1065°-1175°F and the post-anodizing color tint will be white. The ultimate tensile strength will be approximately 46,000 psi.

TYPICAL WELD METAL CHEMISTRY (%)

Si	0.25 max.
Fe	0.40 max.
Cu	0.10 max.
Mn	0.50-1.00
Mg	4.70-5.50
Cr	0.05-0.20
Zn	0.25 max.
Ti	0.05-0.20
Al	Balance
Others*	0.15 total max.

*Be shall not exceed 0.0008 percent.

WASHINGTON ALLOY 4047 (718)
AWS/SFA 5.10ER4047 AWS A5.8
BAISI-4
UNS A94047

DESCRIPTION AND APPLICATION
Washington Alloy 4047 (commonly referred to as “718 aluminum” or AlSi12) is an aluminum filler metal which contains approximately 12% silicon. This alloy is commonly used not only in MIG or TIG applications, but also as a general purpose brazing alloy providing a free-flowing filler metal and good corrosion resistance. Washington Alloy 4047 is recommended for welding or brazing aluminum alloys: 1060, 1350, 3003, 3004, 3005, 5005, 5050, 6053, 6061, 6951 7005 and cast alloys 710.0 and 711.0. Washington Alloy 4047 has an approximate melting range of 1070°-1080°F and the post anodizing color tint is grayish-black.

TYPICAL WELD METAL CHEMISTRY (%)

Si	11.0-13.0
Fe	0.80 max.
Cu	0.30 max.
Mn	0.15 max.
Mg	0.10 max.
Zn	0.20 max.
Al	Balance
Others*	0.15 total max.

*Be shall not exceed 0.0008 percent.

WASHINGTON ALLOY 5183
AWS/SFA 5.10 ER5183
UNS A95183

DESCRIPTION AND APPLICATION
Washington Alloy 5183 (commonly referred to as AlMg 4.5 Mn) aluminum filler metal contains alloying elements 4.3-5.0% magnesium, 0.5-1.0% manganese as well as chromium and titanium. Available in spools or cut lengths for MIG or TIG processes, this alloy is commonly used on marine compo¬nents, drilling rigs, cryogenics, railroad cars, storage tanks and unfired pressure vessels. Base metals commonly welded include 5083, 5086 and 5456 to similar base metals or to 5052, 5652 and 5056. The post-anodizing color tint is white. The approximate melting range is 1075°-1180°F and the average tensile strength as welded is 41,000 psi.

TYPICAL WELD METAL CHEMISTRY (%)

Si	0.40 max.
Fe	0.40 max.
Cu	0.10 max.
Mn	0.5-1.0
Mg	4.3-5.2
Cr	0.05-0.25
Zn	0.25 max.
Ti	0.15 max.
Al	Balance
Others*	0.15 total max.

*Be shall not exceed 0.0008%

Guide to the Choice of Filler Metal for General Purpose Welding

Guide to the Choice of Filler Metal for General Purpose Welding

Base Metal			356.0, A356.0	511.0															
			357.0,	512.0			6005.6061												1060
	201.0	319.0,333.0	A357.0	513.0	7004,7005	6009	6063,6101											1100	1070
	206.0	354.0,355.0	413.0,443.0	514.0	7039,710.0	6010	6151,6201			5154			5052	5005	3004		2014	3003	1080
	224.0	C355.0	A444.0	535.0	712.0	6070	6351,6951	5456	5454	5254i	5086	5083	5652	5050	Alc 3004	2219	2035	Alc 3003	1350
1060,1070,1080,1350	ER4145	ER4145	ER4043a,b	ER5356c,d	ER5356c,d	ER4043a,b	ER4043b	ER5356d	ER4043b,d	ER5356c,d	ER5356d	ER5356d	ER4043b,d	ER1100b,c	ER4043b,d	ER4145b,c	ER4145	ER1100b,c	ER1188b,c,h,j
1100,3003, Alc 3003	ER4145	ER4145	ER4043a,b	ER5356c,d	ER5356c,d	ER4043 a,b	ER4043b	ER5356d	ER4043b,d	ER5356c,d	ER5356d	ER5356d	ER4043b,d	ER1100b,c	ER4043b,d	ER4145b,c	ER4145	ER1100b,c	
2014,2036	ER4145e	ER4145e	ER4145			ER4145	ER4145							ER4145	ER4145	ER4145e	ER4145e		
2219	ER2319a	ER4145e	ER4145b,c	ER4043	ER4043	ER4043a,b	ER4043a,b		ER4043b	ER4043			ER4043b	ER4043a,b	ER4043a,b	ER2319a			
3004, Alc 3004		ER4043b	ER4043.b	ER5356f	ER5356f	ER4043b	ER4043b,f	ER5356d	ER5356f	ER5356f	ER5356d	ER5356d	ER5356C,f	ER5356c,f	ER5356C,f				
5005,5050		ER4043b	ER4043.b	ER5356f	ER5356f	ER4043b	ER4043b,f	ER5356d	ER5356f	ER5356f	ER5356d	ER5356d	ER5356c,d	ER5356C,f					
5052, 5652i		ER4043b	ER4043f	ER5356f	ER5356f	ER4043b	ER5356c.f	ER5356f	ER5356f	ER5356f	ER5356d	ER5356d	ER5654C,j,i						
5083			ER5356c,d	ER535d	ER5183d		ER535d	ER5183d	ER5356d	ER5356d	ER5356d	ER5183d							
5086			ER5356c,d	ER5356d	ER5356d		ER5356d	ER5356d	ER5356d	ER5356d	ER5356d								
5154,5254i			ER4043f	ER5356f	ER5356f		ER5356f	ER5356f	ER5356f	ER5654f,i									
5454		ER4043b	ER4043f	ER5356f	ER5356f	ER4043b	ER5356c,f	ER5356f	ER5554c,f										
5456			ER5356c,d	ER5356d	ER5556d		ER5356d	ER5556d											
6005,6061,6063																			
6101,6151,6201	ER4145	ER4145b,c	ER4043b,f,g	ER5356f	ER5356c,f	ER4043a,b,g	ER4043b,j,g												
6351,6951																			
6009,6010,6070	ER4145	ER4145b,c	ER4043a,b,g	ER4043	ER4043	ER4043a,b,g													
7004,7005,7039		ER4043b	ER4043b,j	ER5356f	ER5356d														
710.0,712.0																			
511.0,512.0,513.0			ER4043f	ER5356f															
514.0,535.0																			
356.0, A356.0.357.0																			
A357.0,413.0,	ER4145	ER4145b,c	ER4043b.h																
443.0, A444.0																			
319.0, 333.0,																			
354.0, 355.0,	ER4145e	ER4145b,c,h																	
C355.0																			
	ER2319a,h																		
201.0,206.0,224.0																			

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 ER5183, ER5356, ER5556, and ER5654 are not recommended for sustained elevated temperature service.
2. Recommendations in this table apply to gas shielded are welding processes. For oxyfuel gas welding, only ER1188, ER1100, ER4043, ER4047, and ER4145 filler metals are ordinarily used.
3. Where no filler metal is listed, the base metal combination is not recommended for welding.

d. ER4145 may be used for some applications.
e. ER4047 may be used for some applications.
f. ER4043 may be used for some applications.
g. ER5183, ER5356, or ER5556 may be used.
h. ER2319 may be used for some applications. It can supply high strength when the weldment is postweld solution heat treated and aged.
i. ER5183, ER5356, ER5554, ER5556, and ER5654 may be used. In some cases, they provide: (1) improved color match alter anodizing treatment. (2) highest weld ductility, and (3) higher weld strength. ER5554 is suitable for sustained elevated temperature service.
j. ER4643 will provide high strength in 1/2 in. (12mm) and thicker groove welds in 6XXX base alloys when postweld solution heat treated and aged.

OTHER AVAILABLE FILLER METALS

Washington Alloy 2319.....AWS/SFA.510 ER2319
Washington Alloy 5554.....AWS/SFA5.10ER5554
Washington Alloy 5654.....AWS/SFA5.10 ER5654
Washington Alloy 4145 (716).....AWS/SFA5.10 ER4145(716)
Washington Alloy 4643.....AWS/SFA5.10 ER4643
Washington Alloy A356.0.....AWS/SFA5.10 R-A356.0
Washington Alloy A357.0.....AWS/SFA5.10 R-A357.0
Washington Alloy C355.0.....AWS/SFA5.10R-C355.0

AVAILABLE PACKAGING AND DIAMETERS

1 lb. (0.45 kg) spools: .023 (0.6 mm), .030 (0.8 mm), .035 (0.9 mm), .040 (1.0 mm), 3/64 (1.2 mm), 1/16 (1.6 mm)
4 lb. (1.81 kg) spools: .023 (0.6 mm), .030 (0.8 mm), .035 (0.9 mm). .040 (1.0 mm), 3/64 (1.2 mm), 1/16 (1.6 mm)
13 lb. (5.90 kg) spools: .023 (0.6 mm), .030 (0.8 mm), .035 (0.9 mm) .040 (1.0 mm), 3/64 (1.2 mm), 1/16 (1.6 mm), 3/32 (2.4 mm)
36 in. (914 mm) rods: .023 (0.6 mm), .030 (0.8 mm), .035 (0.9 mm), .040 (1.0 mm), 3/64 (1.2 mm), 1/16 (1.6 mm), 3/32 (2.4 mm), 1/8 (3.2 mm), 5/32 (4.0 mm), 3/16 (4.8 mm), 1/4 (6.4 mm)

Settings Data

MIG WELDING

Power Source:	DCEP - Direct Current Electrode Positive power sources which are constant-current, constant-voltage or pulsed type. Any push-pull type wire feeder.
Wire Feeders:	*Spray-Arc mode use:* 100% Argon, 100% Helium, 90% Helium-10% Argon or 75% Helium-25% Argon.
Shielding Gas:	*Short-Circuiting Arc mode use:* 100% Argon, 100% Helium or 75% Helium-25% Argon.
Preheating: Preheating:	Most GMAW applications do not require preheating.

REEL DATA

GMAW PROCEDURES FOR GROOVE WELDS IN ALUMINUM ALLOYS

Section thickness in.	Welding position[a]	Joint geometry[b]	Root opening, R in.	No. of weld passes[c]	Electrode diameter, in.	Welding current, A[d,e]	Arc voltage, V[e]	Travel speed, in./min.	Argon flow rate, ft^3/h
1/16	F	A	0	1	0.03	70-110	15-20	25-45	25
	F	F	3/32	1	0.03	70-110	15-20	25-45	25
1/32	F	A	0	1	0.030-0.047	90-150	18-22	25-45	30
	F, V, H, O.	F	1/8	1	0.03	110-130	18-23	23-30	30
1/8	F,V,H	A	0-3/32	1	0.030-0.047	120-150	20-24	24-30	30
	F, V, H, O	F	4/16	1	0.030-0.047	110-135	19-23	18-28	30
3/16	F,V,H	B	0-1/16	1F, 1B	0.030-0.047	130-175	22-26	24-30	35
	F,V,H	E	0-1/16	1	0.047	140-180	23-27	24-30	35
	O	E	0-1/16	2F	0.047	140-175	23-27	24-30	60
	F,V	G	3/32-3/16	2	0.047-0.062	140-185	23-27	24-30	35
	H, O	G	3/16	3	0.047	130-175	23-27	25-35	60
1/4	F	B	0-3/32	1F, 1B	0.047-0.062	175-200	24-28	24-30	40
	F	E	0-3/32	2	0.047-0.062	185-225	24-29	24-30	40
	V, H	E	0-3/32	3F, 1B	0.047	165-190	25-29	25-35	45
	O	E	0-3/32	3F, 1B	0.047-0.062	180-200	25-29	25-35	60
	F,V	G	1/8-1/4	3-Feb	0.047-0.062	175-225	25-29	24-30	40
	O, H	G	1/4	6-Apr	0.047-0.062	170-200	25-29	25-40	60
3/8	F	C-90°	0-3/32	1F, 1B	0.062	225-290	26-29	20-30	50
	F	E	0-3/32	2F, 1B		210-275		25-35	50
	V, H	E	0-3/32	3F, 1B		190-220		24-30	55
	O	E	0-3/32	5F, 1B		200-250		25-40	80
	F,V	G	1/4-3/8	4		210-290		24-30	50
	O,H	G	3/8	10-Aug		190-260		25-40	80
3/4	F	C-60°	0-3/32	3F, 1B	0.062-3/32	340-400	26-31	14-20	60
	F	E	0-1/8	4F, 1B	3-32	325-375	26-31	16-20	60
	V, H, O	E	0-1/16	8F, 1B	0.062	240-300	26-30	24-30	80
	F	D	0-1/16	3F, 3B	0.062	270-330	26-30	16-24	60
	V, H,O	D	0-1/16	6F,6B	0.062	230-280	26-30	16-24	80

a. F, Flat; V, Vertical; H, Horizontal; O, Overhead
b. See diagram of joints on page 77
c. F-Face; B-Back
d. Constant current power source and constant speed electrode feed unit

Settings Data

TIG WELDING

Power Source:	AC or DC designed for GTAW.
Shielding Gas:	*Argon is recommended (100% Ar)*
Tungsten:	*Pure or Zirconiated Tungsten may be used*

REEL DATA

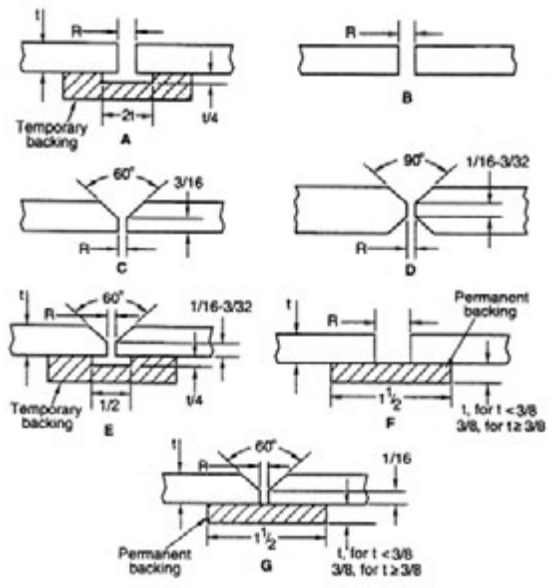
GTAW PROCEDURES FOR FiIIET AND IAP WELDS IN ALUMINUM AIIOYS

Material thick-ness, in.	Weldinga posi-tion	Filler-wire diameter, in.	Electrode diam-eter, in.b	Gas cup i.d., in.	Argon flow, ft3/h	Ac,A	Travel speed, in./min.	Filler consumption, lb./100 ft.
1/16	F, H, V	3/32	1/16-3/32	3/8	16	70-100	8-10	0.5
	O	3/32	1/16-3/32	3/8	20	65-90	8-10	0.5
3/32	F	3/32-1/8	1/8-5/32	3/8	18	110-145	8-10	1
	H,V	3/32	3/32-1/8	3/8	18	90-125	8-10	1
	O	3/32	3/32-1/8	3/8	20	110-135	8-10	1
1/8	F	1/8	1/8-5/32	7/16	20	135-175	8-12	2
	H,V	1/8	3/32-1/8	3/8	20	115-145	8-10	2.5
	O	1/8	3/32-1/8	7/16	25	125-155	8-10	2
3/16	F	5/32	5/32-3/16	1/2	25	190-245	8-10	4.5
	H,V	5/32	5/32-3/16	1/2	25	175-210	8-10	5.5
	O	5/32	5/32-3/16	1/2	30	185-225	8-10	4.5
1/4	F	3/16	3/16-1/4	1/2	30	240-295	8-10	7
	H,V	3/16	3/16	1/2	30	220-265	8-10	9
	O	3/16	3/16	1/2	35	230-275	8-10	7

a. F. Flat: V. Vertical; H, Horizontal: 0, Overhead b. Pure tungsten

Courtesy: 1994-1995 Welding & Fabrication Data Book

JOINT DESIGNS FOR GAS-METAL-ARC WEIOING OF ALUMINUM



a. F. Flat: V. Vertical; H, Horizontal: 0, Overhead b. Pure tungsten

Size	Gauge	Feet/lb.
.023" (0.6 mm)	23	2083
.030" (0.8 mm)	20-1/2	1,215
.035" (0.9 mm)	19	900
3/64" (1.2 mm)	17	520
1/16" (1.6 mm)	14	290
3/32" (2.4 mm)	11	130
1/8" (3.2 mm)	8	70
5/32" (4.0 mm)	6-1/2	45
3/16" (4.8 mm)	4-1/2	31
1/4" (6.4 mm)	2	20

a. F. Flat: V. Vertical; H, Horizontal: 0, Overhead b. Pure tungsten

Causes of Operating Problems

PROBLEM	TIG WELDING	MIG WELDING
Poor Arc Starting	Circuit broken - grounding problem No shielding gas Wrong polarity Defective water-cooling cycle	Circuit broken - grounding problem No shielding gas Wrong polarity Inconsistent wire feeding
Unstable Arc	Inconsistent voltage flow Contaminated joint area Strong magnetic field Oversize electrode diameter Workpiece is too cold	Inconsistent voltage flow Contaminated joint area Strong magnetic field Conduit has too much angle Workpiece is too cold
Gray/Black surface on weld seam	Interrupted flow of shielding gas, leaks in cooling water or protective gas line system; contaminated weld joint or filler metal, nozzle stand-off distance is too large; too little, too much of contaminated shielding gas.	
	Contaminated Tungsten Electrode-caused by contact with the workpiece. Wrong selection of filler metal	Wrong torch position Arc is too long Wrong selection of filler metal
Porosity	Same as above Welding current is too low	Same as above Nozzle contaminated by too much spatter Wrong torch position Inadequate degassing of the weld pool as a result of rapid solidification Wire feed speed too slow Arc length too short Small filler metal o.d.
Lack of fusion or penetration	insufficient welding current Travel speed too fast Arc length too long Contaminated weld joint Wrong groove shape Oxides on filler or base metal	Insufficient welding current Travel speed to fast Arc length too long Contaminated weld joint Wrong groove shape Oxides on filler or base metal
Weld cracks	Wrong selection of filler metal Voltage too high Too little filler metal in joint *Wrong welding technique Contaminated joint area Shrinkage caused by design	Wrong selection of filler metal Voltage too high Too little filler metal in joint *Wrong welding technique Contaminated joint area Shrinkage caused by design

Causes of Operating Problems

PROBLEM	TIG WELDING	MIG WELDING
Dirty Welds	Inadequate shielding gas Contaminated filler metal Contaminated joint area Oxide or water stain on joint area	Inadequate shielding gas Contaminated filler metal Contaminated joint area Oxide or water stain on joint area
Burn-back (MIG WELDING)	If the wire feed speed is too low relative to the arc voltage, the welding wire will “burn-back” into the contact tip causing feeding to stop. Other possible problems are speed too fast - feeding speed too slow - wire too soft or kinked - conduit too long or kinked - worn or dirty liner - too much spatter in contact tip - voltage fluctuation - arcing in contact tip - wrong polarity - over heating of MIG gun	
Color mis-match	Wrong filler metal selection	Wrong filler metal selection

MIG WELDING BEFORE STARTING!!!
For optimum performance, consider these factors before starting:
Use U-grooved drive rolls, align drive rolls correctly, if possible - use wire straighteners; use a straight nozzle, not a curved one; use correct size contact tip and liner; don't crimp or bend the contact tube; replace or clean out contact tube/tip I.D.; check for water or gas leaks; use a proper power supply.
* Wrong welding technique solutions: Minimize stress by clamping the parts. Narrow the heat zone by increasing the traverse speed. Preheat the base metal. Use proper weld pool size. Change from convex to concave (or vice versa) bead shape. Control grain size by minimizing super heated molten metal.

TYPICAL WELD DEPOSIT PROPERTIES

Alloy	Approximate Melting Range (°F)	Density lbs./cu. in.	Average Tensile Strength All weld-metal (as-welded) psi	(MPA)	Post Annodized Color Tint
1100	1190-1215	.098	13,500	(93)	slight golden
2319	1010-1190	.100	37,500	(253)	golden
4043	1065-1170	.097	29,000	(200)	gray
4047	1070-1080	.096	27,500	(190)	gray-black
4145	970-1085	.099	27.000	(186)	gray-black
5183	1075-1180	.096	41,000	(283)	white
5356	1060-1175	.096	38.000	(262)	white
5554	1115-1195	.097	33,000	(230)	white
5556	1065-1175	.096	42,000	(290)	white
5654	1100-1190	.096	32,000	(221)	white
A356.0	1035-1135	.097	(T6) 40,000	(276)	gray
A357.0	1040-1140	.098	(T6) 46,000	(317)	gray
C355.0	1015-1150	.098	(T6) 39,000	(269)	gray

Aluminum Welding & Brazing Alloy

ALUMINUM 345
EXTRUDED MAINTENANCE & REPAIR ELECTRODE
AWS/SFA 5.3 E4043 DC+ (reverse polarity)
UNS A94043

DESCRIPTION AND APPLICATION
An extruded aluminum electrode used for low temperature production and maintenance welding of cast and wrought aluminum sheets, plates, castings and extrusions.

Typical applications include tanks, pipes, appliances, refrigeration equipment, irrigation equipment, automobile parts and parts found in the laundry, chemical and food processing industries.

An all position electrode that produces dense and porosity-free machinable weld deposits. Color match and corrosion resistance of the weld deposit is excellent. Tensile strength is approximately 34,000 psi.

PROCEDURES
Clean the area to be welded. Large or heavy sections should be beveled to a 60° or 70° vee. Align the parts to be welded by tacking the joint(s). Preheating the larger sections to 350°F will allow for a flatter bead as well as reducing the required amperage. Using DC+ reverse polarity, maintain a short arc length while tilting the electrode in the direction of travel. The weaving technique is not recommended because of the faster travel speed required when welding aluminum. Allow the part to cool then remove all slag before making multiple passes. You may want to use a stainless steel wire brush and warm water to remove any flux residue. Many times a 10% sulphuric acid solution is used in the warm water. This will give the weld deposit a cleaner more polished appearance.

SIZE	RECOMMENDED AMPERAGE (DC+)
3/32” (2.4mm) x 14” (350mm)	50-85 amps
1/8” (3.2mm) x 14” (350mm)	85-140 amps
5/32” (4.0mm) x 14”(350mm)	110-165 amps

PACKAGING
5 lb. tubes / 30 lb. master cartons or 1 lb. mini-paks.

FLUXCORED ALUMINUM
TUBULAR TORCH ALLOY

APPLICATION
An all-position, oxyacetylene welding or brazing rod used in repairing broken or cracked aluminum extrusions or castings. Typical applications would include building up machinable deposits on worn or broken parts, model work, mold/die changes and thin sheet metal.

CHARACTERISTICS
Fluxcored Aluminum is one of the most versatile torch rods. The self-contained flux offers protection from handling and moisture. A broad operating temperature range and excellent color match makes this alloy suitable for many applications. It offers good plasticity, high strength and is readily machinable.

PROCEDURES
Remove any plating, dirt, grease or surface corrosion from the area to be welded or brazed. Sand and clean the weld area throughly. The gap to be welded should not exceed 1/8”. Bevel heavy sections to form a 60° to 75° V-notch. Using a slightly carburiz-ing flame, heat the work area by keeping the flame 1” to 2” from the weld area. Continue to heat the weld area while occasionally touching the fluxcored aluminum rod to this area under the torch flame. Do this until small amounts of alloy are deposited and the filler metal starts to flow through the gap of the heated weld area. Be sure that each drop of filler metal flows out and bonds to the base metal, but do not melt the base metal. Allow the welded part to cool and wash away the flux residue with warm water and a stiff brush.

SPECIFICATIONS
Liquidus.....1100°F
Tensile strength.....32,000 psi
Color match.....Good
(Not to be anodized)

3/32 x 32”, 1/8 x 32”, 3/16 x 32”.

PACKAGING
2 lb. tubes /10 lb. master cartons or 1 lb. mini-paks.

ALU-ZINC

DESCRIPTION AND APPLICATION
For repair of zinc-based metals, pot metal, white metals and aluminum.

Washington Alloy Alu-Zinc is a self-fluxing, low temperature joining alloy that can be used with oxy-acetylene or the TIG process, using argon as the shielding gas and AC (high frequency). It is excellent to use for new fabrication, maintenance or repair work. Flux is not necessary on accessible joints.

Common uses include: aluminum windows, doors, furniture, boats, engine heads, motor housings, power mowers, farm and dairy equipment, blocks and crankcases, vacuum cleaners, carburetors, gears and pumps, jigs and fixtures, dies and matchplates, trophies and ornaments, models and patterns, antique car parts and Kirksite dies.

PROCEDURES
Remove all dirt, plating, scale or oxides from the metal surface. Preheat to 400°F+/-. Then turn the torch at an angle, using the side of the flame to continue the heat build-up, making sure that both sides of the joint are the same temperature. Begin to touch the rod to the joint area. Continue the heat build-up until the rod begins to flow, which should be around 730°F-740°F. As the rod flows into the joint, make sure to use the rod end to break up any surface skin that will most likely develop. Use a circular motion or a dipping motion to firmly rub the rod into the joint. Failing to do so may prevent the fusion of the base metal and the filler metal. After the joint is repaired, allow the part to cool at room temperature. Do not quench.

Clean up: After the repair has cooled, use a stainless steel brush or warm water to remove any surface residue. The clean, dry joint can now be plated or painted to match the original finish.

SPECIFICATIONS
Elastic limit.....33,000 psi
Tensile strength.....39,000 psi
Brinell - 500 kg load.....100
Melting range.....715°F-735°F

PACKAGING
Available sizes: 1/8 x 18 - 5 lb. tubes.

OTHER AVAILABLE FILLER METALS

Washington Alloy 2319	AWS/SFA 5.10 ER 2319
Washington Alloy 5554	AWS/SFA 5.10 ER5554
Washington Alloy 5654	AWS/SFA 5.10 ER5654
Washington Alloy 4145 (716)	AWS/SFA 5.10 ER4145(716)

MAGNESIUM

Washington Alloy offers several grades of filler metals for magnesium welding. Washington Alloy AZ 61A and AZ 92A are the most popular wires and produce superior joints with the maximum tensile strengths offered by these alloys. Available in 36" straightened and cut lengths for Gas or TIG welding and on 3/4 lb. and 10 lb. spools for MIG welding.

TIPS FOR WELDING WITH MAGNESIUM

Cleanliness of both the base metal and filler metal is extremely important when welding with magnesium.

Chemical or mechanical cleaning of the joint area and filler metal, to remove any surface oxidation, should precede any welding. This can be accomplished using a solution of 24 oz. chromic acid, 5-1/3 oz. ferric nitrate and 1/16 oz. potassium fluoride in enough water to make one gallon. Bring the solution to 70-90°F, then immerse the part for 3 minutes, rinse in hot water, then air dry. Mechanical cleaning can be done using an aluminum or stainless steel wire brush, steel wool or an aluminum-oxide abrasive cloth. Gloves should be worn when handling cleaned filler metal.

GAS TUNGSTEN ARC (TIG) AND GAS METAL ARC (MIG) WELDING

Flux is not required for TIG or MIG welding processes. Although this is convenient, it means that cleanliness of the base metal and filler metal is even more critical.

Argon is the recommended shielding gas, however, an argon-helium mixture can increase filler metal flow and penetration. Do not use pure helium as this will create undesirable results. TIG welding can be done with AC current, DC reverse polarity or DC straight polarity. AC current will give good penetration. DC reverse polarity (electrode positive) will give shallow penetration but wide weld deposits. DC straight polarity (electrode negative) will give deep penetration but narrow weld deposits. Pure, Thoriated or Zircomated Tungsten may be used.

MIG welding is done with DC reverse polarity (electrode positive). MIG welding will increase weld speed by 2 to 4 times faster than TIG welding. MIG welding is the best process for heavy gage parts.

OXYACETYLENE WELDING

Oxyacetylene welding of magnesium is not commonly used. This process should only be considered for single-pass welding on thin gauges of magnesium. A fluoride or chloride flux should be used on the base metal and filler metal in order to clean and protect the weld pool. However, be sure to remove any flux residue by washing in hot water, pickle for 2 minutes in a chrome pickle solution, then boil in a 6% solution of sodium dichro-mate for 2 hours.

References: American Welding Society ANSI/AWS A5. 19-92 Penton Publishing Co. Welding & Fabricaling Data Book 1994/95.

WASHINGTON ALLOY AZ61A
AWS/SFA5.19ERAZ61A
UNS M11611

TYPICAL CHEMICAL ANALYSIS (%)

Mg	Remainder
Al	5.8-7.2
Be	.0002-.0008
Mn	0.15-0.5
Zn	0.40-1.5
Cu	0.05 max.
Fe	0.005 max.
Ni	0.005 max.
Si	0.05 max.
Others	0.30 max.

AVAILABLE PACKAGING AND DIAM-ETERS

3/4 lb. (0.34 kg) spools:

10 lb. (4.54 kg) spools:

36 in. (914 mm) rods:

WASHINGTON ALLOY AZ92A
AWS/SFA 5.19 ER AZ92A
UNS M11922

TYPICAL CHEMICAL ANALYSIS (%)

Mg	Remainder
Al	8.3-9.7
Be	.0002-.0008
Mn	0.15-0.5
Zn	1.7-2.3
Cu	0.05 max.
Fe	0.005 max.
Ni	0.005 max.
Si	0.05 max.
Others	0.30 max.

AVAILABLE PACKAGING AND DIAM-ETERS

3/4 lb. (0.34 kg) spools

10 lb. (4.54 kg) spools:

36 in. (914 mm) rods:

OTHER AVAILABLE MAGNESIUM ALLOYS

EZ33A	(AMS 4396)	UNS M 12331	MIL-R-6944
QE22A	(AMS 4418)	UNS M18220	Fed-QQ-M-56 QE22A
AZ101A		UNS M11101	

Magnesium
Typical Physical Properties and Parameters

TYPICAL WELD DEPOSIT PROPERTIES

	AZ61A	AZ92A	EZ33A	AZ101A	QE22A
Tensile Strength (psi	44,000	25,000	23,000	22,000	40,000
Yield Strength (psi)	30,000	14,000	16,000	12,000	30,000
Elongation (% in 2")	16	2	3	2	4
Shear Strength (psi)	20,000	18,000	19,000	18,000	30,000
Brinell Hardness	60	65	50	53	78
Melting Point (°F)	1140	1110	1189	1100	1140
Weight (ft./lb.)					
3/64	744				
1/16	419	412	412	412	412
3/32	186	183	183	183	183
1/8	105	103	103	103	103

TIG (GTAW) POWER-SOURCE AC machines with a high frequency current or DC machines with continuous amperage control both in reverse polarity (electrode positive)

TUNGSTEN: Pure, Zirconiated or Thoriated Tungsten.

SHIELDING GAS: Argon or a 75% Argon, 25% Helium mixture. Helium allows for lower welding currents, but don't use Helium alone as you will get spatter and arc turbulence.

Weld Rod Dia	Amps	Gas Flow (CFT/HR)
3/32	35-125	12
1/8	160 175	15
5/32	200-250	20
3/16		20

MIG (GMAW) POWER-SOURCE DC machines in reverse polarity (electrode positive)

a. constant voltage DC machines for short circuit welding (3/16 or less)
b. constant current (drooping volt-ampere output) DC machines for spray-arc welding. (Use spray-arc for 3/16" and larger base plates.)
c. constant potential DC machines, designed to pulse the secondary current output need to be used for pulse-induced arc transfer welds. (Use pulse for base metals thinner than 3/16".)

SHIELDING GAS: Argon is preferred. Argon-Helium mixtures may be used but Helium alone will cause a lot of spatter and arc turbulence

Welding Procedure	Wire Dia.	Amps	Volts	Gas Flow (CFT/RH)	
Short-circuiting	.040	25-40	13-14	40-60	
Short-circuiting	1/16	70-95	14-16	40-60	
Short-circuiting	3/32	15-175	14-15	40-60	
Spray-arc	1/16	240	27	50-80	
Spray-arc	3/32	520-420	24-30	50-80	
Pulsed-arc	.040	50	21	40-60	Pulse voltage: 55
Pulsed-arc	1/16	10-175	24-25	40-60	Pulse volgage: 52-55
Pulsed-arc	3/32	210	29	40-60	Pulse voltage: 55

Welding speed was 24-36 inches per minute

Copper-Coated Arc Gouging Carbons for Cutting and Gouging

Washington Alloy Copper-Coated Arc Gouging Carbons are designed for cutting and gouging metals such as carbon steel, stainless steel, copper, aluminum, and some high temperature alloys. The process is one in which an air-carbon arc torch is used to create an electric arc which melts away the metal, then uses compressed air to "blow" the molten metal out of the groove.

Washington Alloy Copper-Coated Arc Gouging Carbons have a special balance of carbon and graphite covered with a thin high-purity copper coating. High density, uniform properties and dimensions produce excellent arc stability and slag-free gouges.

Washington Alloy Copper-Coated Arc Gouging Carbons are available in three styles.

1. Copper-Coated DC Pointed Carbons are the most popular style. These are for general purpose grooving and cutting-specifications listed below.
2. Jointed Copper-Coated Carbons are designed to be connected by use of "male" and "female" fittings. This capability eliminates stub loss and allows for mechanized gouging by not having to renew the electrode.
3. Flat Copper-Coated Carbons are designed for shallow penetration and scarfing. Excellent for removing rivet heads or weld deposit crowns and for getting into corners.
4. Half Round.

Physical Properties

Description	Packaging inner ctn./ mas. ctn.	Electrical Resistance (Ω/in.)	Breaking Strength (lbs./In2)	Apparent Specific Gravity	Ash Content (%)
1/8 x 12"	100/1000	0.0006	5600	1.70	0.35
5/32 x 12"	100/1000	0.0005	5600	1.70	0.35
3/16 x 12"	50/500	0.0005	5600	1.70	0.35
1/4x12"	50/500	0.0005	5500	1.70	0.38
5/16 x 12"	50/500	0.0005	5500	1.70	0.38
3/8 x 12"	50/500	0.0005	5500	1.70	0.38
1/2 x 12"	20/200	0.0006	5400	1.70	0.38

Working Properties

Description	DC Reverse Polarity (AMPS)	Metal Removal oz./in.	Consumption Rate (in./min.)	Groove	
				width (in.)	depth (in.)
1/8 x 12"	100~150	0.89	4.20	15/64	3/32
5/32 x 12"	100~200	0.97	4.00	9/32	9/64
3/16 x 12"	150~250	1.18	3.97	5/16	5/32
1/4 x 12"	200~300	1.75	3.84	25/64	13/64
5/16 x 12"	250~350	2.96	3.19	7/16	9/32
3/8 x 12"	350~450	4.4	2.70	1/2	11/32
1/2 x 12'	700~900	6.35	1.81	11/16	7/16

Arc Gouging Carbon Electrodes

Electrode Gouging Carbons **100 Pieces Each**	**TG G/C 02**	1/8 X 12"
	TG G/C 03	5/32 X 12"
	TG G/C 04	3/16 X 12"
	TG G/C 05	1/4 X 12"
	TG G/C 06	5/16 X 12"
	TG G/C 07	3/8 X 12"
	TG G/C 08	1/2 X 14"

Non Copper Coated **100 Pieces Each**	**TG G/C 05NC**	1/4 X 12" NON-COPPER CARBON
	TG G/C 06NC	5/16 X 12" NON-COPPER CARBON
	TG G/C 07NC	3/8 X 12" NON-COPPER CARBON

Hollow **100 Pieces Each**	**TG G/C/H 05**	1/4 X 12" Hollow Carbon
	TG G/C/H 06	5/16 X 12" Hollow Carbon
	TG G/C/H 07	3/8 X 12" Hollow Carbon

Jointed **100 Pieces Each**	**TG G/C/J 07**	3/8 X 17"
	TG G/C/J 08	1/2 X 17"
	TG G/C/J 09	5/8 X 17"
	TG G/C/J 10	3/4 X 17"

Flat Style **100 Pieces Each**	**TG G/CF 04**	3/16 X 5/8 X 12" (FLAT STYLE)
	TG G/CF 071	3/8 X 5/32 X 12" (FLAT STYLE)
	TG G/CF 072	3/8 X 3/16 X 12" (FLAT STYLE)

COPPER BASED WELDING & BRAZING ALLOYS

NAVAL BRONZE ALLOY NO. 470
WS A5.8 Class RBCuZn-A
UNS/CDA C47000

DESCRIPTION AND APPLICATIONS
Washington Alloy Naval Bronze is a 1% tin filler metal used for brazing or oxyacetylene welding of steel, cast iron, malleable iron, copper-bronze and nickel alloys. The addition of tin improves strength and corrosion resistance in the weld deposit. A borax-boric acid flux is generally required. Joint clearances should be 0.002" to 0.005" wide. Preheating may be desirable for some applications. A neutral or slightly oxidizing flame should be used.

NICKEL BRONZE ALLOY NO. 680
AWS A5.8 Class RBCuZn-B †ASME
UNS/CDA C68000

DESCRIPTION AND APPLICATIONS
Washington Alloy Nickel Bronze (also referred to as Manganese Bronze) is similar to Naval Bronze, however iron, manganese and nickel have been added to the analysis. The iron and manganese increases the hardness and strength of the weld deposit while nickel ensures uniform distribution of iron in the deposit. Nickel Bronze is primarily used to braze or oxyacetylene weld steel, cast iron, brass and bronze. Also used for building-up wearing surfaces and bearings. Flux required. Use boric acid or borax commercial flux. A neutral or slightly oxidizing flame should be used. Preheating may be required for some applications.

LOW FUMING BRONZE ALLOY NO. 681
AWS A5.8 Class RBCuZn-C
UNS/CDA C68100

DESCRIPTION AND APPLICATIONS
Washington Alloy Low Fuming Bronze is a general-purpose oxyacetylene brazing rod used for steel, copper alloys, cast iron, nickel alloys and stainless steel. A balanced chemical analysis of copper and zinc as well as alloying elements of tin, iron, manganese and silicon produce weld deposits with excellent mechanical properties. High strength, ductile and sound weld deposits are easily attained simply by applying a neutral or slightly oxidizing flame. The high silicon content of Washington Alloy Low Fuming Bronze keeps fumes to a minimum. Preheating is required for some applications and bronze brazing flux is required for the bare rods.
*Order as bare or flux-coated

NICKEL SILVER ALLOY NO. 773
A5.8 Class RBCuZn-D
UNS/CDA C77300

DESCRIPTION AND APPLICATIONS
Washington Alloy Nickel Silver filler metal contains 10% nickel and is used primarily for brazing or oxyacetylene welding of steel or cast iron where good color match is desirable. The weld deposits of Washington Alloy Nickel Silver have very high tensile strength, good ductibility and excellent corrosion resistance. The weld deposits are machinable and work harden when put into service. For this reason Nickel Silver is commonly used for building-up or overlaying worn parts such as gear teeth, bearings and valve seats. It is also used in the matrix of tungsten carbide rods where it acts as a "binder" for the tungsten carbide particles. Excellent for tubular structures. A boric acid or borax flux is required. Preheating may be desired for some applications. A neutral or slightly oxidizing flame is recommended.
*Order as bare or flux-coated.

SILICON BRONZE ALLOY NO. 656
AWS A5.7 ERCuSi-A
UNS/CDA C65600

DESCRIPTION AND APPLICATIONS
Washington Alloy Silicon Bronze is a copper based tiller metal containing 3% silicon and small amounts of manganese, tin and zinc. Primarily used for MIG, TIG and oxyacetylene welding of copper, copper-silicon and copper-zinc base metals to themselves and to steel. Excellent for plain or galvanized steel sheet metal as well as other coated steels. Washington Alloy Silicon Bronze is also used for surfacing areas subjected to corrosion.

The oxyacetylene gas flame should be slightly oxidizing. Keep the weld puddle small in order to promote fast solidification and minimize cracking. A high boric acid flux should be used both before and during welding. Preheating is NOT recommended.

DEOX COPPER ALLOY NO. 189
AWS A5.7 Class ERCu
UNS/CDA 18980

DESCRIPTION AND APPLICATIONS
Washington Alloy DEOX Copper is a 98% copper filler metal used for MIG, TIG and oxyacetylene welding of copper and copper-alloyed base metals. DEOX Copper contains small amounts of phosphorus and silicon which act as the deoxidizing agents to promote sound weld joints. Washington Alloy DEOX Copper is easy flowing and produces weld deposits that are porosity free, electrically conductive and the color will match that of copper. Excellent for joining copper to mild steel, for overlaying steel and for the fabrication of copper pipes, tanks and copper fittings.

The oxyacetylene gas flame must be neutral or slightly oxidizing. Tip size must be one to two sizes larger than the base plate. Preheating should be done only if the part is thick. A boric acid or borax flux is recommended.

Copper Based Welding & Brazing Alloys

PHOS-BRONZE A ALLOY NO. 518
AWS A5.7 Class ERCuSn-A
UNS/CDA C51800

DESCRIPTION AND APPLICATIONS
Washington Alloy Phos-Bronze A filler metal is used for MIG and TIG welding of tin-bronze base metals such as 509 to 519 series, for brass and for overlay welding of steel.
Phos-Bronze A contains approximately 5% tin and up to 0.35% phosphorus. The tin content increases the wear resistance of the weld deposit while the phosphorus acts as a deoxidizer. Preheating is recommended.

PHOS-BRONZE C ALLOY NO. 521
AWS A5.7 Class ERCuSn-C
UNS/CDA C52100

DESCRIPTION AND APPLICATIONS
Washington Alloy Phos-Bronze C filler metal is used quite extensively for surfacing applications. The higher tin (Sn) content (7.0-9.0%) gives "PBC" weld deposits greater hardness and higher tensile/yield strength than Phos-Bronze A. "PBC" is commonly used for base metals of similar composition, for joining brass alloys and for joining cast iron to carbon steel. Preheating is recommended.

ALUMINUM BRONZE A-1 ALLOY NO. 610
AWS A5.7 Class ERCuAl-Al
UNS/CDA C61000

DESCRIPTION AND APPLICATIONS
Washington Alloy Aluminum Bronze A1 is an iron-free aluminum bronze filler metal used for MIG and TIG overlay welding of bearing and wear resistant surfaces exposed to corro¬sive environments such as salt or brackish water and commonly used acids. Aluminum Bronze A-1 is not recommended for joining. Commonly used in steel and pulp mills to overlay tube sheets, valve seats and refineries.

ALUMINUM BRONZE A-2 ALLOY NO. 618
AWS A5.7 Class ERCuAl-A2
†ASME SFA5.7 ERCuAl-A2
UNS/CDA C61800

DESCRIPTION AND APPLICATIONS
Washington Alloy Aluminum Bronze A-2 is an iron-bearing MIG and TIG filler metal used for joining aluminum bronze of similar composition, silicon and manganese bronze, high strength copper-zinc alloys, some copper-nickel alloys, ferrous metals and dissimilar metals. Dissimilar metal combinations would include aluminum bronze to steel and copper to steel. Washington Alloy Aluminum Bronze A-2 is excellent for building-up or overlaying metal for wear and corrosion resistant surfaces. Weld deposits exhibit high mechanical properties, tensile strength, yield strength and hardness. Most common applications would include marine maintenance and. repair welding of ship propellers; pump housings, rigging jacks, piston heads, bearings and many overlay or surfacing applications.

ALUMINUM BRONZE A-3 ALLOY NO. 624
AWS A5.7 Class ERCUAl-A3
UNS/CDA C62400

DESCRIPTION AND APPLICATIONS
Washington Alloy Aluminum Bronze A-3 contains a higher iron (Fe) content than Aluminum Bronze A-2. The higher iron content gives "A-3" greater strength when joining aluminum bronze castings of similar composition. "A-3" is often used for piston overlay and bearing surface applications which require higher strength, while maintaining good ductility.

NICKEL-ALUMINUM BRONZE ALLOY
AWS A5.7 Class ERCuNIAl
UNS/CDA C63280

DESCRIPTION AND APPLICATIONS
Washington Alloy Nickel-Aluminum Bronze filler metal is used for MIG and TIG welding of cast and wrought nickel-aluminum bronze parts such as ship propellers, where high resistance to corrosion, erosion and cavitation in salt or brackish water is required. Nickel-Aluminum Bronze is a very popular filler metal in offshore technology for such items as sea-water desalting, shipbuilding and repair. Also used in the power plant and chemical industry for pumps and tube systems.

Copper Based Welding &Brazing Alloys

MANGANESE-NICKEL-ALUMINUM BRONZE ALLOY
AWS A5.7 Class ERCuMnNiAl
UNS/CDA C63380

DESCRIPTION AND APPLICATIONS
Washington Alloy Manganese-Nickel-Altiminum Bronze filler metal is designed for MIG and TIG welding or surfacing of cast or wrought base metals of similar analysis. Especially suited for welding ship propellers where resistance to corrosion, erosion and cavitation is required. Manganese-Nickel-Aluminum Bronze is also used for joining or surfacing copper alloys of unalloyed and low alloy steel as well as grey cast iron. Good toughness and hardness.

WASHINGTON ALLOY 67
AWS A5.7 Class ERCuNI
UNS C71581

DESCRIPTION AND APPLICATIONS
Washington Alloy 67 is a copper-nickel filler metal used for MIG, TIG, oxyacetylene and submerged arc welding of wrought or cast 70/30. 8/20 and 90/10 copper-nickel to themselves or to each other. Excellent for joining copper-nickel alloys to nickel-copper Alloy 400, R-405, K-500 or high nickel alloy 200. Note: Washington Alloy 67 can be used for overlaying on steel, however a barrier layer of Washington Alloy 61 should be used for the first pass when MIG welding. Washington Alloy 60 should be used for the first pass when submerged arc welding.

COPPER BASED MIG & TIG ALLOYS

AVAILABLE SIZES AND PACKAGING												
Package Form (in.) (mm)	.023 (0.6)	.030 (0.8)	.035 (0.9)	.045 (1.2)	1/16 (1.6)	3/32 (2.4)	1/8 (3.2)	5/32 (4.0)	3/16 (4.8)	1/4 (6.4)	3/8 (9.5)	**MASTER CARTON**
2-2-1/2#SP00LS (4")	X	X	X	X	X							20 Spools
10-12-1/2#Spools (8")	X	X	X	X	X							4 Spools
25 - 33# Spools (12")	X	X	X	X	X	X	X					1 Spool
50 - 60# Coils				X	X	X	X	X	X			1 Coil
*36" Cut Lengths	X	X	X	X	X	X	X	X	X	X	X	50 lbs.**

*Note: Flux-coated 1/16 (1.6 mm) is only available in 18" lengths.
**10 lb. tubes in a 50 lb. master carton is available upon request
***Flag-tagging is also available upon request.

COPPER-BASED FLUX-COATED ELECTRODES

RAINIER 3A

AWS A5.6 Class ECuSn-C DC
DC Reverse Polarity (Electrode +)
All-Position Phosphor (Tin) Bronze Electrode for Copper, Steel, Cast Iron and Galvanized Iron
UNS/CDA W60521

APPLICATIONS

Rainier 3A is a multipurpose flux-coated electrode used for joining steel and cast iron parts to copper, brass and bronze. Excellent for overlays on shafts, pumps, impellers and propeller blades. Used for building-up bearing journals and frictional wear surfaces on heavier sections. Other uses include ornamental iron, galvanized iron and as a substitute for torch alloys on larger sections.

FEATURES

Rainier 3A is specially formulated to be used in any position with a minimum of spatter. Weld deposits are ductile, strong and machinable. Rainier 3A deposits offer good corrosion resistance to salt water and chemicals. Provides a good color match on bronze and will work harden.

SPECIFICATIONS

Tensile strength (psi).....Up to 65,000
Elongation in 2" (%).....45-50
Brinell hardness.....85-100
Machinability.....Excellent

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32	3/16
(mm)	2.4	3.2	4.0	4.8
(Amps)	60-115	100-150	125-200	190-250

PROCEDURES

Clean the weld area. Bevel edges to a 45° vee. Thin sections generally do not require preheating. However heavier sections of cast iron and steel should be preheated to 200°F (93°C), phosphor (tin) bronze to 400°F (205°C) and other copper alloys to 700°F (371°C). Maintain the preheat temperature during welding and between passes. Use DC reverse polarity (electrode +). Holding the electrode 90° to the workpiece, maintain a medium arc length and weave slightly. For thicker deposits shorten the arc length and make stringer beads. Allow the part to cool slowly before removing the slag with a chipping hammer and wire brush.

NOTE: RAINIER 7A, WHICH MEETS AWS A5.6 CLASS ECuSn-A IS AVAILABLE UPON REQUEST.

RAINIER 4A

AWS A5.6 Class ECu
DC Reverse Polarity (Electrode +)
High Purity Copper Electrode for Joining Copper and Overlaying Steel
UNS/CDA W60189

APPLICATIONS

Rainier 4A is a copper-cored flux-coated electrode used to surface, buildup, and fabricate electrolytic tough pitch and oxygen-free copper. Excellent for applications that require high corrosion resistance. Commonly used to overlay steel or to join heavier sections of copper to steel.

FEATURES

Rainier 4A produces high purity copper weld deposits. Corrosion resistance and electrical conductivity is excellent. Perfect color match to copper.

SPECIFICATIONS

Tensile strength (psi).....Up to 35,000
Elongation (%).....Approx. 35
Brinell hardness.....Rockwell F 20-40
Machinability.....Excellent

PROCEDURES

Clean joint area of all dirt, grease, and oxides. Bevel heavy sections. Porosity free welds on heavy sections can be achieved by preheating and maintaining the preheat temperature during the entire welding operation. Silicon Bronze should not be preheated above 150°F. Pure copper requires a 900°F to 1000°F preheat, while all other copper base alloys require a 500°F to 700F preheat. Thin sections of steel do not require preheating, however if the base metal is warmed a lower amperage can be used. Using DC reverse polarity (electrode+) and the largest diameter electrode as possible, maintain a short arc length. Stress and distortion can be avoided by peening each deposit between passes. Allow the part to cool slowly before removing slag with a chipping hammer and wire brush.

RAINIER 5A

AWS A5.6 Class ECuAl-A2
DC Reverse Polarity (Electrode +)
UNS/CDA W60614

APPLICATIONS

Rainier 5A is a flux-coated electrode designed for overlays exposed to frictional wear or corrosives such as salt water, alkalies and some acids. Ideal for aluminum bronze, manganese bronze, silicon bronze, bronze to steel and cast iron. Also used on malleable iron, galvanized iron, stainless steel and as a build-up on bearing surfaces. Some common applications are: brake drums, hydraulic pistons, tractor gear housings, paper mill rolls, impellers, motor bases, pickling hooks, ship propellers, mixer arms, yokes, press rams, valve seats, bushings, foundry flasks and bearings.

FEATURES

Rainier 5A produces strong, dense, ductile and crack-free weld deposits in so many ferrous and nonferrous combinations of dissimilar metals. Weld deposits are extremely tough and will work harden under compressive loads. Overall — an excellent choice.

SPECIFICATIONS

Tensile strength (psi).....Up to 100.000
Yield Strength (psi).....Up to 63,000
Elongation in 2" (%).....24-27
Brinell hardness.....130-150
Machinability.....Excellent

AVAILABLE SIZES AND AMPERAGE

(in)	1/8	5/32	3/16
(mm)	3.2	4.0	4.8
(Amps)	90-120	115-150	140-210

PROCEDURE

Clean the weld area. Bevel heavy sections. Preheat copper base alloy and heavy sections of steel or cast iron at 250°F to 400°F, depending on the thickness of the part. Use DC reverse polarity (electrode +). Holding the electrode 10-15° off perpendicular, maintain a short arc length and apply thin layers using stringer beads or the weaving technique. Allow the part to cool slowly. Use a chipping hammer and brush to remove slag between passes.

Copper-Based Flux-Coated Electrodes

RAINIER 6A

AWS A5.6 Class ECuSi
AC-DC Reverse Polarity
(Electrode +) All Position
AC/DC All-Purpose Electrode for "Arc Brazing"
Cast Iron to Steel.
UNS/CDA W60656

APPLICATIONS

Rainier 6A flux-coated electrodes are used for welding or building-up silicon bronze as well as other copper alloys. It is an excellent choice for applications involving cast iron to steel or where the part is exposed to corrosives. Rainier 6A is commonly used on bronze impellers, bronze wear plates, hydraulic piston overlays, track wheels, gears, sprockets and quite often farm implements.

FEATURES

Rainier 6A performs well in any position utilizing AC as well as DC machines. Rainier 6A weld deposits are strong, ductile and crack resistant — even when welding on dirty, oily, burned cast or malleable parts. The high silicon content of this electrode allows it to be used as a welding or brazing electrode.

SPECIFICATIONS

Tensile strength <psi).....Up to 60,000
Yield strength (psi).....Up to 42,000
Elongation in 2" (%).....52-55
Brinell hardness.....80-100
Machinability.....Excellent

AVAILABLE SIZES AND AMPERAGE

(in)	3/32	1/8	5/32	3/16
(mm)	2.4	3.2	4.0	4.8
(Amps)	40-80	80-125	120-150	140-215

PROCEDURE

Clean the weld area. Heavier sections should be beveled and preheated up to 500°F depending on the thickness of the part. Thin sections do not require preheating. Maintain a medium arc length and deposit stringer beads in groove or overlay welding and use weave beads for rapid overlays, large areas and for welding ferrous metals. Peen the weld deposit and remove slag between passes.

WASHINGTON ALLOY 187

AWS/SFA5.6 Class ECuNi
UNS#W60715
UNS/CDA W60715

DESCRIPTION

Washington Alloy 187 is a 70% copper-30% nickel flux-coaled electrode designed for welding wrought or cast forms of 70/30, 80/20 and 90/10 copper-nickel alloys. This electrode is also used for many dissimilar applications such as joining nickel-copper Alloy 400, R405 and K500 or high nickel alloy 200 to the copper-nickel alloys.

APPLICATIONS

The most popular use of Washington Alloy 187 would involve marine applications where it offers excellent resistance to the corrosive effects of salt water. Also used for welding the clad side of copper-nickel clad steel.

TYPICAL WELD METAL CHEMISTRY (%)

*Ni	29.0-33.0
Mn	1.00-2.50
Fe	0.40-0.75
Si	0.50 max.
Cu	Balance
Ti	0.50 max.
Pb	0.02 max.
P	0.02 max.
Other (total)	0.50 max.

-Includes Cobalt (Co)

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)

Tensile strength (psi).....50,000 min.
Yield strength (psi).....20,000 min.
Elongation in 2" (%).....30
Brinell hardness.....60-80

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)

3/32 (2.4 mm).....50-75 amps
1/8 (3.2 mm).....75-110 amps
5/32 (4.0 mm).....110-145 amps
3/16 (4.8 mm).....145-185 amps

WELDING POSITIONS

Flat, horizontal, vertical overhead.

Alloy	UNS No.	Oxfuel Gas Welding	SMAW	GMAW	GTAW	Resistance Welding	Solid-Stale Welding	Brazing	Soldering	Beam Welding
ETP Copper	C11000-C11900	NR	NR	F	F	NR	G	E	G	NR
Oxygen-Free Copper	C10200	F	NR	G	G	NR	E	E	E	G
Deoxidized Copper	C12000-C123000	G	NR	E	E	NR	E	E	E	G
Beryllium-Copper	C17000-C17500	NR	F	G	G	F	F	G	G	F
Cadminium/Chromium	C16200-C18200	NR	NR	G	G	NR	F	G	G	F
Copper										
Red Brass - 85%	C23000	F	NR	G	G	F	G	E	E	-
Low Brass - 80%	C24000	F	NR	G	G	G	G	E	E	-
Cartridge Brass - 70%	C26000	F	NR	F	F	G	G	E	E	-
Leaded Brasses	C31400-C38590	NR	NR	NR	NR	NR	NR	E	G	-
Phosphor Bronzes	C50100-C52400	F	F	G	G	G	G	E	E	-
Copper-Nickel - 30%	C71500	F	F	G	G	G	G	E	E	F
Copper-Nickel -10%	C70600	F	G	E	E	G	G	E	E	G
Nickel Silvers	C75200	G	NR	G	G	F	G	E	E	-
Aluminum Bronzes	C61300									
	C61400	NR	G	E	E	G	G	F	NR	G
Silicon Bronzes	C65100									
	C65500	G	F	E	E	G	G	E	G	G

Chemical Composition of Copper Based Alloys

	Cu Copper	Zn Zinc	Fe Iron	Si Silicon	Al Alminum	Pb Lead	Mn Mangnese	P Phophrus	Ni Nickel(+Co)	Sn Tin	Total Other Elements
Naval Bronze	57.0-61.0	BAL	—	—	0	0	—	—	—	0.25-1.00	0.5
Nickel Bronze	56.0-60.0	BAL	0.25-1.20	0.04-0.15	0	0	0.01-0.50	—	0.20-0.80	0.80-1.10	0.5
Low Fuming Bronze	56.0-60.0	BAL	0.25-1.20	0.04-0.15	0.01	0.05	0.01-0.50	—	—	0.80-1.10	0.5
Nickel Silver	46.0-50.0	BAL	—	0.04-0.25	0	0	—	0	9.0-11.0	—	0.5
Silicon Bronze	BAL	1	0.50	2.8-4.0	0.01	0.02	1.5	—	—	1	0.5
Deox Copper	98.0 min	—	—	0.50	0.01	0.02	0.5	0.15	—	1	0.5
Phos-Bronze A	BAL	—	—	—	0.01	0.02	—	0.100.35	—	4.0-6.0	0.5
Phos-Bronze C	BAL	0.2	0.1	—	—	0.05	—	0.3-0.35	—	7.0-9.0	0.5
Aluminum Bronze A-1	BAL	0.2	—	0.10	6.0-8.5	0.02	0.5	—	—	—	0.5
Aluminum Bronze A-2	BAL	0.02	1.5	0.10	8.5-11.0	0.02	—	—	—	—	0.5
Aluminum Bronze A-3	BAL	0.1	2.0-4.5	0.10	10.0-11.5	0.02	—	—	—	—	0.5
Nickel Aluminum Bronze	BAL	0.1	3.0-5.0	0.1	8.5-9.5	0.02	0.60-3.50	—	4.0-5.50	—	0.5
Manganese-Nickel Aluminum Bronze	BAL	0.15	2.0-4.0	0.1	7.0-8.5	0.02	11.0-14.0	—	1.5-3.0	—	0.5
Alloy 67 Copper-Nickel	BAL	—	0.40-0.75	0.25	—	0.02	1	0.02	29.0-32.0	—	0.05 Ti 0.20-0.50

Single values are maximum, unless otherwise specified.

COMMON NAME	AWS SPEC. AWS CLASS	APPROX. MELTING TEMPERATURE (°F) (°C)	AVERAGE AS-WELDED BRINELL HARDNESS	TENSILE STRENGTH MIN (PSI) (MPA)
Naval Bronze	A5.8/A5.27 RBCuZn-A	1650(899)	70-90	50,000 (345)
Nickel Bronze (Manganese Bronze)	A5.8/A5.27 RBCuZn-B	1620(882)	80-110	56,000 (386)
Low Fuming Bronze (LFB or LFBFC)	A5.8/A5.27 RBCuZn-C	1630(888)	80-110	56,000 (386)
Nickel Silver	A5.8/A5.27 RBCuZn-D	1715(935)	90-110	60,000(414)
Silicon Bronze (Everdur)	A5.7 ERCuSi-A	1866(1019)	80-110	50,000 (345)
Deox Copper	A5.7/A5.27 ERCu	1967(1075)	Rockwell F25	25,000(172)
Phos-Bronze A	A5.7 ERCuSn-A	1922(1050)	70-85	35,000 (240)
Phos-Bronze C	A5.7 ERCuSn-C	1880(1026)	68-83	40,000 (280)
Aluminum Bronze A-1	A5.7 ERCuAl-A1	1898(1036)	80-110	55,000 (380)
Aluminum Bronze A-2	A5.7 ERCuAl-A2	1904(1040)	130-150	60,000(414)
Aluminum Bronze A-3	A5.7 ERCuAl-A3	1925(1051)	140-180	65,000 (450)
Nickel Aluminum Bronze	A5.7 ERCuNiAl	1930(1054)	160-200	72,000 (480)
Manganese-Nickel-Aluminum Bronze	A5.7 ERCuMnNiAl	1805(985)	160-200	75,000(515)
Alloy 67 (Copper-Nickel)	A5.7 ERCuNi	2260(1238)	60-80	50,000 (345)

TITANIUM

WASHINGTON ALLOY-COMMERCIAL PURE TITANIUM

AWS A5.16 Classes ERTi-1, 2, 3 and 4/AMS 4951

Washington Alloy Commercial Pure Titanium is a TIG and MIG filler metal used for welding commercial pure titanium alloys commonly found in applications requiring high temperature resistance and resistance to chemical reagents. Although there are four grades of Commercial Pure Titanium filler metals, C.P. Grade 2 (ERTi-2) is the most popular because of its good balance of strength, formability and weldability.

The most common application of Commercial Pure Titanium is the aircraft industry, where tensile strength and weight ratios are so critical. Other uses would include cryogenic and petrochemical applications such as chemical process heat exchangers, pressure vessels and piping systems, pulp bleaching systems, electro chemical and chemical storage tanks.

FILLER METAL CHEMISTRY (%)

	ERTi-1
C	0.030
0	0.100
H	0.005
N	0.015
Fe	0.100
Ti	Balance
	ERTi-2
C	0.030
0	0.100
H	0.008
N	0.020
Fe	0.200
Ti	Balance
	ERTi-3
C	0.030
0	0.10-0.15
H	0.008
N	0.020
Fe	0.200
Ti	Balance
	ERTi-4
C	0.030
0	0.15-0.25
H	0.008
N	0.020
Fe	0.300
Ti	Balance
	AMS4951
C	0.080
0	0.180
H	0.005
N	0.050
Fe	0.200
Ti	Balance

***All single values of chemical compositions shown are maximum percentage.**

MINIMUM MECHANICAL PROPERTIES

	ERTi-1	ERTi-2	ERTi-3
Tensile strength (psi)	35,000	50,000	65,000
Yield strength (0.2% offset) psi	25,000	40,000	55,000
Elongation (%)	24	20	18
ERTi-4 AMS4951			
Tensile strength (psi)	80,000	50,000	
Yield strength (0.2% offset) psi	70,000	25,000	
Elongation (%)	15	35	

WASHINGTON ALLOY ERTi-5

AWS A5.16 Class ERTi-5
AMS 4954

Washington Alloy ERTi-5 is a TIG, MIG and submerged arc filler metal used for welding 6% Aluminum - 4% Vanadium alloys. The weld deposits of Washington Alloy ERTi-5 exhibit high fatigue strength, toughness, ductility and are heat treatable. Widely used in the cryogenic, petrochemical and aircraft industry. Aircraft uses would include the airframes; turbine engine parts such as the blades, discs, wheels and spacer rings. Other applications would include industrial fans, pressure vessels, compressor blades and rocket motor cases.

FILLER METAL CHEMISTRY (%)

C	0.050 max.
O	0.180 max.
H	0.015 max.
N	0.030 max.
Fe	0.300 max.
Ti	Balance
Al	5.5-6.7
V	3.5-4.5
Yt	0.005 max.

MINIMUM MECHANICAL PROPERTIES

Tensile strength (psi) 130,000
Yield strength (0.2% offset) (psi) 120,000
Elongation (%) .10

WASHINGTON ALLOY ERTi-23

AWS A5.16 Class ERTi-23
AMS 4956

Washington Alloy ERTi-23 is comparable in chemical composition to ERTi-5, but slightly lower aluminium and lower levels of oxygen and other interstitial elements improve fabricability, weldability, and toughness. ERTi-23 is used in many high strength industrial applications such as shafts where very high strength, but better toughness and fabricability then ERTi-5 are desired.

FILLER METAL CHEMISTRY (%)

C	0.030
O	0.100
H	0.005
N	0.012
Fe	0.150
Ti	Balance
Al	5.5-6.5
V	3.5-4.5
Yt	0.005

MINIMUM MECHANICAL PROPERTIES

Tensile strength (psi).....130,000
Yield strength (0.2% offset) (psi).....120,000
Elongation (%).....10

TIPS FOR WELDING WITH TITANIUM

Welding with titanium requires extreme cleanliness. Grind or file off mill scale. Clean surface oxides with a 35% nitric - 5% hydro¬fluoric acid solution at room temperature, then rinse with water and air dry. Grease or oils should be cleaned with a nonchlorinated degreasing solvent, acetone or methanol. Light oil can be washed away with a normal household detergent, then air-dried.

Titanium is a reactive metal and as such it is sensitive to embrittlement by oxygen, nitro¬gen and hydrogen, within the weld zone area, at temperatures above 500°F. Consequently the weld metal must be protected against atmospheric contamination that may be caused by these elements. This can be most easily attained by holding the shielding gas over the weld area until it cools to approxi¬mately 600°F.

Argon is the recommended shielding gas, however an argon-helium mixture will give greater penetration although at the expense of arc stability.

MANUAL GTA WELDING

Wire Diameter (in.)	Current (A)	Voltage (V)	Travel Speed in./min.	Deposition Rate lb./h
0.0621/16	180	16	5 to15	0.50 to 0.70
0.093 3/32	190	17	5 to15	0,80 to 0.90
0.1251/8	205	19	5 to15	1.20 to 1.36

Courtesy: Penton Publishing Co.: Welding & Fabricating Data Book 1990/91.

NICKEL-BASED ALLOY MIG, TIG & SUBARC WIRES

WASHINGTON ALLOY 60
AWS A5.14 Class ERNiCu-7
UNS N04060

Washington Alloy 60 is primarily designed for MIG, TIG and submerged arc welding of nickel-copper (Monel®) alloys 400 and 404 to themselves or to each other.

Washington Alloy 60 is also used for dissimilar applications such as joining nickel-copper (Monel®) alloys to nickel base alloy 200 and for joining nickel-copper (Monel®) alloys 400 and 404 or nickel base alloy 200 to copper-nickel and copper alloys. Note: When overlaying on steel, use Washington Alloy 61 for the first layer.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	62.0-69.0
C	0.15 max.
Mn	4.0 max.
Fe	2.5 max.
S	0.015 max.
Si	1.25 Max.
Cu	Balance
Al	1.25 max.
Ti	-1.5-3.0
P	0.02 max.
Others (total)	0.50 max.

*Includes Cobalt (Co)

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....70,000
Yield strength (0.2% offset) (psi).....30,000
Elongation (%).....30

WASHINGTON ALLOY 61
AWS A5.14 Class ERNi-1
UNS N02061

Washington Alloy 61 is a high nickel filler metal used for MIG, TIG or plasma arc welding of high nickel base 200 or low carbon nickel 201 to themselves or to each other. Washington Alloy 61 is also used for joining nickel 200 and 201 to dissimilar metals such as carbon steel, stainless steel, Inconel® and Incoloy® alloys, copper-nickel alloys and Monel® alloys. Excellent for overlaying on steel and for welding cast iron. Titanium content in the wire controls weld metal porosity.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	93.0min.
C	0.15 max.
Mn	1.0 max.
Fe	1.0 max
S	0.015 max
Si	0.75 max
Cu	0.25 max
Al	1.5 max.
Ti	2.0-3.5
P	0.03 max.
Others (total)	0.50 max

*Includes Cobalt (Co)
MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....60,000
Yield strength (0.2% offset) (psi).....35,000
Elongation (%).....20

WASHINGTON ALLOY 62
AWS A5.14 Class ERNiCrFe-5
AMS 5679
UNS N06062

Washington Alloy 62 is a nickel-chromium-iron filler metal designed specifically for welding maximum 2" thick base metals of Inconel® 600 using MIG, TIG, submerged arc, plasma arc and oxyacetylene processes. (For sections larger than 2" thick use Washington Alloy 82.) The higher columbium (Cb) and tantalum (Ta) content of Washington Alloy 62 minimizes cracking in thicker base metals where high stresses are encountered.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	70.0 min.
C	0.08 max
Mn	1.0 max.
Fe	6.0-10.0
S	0.015 max.
Si	0.35 max.
Cu	0.50 max
Cr	14.0-17.0
*Cb	1.5-3.0
P	0.03 max.
Co	0.12 max.
Others (total)	0.50 max.

*Includes Tantalum (Ta): 0.30 max.

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....80,000
Yield strength (0.2% offset) (psi).....40,000
Elongation (%).....30

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered nonstandard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY 65
AWS A5.14 Class ERNiFeCr-1
UNS N08065

Washington Alloy 65 filler metal is designed for MIG or TIG welding of Incoloy® 825 to itself or to other nickel-iron-chromium-molybdenum-copper alloys.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	38.0-46.0
C	0.05 Max.
Mn	1.0 Max
Fe	22.0 min.
S	0.03 max.
Si	0.50 max
Cu	1.5-3.0
Cr	19.5-23.5
Al	0.20 max.
Ti	0.60-1.2
Mo	2.5-3.5
P	0.03 max
Others (total)	0.50 max

*Includes incidental Cobalt (Co)

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....80,000
Yield strength (0.2% offset) (psi).....35,000
Elongation (%).....25

WASHINGTON ALLOY 67
AWS A5.7 Class ERCuNi
UNS C71580

Washington Alloy 67 is a copper-nickel filler metal used for MIG, TIG, oxyacetylene and submerged arc welding of wrought or cast 70/30, 80/20 and 90/10 copper-nickel to themselves or to each other. Excellent for joining copper-nickel alloys to nickel-copper Monel® 400, R-405, K-500 or high nickel alloy 200. Note: Washington Alloy 67 can be used for overlaying on steel, however a barrier layer of Washington Alloy 61 should be used for the first pass when MIG welding. Washington Alloy 60 should be used for the first pass when submerged arc welding.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	29.0-32.0
Mn	1.0 max.
Fe	0.40-0.75
S	0.01 max.
Si	0.25 max
Cu	Balance
Ti	0.20-0.50
P	0.02 max.
Pb	0.02 max.
Others (total)	0.50 max.

*Includes Cobalt (Co)

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....50,000
Yield strength (0.2% offset) (psi).....20,000
Elongation (%).....30
Brinell hardness (500 kg load)..... 60-80

WASHINGTON ALLOY 82
AWS A5.14 Class ERNiCr-3
UNS N06082

Washington Alloy 82 is a nickel-chromium-iron filler metal used for MIG, TIG, submerged arc and plasma arc welding of nickel base Inconel® 600 and 601 as well as Incoloy® 800 and 800 HT to themselves or to carbon steel, stainless steel, high nickel base 200 and to nickel-copper Monel® 400. Washington Alloy 82 can also be used for joining high nickel base 200 to stainless steel, nickel-copper Monel® 400 to carbon steel and for overlaying on steel.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	67.0 min
C	0.10 max.
Mn	2.5-3.5
Fe	3.0 max.
S	0.015 max.
Si	0.50 max
Cu	0.50 max
Cr	18.0-22.0
Ti	0.75 max.
*Cb	2.0-3.0
Co	0.12 max.
P	0.03 max.

*Includes Tantalum (Ta): 0.30 max.

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....80,000
Yield strength (0.2% offset) (psi).....40,000
Elongation (%).....30

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered nonstandard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY 625
AWS A5.14 Class ERNiCrMo-3
†AMS 5837
UNS N06625

Washington Alloy 625 is a nickel-chromium-molybdenum filler metal used for MIG, TIG, submerged arc and plasma arc welding of Inconel® alloys 601, 625 and 690 as well as Incoloy® alloys 800, 825 and 800HT to themselves or to each other. Washington Alloy 625 is excellent for joining these Inconel® and Incoloy® alloys to dissimilar metals such as carbon steel, low alloy steel, ferritic and austenitic stainless steels. This filler metal produces weld deposits with excel lent corrosion and oxidation resistance against phosphoric acids, organic acids and seawater. Good resistance against pitting and stress corrosion cracking in chloride containing environments. The weld deposits exhibit high strength and fatigue resistance over a broad range of temperatures ranging from cryogenic up to 1800°F.

Washington Alloy 625 is most commonly used in the chemical processing industry, pollution control equipment, marine equipment, nuclear reactor components, pump shafts. Also used in the aerospace industry for thrust reverser assemblies, fuel nozzles, after-burners and combustion systems.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	58.0 min.
C	0.10 max.
Mn	0.50 max.
Fe	5.0 max.
S	0.015 max.
Cu	0.50 max.
Ti	0.40 max.
Cr	20.0-23.0
*Cb	3.15-4.15
Mo	8.0-10.0
Si	0.50 max.
P	0.02 max.
Al	0.40 max.
Others (total)	0.50 max.

‘Includes Tantalum (Ta)

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....110,000
Yield strength (0.2% offset) (psi).....60,000
Elongation in 2” (%).....30

WASHINGTON ALLOY 718
AWS A5.14 Class ERNiFeCr-2
†AMS 5832
UNS N07718

Washington Alloy 718 is a nickel-chromium-columbium-molybdenum filler metal designed specifically for TIG welding of Inconel® alloys 718, 706 and X-750. The weld deposit of Washington Alloy 718 offers exceptional high strength and good ductility at temperatures up to 1300°F. Good weldability and formability as well as excellent cryogenic properties account for the many applications of this filler metal. The weld deposits of Washington Alloy 718 will precipitation hard en on heat treatment. Primarily for welding aircraft high strength components and liquid rocket components exposed to cryogenic temperatures.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	50.0-55.0
C	0.08 max.
Mn	0.35 max.
Fe	Balance
S	0.015 max.
Si	0.35 max.
Cu	0.30 max.
Cr	17.0-21.0
Al	0.20-0.80
Ti	0.65-1.15
*Cb	4.75-5.50
Mo	2.80-3.30
P	0.015 max.
B	0.006 max.
Co	Incidental

*Includes Tantalum (Ta)

MINIMUM MECHANICAL PROPERTIES (age-hardened)

Tensile strength (psi).....165,000
Yield strength (0.2% offset) (psi).....135,000
Age hardened at 1325°F/8 hours,
furnace cool to 1150°F at 100°F/hour, then air cool.

WASHINGTON ALLOY C276
AWS A5.14 Class ERNiCrMo-4
UNS N10276

Washington Alloy C276 is a nickel-chromium-molybdenum filler metal developed for MIG and TIG welding of Hastelloy® C and Hastelloy® C-276 to themselves, to stainless steel or to other nickel base alloys. Washington Alloy C276 offers excellent resistance to pitting, stress-corrosion cracking and oxidizing atmospheres up to 1900°F.

This filler metal is frequently used for welding the clad side of joints on steel in the chemical, petrochemical and petroleum industries. Washington Alloy C276 offers excellent resistance to a wide range of chemicals including the corrosive effects of wet chlorine gas, hypochlorite and chlorine dioxide solutions. Other uses would include hot contaminated mineral acids, solvents, solutions (organic and inorganic) contaminated by chlorine or chlorides, dry chlorine acetic or ferric acids, seawater and brine solutions.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
C	0.02 max.
Mn	1.0 max.
Fe	4.0-7.0
S	0.03 max.
Cu	0.50 max.
P	0.04 max.
Cr	14.5-16.5
Mo	15.0-17.0
W	3.0-4.5
V	0.35 max.
Co	2.50 max.
Si	0.08 max.
Others (total)	0.50 max.

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....100,000
Yield strength (0.2% offset) (psi)..... 61

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications arc considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY 92
AWS A5.14 Class ERNiCrFe-6
†AMS 5675
UNS N07092

Washington Alloy 92 is a nickel-chromium-iron filler metal used for cladding or overlaying on steel and for joining dissimilar combinations of nickel base Inconel® and Incoloy® alloys to each other or to carbon steel and stainless steel. Excellent for joining austenitic and ferritic stainless steels to each other or to high nickel base 200, nickel-copper Monel® alloys and to carbon steel. Washington Alloy 92 can be used with MIG, TIG, submerged arc and plasma arc welding processes. The weld deposits of Washington Alloy 92 will precipitation harden on heat treatment, with the hardness determined by temperature and the length of time the weld deposit is exposed to that temperature.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	67.0 min.
C	0.08 max.
Mn	2.0-2.7
Fe	8.0 max.
S	0.015 max.
Si	0.35 max.
Cu	0.50 max.
Cr	14.0-17.0
Ti	2.5-3.5
P	0.03 max.
Others (total)	0.50 max.

*Co is incidental

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....80,000
Yield strength (0.2% offset) (psi).....40,000
Elongation (%).....30

WASHINGTON ALLOY X
AWS A5.14 Class ERNiCrMo-2
†AMS 5798
UNS N06002

Washington Alloy X is a nickel-chromium-molybdenum "superalloy" used for MIG, TIG or plasma arc welding of similar base metals such as Hastelloy® X to itself or to stainless steel, carbon steel and low alloy steels. This filler metal offers an exceptional combination of oxidation, corrosion and thermal shock resistance. The weld deposits of Washington Alloy X exhibit high temperature strength and resists weld metal fatigue at temperatures up to 2200°F. Washington Alloy X is commonly used in the aerospace industry for engine tailpipes, turbine blades, nozzle vanes and after burner components. It is also used in petro-chemical applications to combat stress corrosion cracking.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
Cr	20.5-23.0
Mo	8.0-10.0
W	0.2-1.0.
P	0.04 max.
Si	1.0 max.
Co	0.5-2.5
Fe	17.0-20.0
Mn	1.0 max.
C	0.05-0.15
S	0.03 max.
Cu	0.50 max.
Others (total)	0.50 max.

AVERAGE MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....109,500
Yield strength (0.2% offset) (psi).....55,900
Elongation in 2" (%).....45
Rockwell hardness.....B 92

WASHINGTON ALLOY
"WASPALOY"®
AMS 5828

Washington Alloy Waspaloy® filler metal is used for MIG, TIG and resistance welding of similar base metals, usually in critical applications requiring high strength at elevated temperatures. The weld deposits of this filler metal exhibit excellent mechanical properties at temperatures up to 1400°F with good oxi¬dation and corrosion resistance at temperatures as high as 1600°F. Washington Alloy Waspaloy® is commonly used in gas turbine atmospheres; turbine blades, shafts, turbine and compressor discs, spacers, fasteners and jet engine hardware. Suitable for replacing "Nimonic 90" in certain applications.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
Co	12.0-15.0
Cr	18.0-21.0
Mo	3.5-5.0
Fe	2.0 max.
C	0.02-0.10
B	0.003-0.010
Mn	0.10 max.
Si	0.10 max.
P	0.01 max.
S	0.01 max.
Ti	2.75-3.50
Al	1.20-1.60
Cu	0.10 max.
Zr	0.04 max.

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft speculations, however material supplied to both ASME and MIL specifications are considered non¬standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY W
AWS A5.14 Class ERNiMo-3
†AMS 5786
UNS N10004

Washington Alloy W filler Metal is designed for MIG, TIG, submerged arc and plasma arc welding of similar nickel-molybdenum alloys such as Hastelloy® W. However this "super alloys used in high temperature service applications. The weld deposit of Washington Alloy W exhibits good mechanical properties up to 1800°F, power it does exhibit poor oxidation resistance above 1400°F and it should not be used for service application in excess of 750 hours. Washington Alloy W is used in the aerospace industry for jet engine repair and maintenance, gas turbine parts and rotor hubs.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
Mo	23.0-26.0
Cr	4.0-6.0
Fe	4.0-7.0
Si	1.0 max
W	1.0 max
C	0.12 max
Mn	1.0 max
P	0.04 max
S	0.03 max
Co	2.50 max
V	0.60 max
Cu	0.50 max
Others (total)	0.50 max

*Co is incidental

MINIMUM MECHANICAL PROPERTIES (as welded)

Tensile strength (psi).....100,000
Elongation in 2" (%).....25

WASHINGTON ALLOY 600
AMS 5687

Washington Alloy 600 is a high nickel-high chromium filler metal designed to provide high strength weld deposits with good oxidation and corrosion resistance in severely corrosive environments subjected to elected temperatures. The weld deposits of Washington Alloy 600 have excellent resistance to stress corrosion cracking at subzero, room and elected temperature. Washington Alloy 600 is commonly used for nuclear reactor components, chemical and food processing equipment, heat treatment furnace components and heat exchangers. Also used for aircraft engines and exhaust equipment.

TYPICAL FILLER METAL CHEMISTRY (%)

*Ni	Balance
C	0.10 max
Mn	1.0 max.
Fe	6.0-10.0
S	0.015 max.
Cr	14.0-17.0
Si	0.50 max.
Cu	0.50 max.
Others (total)	0.50 max.

Includes Cobalt (Co)

WASHINGTON ALLOY 617
AWS A5.14 Class ERNiCrCoMo-1
UNS N06617

Washington Alloy 617 is a nickel chromium cobalt molybdenum filer metal designed primarily for MIG and TIG welding of Inconel® 617 base material. Excellent for high temperature applications involving dissimilar metals such as joining Inconel® 600, 601 and Incoloy® 800 HT. Washington Alloy 617 weld deposits have excellent mechanical stability, oxidation and corrosion resistance as well as good stress rupture properties at temperatures up to 2000°F. This filler metal is commonly used in the aerospace industry for engine components, after burners, turbine seals; heat treating equipment and many other high temperature service applications.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
Cr	20.0-24.0
Mo	8.0-10.0
Cu	0.500 max.
Fe	3.0 max.
Ti	0.60 max.
C	0.05-0.15
Mn	1.0 max.
P	0.03 max.
S	0.015 max.
Si	1.0 max.
Co	10.0-15.0
Al	0.80-1.50
Others (total)	0.50 max.

Tensile strength (psi).....90,000
Elongation in 2" (%).....41

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable spec fiction. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based and Cobalt-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY R-41
AMS 5800

Washington Alloy R-41 is a nickel-chromium-cobalt-molybdenum filler metal used for MIG, TIG and resistance welding of Rene® 41 base metal. The weld deposits of Washington Alloy R-41 offer excellent strength and oxidation resistance in the 1000^0 F to 1800^0 F range. This filler metal is commonly used for jet and rocket engine components such as turbine wheels, turbine wheels, turbine blades, afterburner parts, combustion chamber liners; airframe and missile components.

TYPICAL FILLER METAL CHEMISTRY (%)

C	0.12 max.
Mn	0.10 max.
Si	0.50 max.
S	0.015 max.
Cr	18.0-20.0
Ni	Balance
Co	10.0-12.0
Fe	5.0 max.
Mo	9.0-10.5
Ti	3.0-3.3
Al	1.4-1.6
B	0.003-0.010
Other (total)	0.02 max.

WASHINGTON ALLOY 31*
AMS 5789

Washington Alloy 31 is a cobalt case filler metal designed for Haynes® Stellite® No. 31 to itself or to nickel base or stainless steel alloys. The weld deposits of Washington Alloy 31 have good stress-rupture resistance and creep strength properties. Excellent for oxidizing and reducing atmospheres up to 2100^oF.Washington Alloy 31 has an “as-cast” tensile strength of 63,200 psi with a 15% elongation at 1500^oF. Primarily used in the aerospace industry for welding gas turbines and other jet engine components.

TYPICAL FILLER METAL CHEMISTRY (%)

Co	Balance
Ni	9.5-11.5
Cr	24.5-26.5
W	7.0-8.0
Fe	2.0 max.
Mn	1.0 max.
C	0.45-0.55
P	0.04 max.
S	0.04 max.
Si	1.0 max.

*Note: This filler metal is also available as a flux-coated electrode for shielded metal arc welding.

WASHINGTON ALLOY L605*
AMS 5796
(AMS 5795B for Flux-Coated Electrode)

Washington Alloy L605 is a cobalt base filler metal used for MIG, TIG and plasma arc welding of Haynes® NO. 25 to itself or to nickel base or stainless steel alloys. This filler metal yields a weld deposit with excellent resistance to oxidation and carburization at temperatures up to 1900^oF. Washington Alloy L605 has good fabricability and is used for industrial furnace applications such as furnace muffles and is used for industrial furnace applications such as furnace muffles and liners in high temperature kilns. Also used in jet engine components such as turbine blades, combustion chamber, turbine rings and afterburner parts. (Commonly referred to as alloy No. 25.)

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	9.0-11.0
Co	Balance
Cr	19.0-21.0
W	14.0-16.0
Fe	3.0 max.
C	0.05-0.15
Si	1.0 max.
Mn	1.0-2.0
P	0.030 max.
S	0.030 max,

*Note: This filler metal is also available as a flux-coated electrode for shielded metal arc welding.

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specification, however material supplied to both ASME and MILL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY N155*
AMS 5794
†(AMS 5795D for Flux-Coated Electrode)

Washington Alloy N155 filler metal is designed for MIG, TIG and resistance welding of Multimet® 155 base metal to itself or to nickel base or stainless steel alloys. This filler metal produces weld deposits with excellent oxidation and corrosion resistance in reducing conditions such as weak hydrochloric acid solutions and sulfuric acids. Washington Alloy N155 weld deposits offer excellent resistance to stress up to 1500°F and moderate resistance to stress up to 2000°F. Washington Alloy N155 is most commonly used in the aerospace industry for jet engine parts including tailpipes, afterburner parts, turbine blades, nozzles and combustion chambers

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	19.0-21.0
Co	18.5-21.0
Cr	20.0-22.50
Mo	2.5-3.5
W	2.0-3.0
Fe	Balance
C	0.10 max.
N	0.10-0.20
*Cb	0.75-1.25
Si	1.0 max.
Mn	1.0-2.0
P	0.04 max.
S	0.03 max.

*Includes Tantalum (Ta)

*Note: This filler metal is also available as a flux-coated electrode for shielded metal arc welding.

WASHINGTON ALLOY 188
AMS 5801

Washington Alloy 188 is a cobalt base filler metal used for MIG, TIG and resistance welding of Haynes® No. 188 base metal to itself or to nickel base or stainless steel alloys. The weld deposits of this filler metal exhibit high temperature strength and post aging ductility at temperatures up to 2100°F. Excellent oxi¬dation resistance is provided by the addition of lanthanum (La) to the filler metal analysis.
Washington Alloy 188 is most commonly used for gas turbines, airframes, chemical environments and nuclear applications. Also used to weld transition ducts, flame holders, combustion cans and liners in jet engines

TYPICAL FILLER METAL CHEMISTRY (%)

Co	Balance
Cr	20.0-24.0
Ni	20.0-24.0
W	13.0-16.0
Fe	3.0 max.
C	0.05-0.15
Si	0.20-0.50
Mn	1.25 max.
La	0.3-0.15
P	0.02 max.
S	0.015 max.

WASHINGTON ALLOY B-2
AWS A5.14 Class ERNiMo-7
UNS N10665

Washington Alloy B-2 is a nickel-molybdenum filler metal used for MIG and TIG welding of Hastelloy® B-2 to itself, to steel or to other nickel-base alloys. The weld deposits of this filler metal exhibit excellent corrosion resistance to many chemicals, with particularly high resistance to hydrochloric acids at all concentrations and temperatures, to aluminum chloride catalysts and other reducing chemicals. Washington Alloy B-2 offers excellent resistance to pitting and stress corrosion cracking commonly caused by sulphuric, acetic, phosphoric and hydrochloric acids. Oxidation resistance to 1500°F and usable strength up to 2000°F.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
Mo	26.0-30.0
C	0.02 max.
Mn	1.0 max.
Fe	2.0 max.
Cu	0.50 max.
Si	0.10 max.
Co	1.0 max.
Cr	1.0 max.
W	1.0 max.
P	0.04 max.
S	0.03 max.
Others (total)	0.50 max.

MINIMUM MECHANICAL PROPERTIES (as welded).

Tensile strength (psi).....110,000 min.
Elongation in 2" (%)…….....55 min.

† Washington Alloy Nickel-Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specification, however material supplied to both ASME and MILL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based and Cobalt-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY C22®
AWS A5.14 Class ERNiCrMo-10
UNS N06022

DESCRIPTION

Washington Alloy C22® is a nickel chromium molybdenum alloy wire designed for joining Hastelloy® C22®, 625, 825 or combinations of these alloys, or other Ni-Cr-Mo alloys to themselves or to stainless steels. Washington Alloy C22® is equivalent to Hastelly® C22® and is also used extensively for overlays and cladding of lower alloy steels. Washington Alloy C22® weld deposits offer better overall resistance to weld metal corrosion than most other Ni-Cr-Mo alloys such as C276, C4 and 625. Washington Alloy C22® has outstanding resistance to pitting, crevice corrosion and stress-corrosion cracking. This alloy is used in chemical processing application involving ferric and cupric and inorganic, chlorine formic and acetic acids, acetic anhydride, sea water, and brine solutions.

TYPICAL FILLER METAL CHEMISTRY (%)

Cr	20.0-22.5
Mo	12.5-14.5
Fe	2.0-6.0
W	2.5-3.5
Cu	0.500 max.
V	0.350 max.
Co	2.500 max.
C	0.015 max.
Mn	0.500 max.
Si	0.080 max.
Ni	Balance

TYPICAL MECHANICAL PROPERTIES (as welded)

Yield point (psi).....76,500
Tensile strength (psi).....113,000
Elongation in 2” (%).....47

Hastelloy® and C22® are registered trademarks of Haynes International

WASHINGTON ALLOY G30®
AWS A5.14 Class ERNiCrMo-11
UNS N06030

DESCRIPTION

Washington Alloy G30® is equivalent to Hastelly® G30® and is designed for welding alloys of similar composition (G30) including alloys G and G3. Washington Alloy G30 is commonly used for joining, overlaying and cladding of low alloy steels, carbon steels, stainless steels and nickel alloys in parts exposed to phosphoric acid in various solutions, and many other environments containing highly oxidizing acids. Applications include welding and cladding of processing equipment for nuclear fuel re-processing, nuclear waste reprocessing, pesticide and fertilizer manufacturing.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	Balance
Cr	28.0-31.5
Fe	13.0-17.0
Co	5.000 max.
Mo	4.0-6.0
W	1.5-4.0
Cu	1.0-2.4
Cb+Ta	0.3-1.5
C	0.030 max.
Mn	1.500 max.
Si	0.800 max.

TYPICAL MECHANICAL PROPERTIES (as welded)

Yield point-2% offset (psi).....68,000
Tensile strength (psi).....102,000
Elongation in 2” (%).....36

Hastelloy® and G30® are registered trademarks of Haynes International

WASHINGTON ALLOY 69 (X750)
AWS A5.14 Class ERNiCrFe-8
UNS N07069 AMS 5778

DESCRIPTION

Washington Alloy 69 (X750) is a special purpose age-hardening nickel-chromium-iron alloy wire with the addition of 2-1/2% titanium for higher strength at temperatures in the 1600°F range. Washington Alloy 69 (X750) weld deposits exhibit excellent resistance to oxidizing combustion gases at these high temperatures, making this alloy suitable for welding jet engine turbine and aircraft parts such as the turbine blades and aircraft parts such as the turbine blades and vanes, turbine disks and turbine springs. This alloy steels and for welding of lower alloy steels clad with Ni-Cr-Fe alloys.

TYPICAL FILLER METAL CHEMISTRY (%)

Ni	70.0 min.
Cr	14.0-17.0
Fe	5.0-9.0
Ti	2.0-2.75
Cb+Ta	0.70-1.20
Al	0.40-1.0
C	0.080 max
Mn	1.000 max.
Si	0.500 max.
Cu	0.500 max.

TYPICAL MECHANICAL PROPERTIES (as welded)

Yield point-2% offset (psi).....90,000
Tensile strength (psi).....125,000
Elongation in 2” (%).....5
Age Hardening.....1950°F/2 hrs., air cooled followed by 1300°F/20 hrs., air cooled

Nickel-Based and Cobalt-Based Alloy MIG, TIG & Subarc Wires

WASHINGTON ALLOY A-286
AMS 5804 UNS S30815

DESCRIPTION

Washington Alloy A-286 is a nickel-chromium-molybdenum-titanium-vanadium-boron super alloy that produces a dense, fine-grained structure with excellent resistance to heat and corrosion. Washington Alloy A-286 is designed to weld sheet, plate, and tubes of similar chemistry (15 Cr, 25.5 Ni, 1.2 Mo, 2.1 Ti, 0.30 V, 0.006 B). Washington Alloy A-286 responds to solution heat treatment and is used extensively for fabricating military jet engine exhaust systems, marine propulsion systems and rebuilding turbine shafts.

TYPICAL FILLER METAL CHEMISTRY (%)

C	0.08 max.
Mn	2.00 max
Si	1.00 max.
Cr	13.0-16.0
Mo	1.00-1.50
Ni	24.0-27.0
Ti	1.90-2.30
V	0.10-0.50
B	0.001-0.10

TYPICAL MECHANICAL PROPERTIES (as welded)

Yield point-2% offset (psi).....90,000
Tensile strength (psi).....122,000
Elongation in 2” (%).....30
Hardness (BHN).....200

Guide to Available AMS Alloys

AMS#	GRADE	MIL-R-5031B CLASS		AMS#	GRADE	MIL-R-5031B CLASS
4182	5056 Aluminum			5698	Inco® X-750	
4184	4145 Aluminum			5774	AM350	
4185	4047 Aluminum			5776	410 Stainless Steel	
4190	4043 Aluminum			5778	Inco®69	14
4191	2319 Aluminum			5780	AM355	
4395	AZ92A Magnesium			5782	19-9W M0(349)	6
4396	EZ33A Magnesium			5784	29CR-9NI (312)	
4701	Copper Annealed			5786	Hastelloy®W	12
4730	Monel® 400			5787	Hastelloy®W coated	
4951	Commercial Pure Titanium			5789	Stellite® 31	
4953	5AL2.5 SN Titanium			5794	N-155	9
4954	6AL4V Titanium Standard			5796	L-605	13
4955	8AL-1MO-1V Titanium			5798	Hastelloy® X	
4956	6AL4V Titanium ELI			5799	Hastelloy® X coated	
5555	Nickel 205			5800	Rene 41®	
5621	420			5801	Haynes® 188	
5660	Incoloy®901			5804	A-286 Standard	
5675	Inco®92			5813	WHP 15-7 Standard	
5676	Nichrome V	7		5817	Greek Ascoloy	
5679	Inco©62	8A		5821	410 Stainless Steel Mod	
5680	347 Stainless Steel	5A		5823	Jethete	
5683	Inco®42			5824	17-7PH	
5684	132			5825	17-4PH	
5685	305 Safety Wire			5827	630-15,16	
	HAST-B	10		5828	Waspaloy®	
5687	Inco®600			5832	Inco® 718	
	HAST-C-276	11		5836	82	
5689	321 Stainless Steel			5837	Inco® 625	
5690	316 Stainless Steel	4		5840	PH 1308 MO	
5694	310 Stainless Steel	3		6350	4130	
5697	304 Stainless Steel			6458 6451 6462 6466	17-22-AS 6130 Premium 6130 Standard 502	

† Washington Alloy Nickel Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

NICKEL BASED ALLOY FLUX COATED ELECTRODES

WASHINGTON ALLOY 182
AWS/SFA 5.11 Class ENiCrFe-3
W86182

DESCRIPTION
Washington Alloy 182 is a "General Purpose" nickel-chromium-iron flux-coated electrode used for joining many dissimilar combinations of nickel base alloys, of the nickel chromium type, to themselves or to stainless or mild steels. This electrode will consistently produce x-ray quality and machinable weld deposits. Excellent for welding Inconel® 600 to itself or to carbon steel and stainless steel; or high chromium Incoloy® 800 to nickel-copper Monel® 400 or nickel or nickel base alloy 200. Washington Alloy 182 is also used for joining nickel base alloy 200 to stainless steel and nickel-copper Monel® 400 to carbon steel.

APPLICATIONS
Since Washington Alloy 182 is so versatile, it can be used for countless applications. However more common applications include the chemical or petrochemical industries and the nuclear industry where it is used to weld dissimilar joints between vessels and primary piping. Washington Alloy 182 is often used for welding the clad side of nickel-chromium-iron clad steel and for re-surfacing steel.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	59.0 min.
C	0.10 max.
Mn	5.0-9.5
Fe	10.0 max.
S	0.015 max.
Cu	0.50 max.
Si	1.0 max.
Cr	13.0-17.0
Ti	1.0 max.
*Cb	1.0-2.5
Co	0.12 max.
Others	0.50 max.

*Includes Tantalum (Ta) 0.30 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....80,000 min.
Yield strength (psi).....45,000 min.
Elongation in 2° (%).....30 min.
Avg. Charpy V-notch impact value.....60 ft.-lbs. @ -320°F

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)

3/32 (2.4mm).....75-100 amps
1/8 (3.2mm).....100-140 amps
5/32 (4.0mm).....140-180 amps
3/16 (4.8mm).....170-210 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

WASHINGTON ALLOY 112
AWS/SFA5.11 Class ENiCrMo-3
W86112

DESCRIPTION
Washington Alloy 112 is a nickel-chromium-molybdenum flux-coated electrode designed for shielded metal-arc welding of Inconel® 625 or 601, for high strength welds on 9% nickel steels and for overlaying carbon steel. Washington Alloy 112 is also used for joining dissimilar combinations of steels or stainless steels to nickel-iron-chromium alloys such as Incoloy® 800 or 801.

APPLICATION
More common uses of Washington Alloy 112 include the nuclear industry where it is used for pressure vessel superheaters, steam separators and tube plates. This electrode is commonly used in cryogenic installations; chemical and petrochemical applications; and for heat treatment and case hardening indus¬trial furnace parts. More specific uses include joining Inconel® 625, 718, X-750 and 706 to 9% nickel steels; for welding Incoloy® 825 to carbon steel, stainless steel and low alloy steel; for joining Inconel® 625, Monel® K-500, Incoloy® 800 and 825 to Inconel® 706, 718 and X-750; and for joining Incoloy® 825 and 800.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	55.0 min.
C	0.10 max.
Mn	1.0 max.
Fe	7.0 max.
S	0.02 max.
Cr	20.0-23.0
*Cb	3.15-4.15
Mo	8.0-10.0
Si	0.75 max.
Co	0.12 max.
Others	0.50 max.

*Includes Tantalum (Ta)

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....110,000 min.
Yield strength (psi).....60,000 min.
Elongation in 2" (%).....30 min.
Avg. Charpy V-notch impact value.....41 ft.-lbs. @-300°F

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)

3/32 (2.4mm).....70-95 amps
1/8 (3.2mm).....100-135amps
5/32 (4.0mm).....130-175 amps
3/16 (4.8mm).....175-210 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

WASHINGTON ALLOY 141
AWS/SFA5.11 Class ENi-1
W82141

DESCRIPTION
Washington Alloy 141 is a high nickel con¬tent flux-coated electrode designed for weld¬ing wrought and cast forms of commercially pure nickel to themselves or to steel. This electrode is commonly used for dissimilar welding applications involving nickel base alloys 200 or 201 to iron base and nickel base alloys. Washington Alloy 141 is excellent for overlaying on steel and for welding the clad side of nickel clad steel.

APPLICATIONS
Typical applications of Washington Alloy 141 would involve the chemical industry, soda fabrication, fatty acid fabrication, vinyl chloride production, sodium metal silicate production and within the paper industry. Washington Alloy 141 should be considered where high resistance to corrosion and high temperatures is required.

TYPICAL WELD METAL CHEMISTRY (%)

*Ni	92.0 min.
C	0.10 max.
Mn	0.75 max.
Fe	0.75 max.
S	0.02 max.
Si	1.25 max.
Ti	1.0-4.0
Al	1.0 max.
Cu	0.25 max.
Others	0.50 max.

Includes Cobalt (Co)

MINIMUM MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....60,000 min.
Yield strength (psi).....30,000 min.
Elongation in 2" (%).....20 min.

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....65-90 amps
1/8 (3.2mm).....85-130 amps
5/32 (4.0mm).....110-160 amps
3/16 (4.8mm).....170-220 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

† Washington Alloy Nickel Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy Flux Coated Electrodes

WASHINGTON ALLOY 190
AW/SFA5.11 Class ENiCu-7
UNS W84190

DESCRIPTION
Washington Alloy 190 flux-coated elec¬trodes are designed for shielded metal arc welding of nickel-copper Monel® 400 and 404 to themselves and to steel. This electrode is perfect for joining many nickel-copper alloys to copper, copper-nickel, carbon steel and low alloy steel. Washington Alloy 190 is also used for overlaying on steel and for weld¬ing the clad side of joints in steel clad with a nickel-copper alloy.

APPLICATIONS
Washington Alloy 190 is a very popular electrode. Most common uses include elec-troplating and chemical pickling equipment, polyvinylchloride production plants, sea water desalination plants and in waste water treatment plants.

TYPICAL WELD METAL CHEMISTRY (%)

*Ni	62.0-69.0
C	0.15 max.
Mn	4.0 max.
Fe	2.5 max.
S	0.015 max.
Si	1.5 max.
Cu	Balance
Ti	1.0 max.
Al	0.75 max.
P	0.02 max.

*Includes Cobalt (Co)

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....70,000 min.
Yield strength (psi).....30,000 min.
Elongation in 2" (%).....30 min.
Avg. Charpy V-notch impact
impact value.....89 ft.-lbs. @ 68°F

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....70-90 amps
1/8 (3.2mm).....90-125 amps
5/32 (4.0mm).....110-160 amps
3/16 (4.8mm).....155-185 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

WASHINGTON ALLOY "A"
AWS/SFA5.11 Class ENiCrFe-2
W86133

DESCRIPTION
Washington Alloy "A" is a nickel-chromium-iron flux-coated electrode designed primarily for shielded metal arc welding of Incoloy® 800 to itself or to 9% nickel steels. This electrode is used for welding a variety of dissimilar wrought or cast forms of carbon steel, austenitic and ferritic stainless steel, and nickel-chromium Inconel® 600 to them¬selves or to each other. Washington Alloy "A" is frequently used for joining Incoloy® 800 to high nickel alloys 200 and 201 or to nickel-copper Monel© 400 and K-500.

APPLICATIONS
Washington Alloy "A" is excellent for over¬laying nickel-chromium alloy on steel. More common applications include the welding of 5% and 9% nickel steel transport or storage tanks used for cryogenic products. The chem¬ical or petrochemical industries use Washington Alloy "A" for many applications such as valve seats and gates, coal gasifica¬tion and wet process desulphurization equipment.

TYPICAL WELD METAL CHEMISTRY (%)

Ml	62.0 min.
C	0.10 max.
Mn	1.0-3.5
Fe	12.0 max.
S	0.02 max.
Si	0.75 max.
Cr	13.0-17.0
Mo	0.5-2.50
*Cb	0.5-3.0
Co	0.12 max.

'Includes Tantalum (Ta) 0.30 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....80,000 min.
Yield strength (psi).....40,000 min.
Elongation in 2" (%).....30 min.
Avg. Charpy V-notch impact
value.....60 ft.-lbs. @-320°F

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....70-90 amps
1/8 (3.2mm).....100-135 amps
5/32 (4.0mm).....130-180 amps
3/16 (4.8mm).....190-220 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

WASHINGTON ALLOY FC-276
AWS/SFA5.11 Class ENiCrMo-4
UNS W80276

DESCRIPTION
Washington Alloy FC-276 is a flux-coated electrode designed for welding low carbon nickel-chromium-molybdenum Hastelloy® C and Hastelloy® C-276 to themselves or to stainless steel or nickel base alloys. This elec-trode offers excellent resistance to pitting, stress-corrosion cracking and oxidizing up to 1900°F. Washington Alloy FC-276 is used for welding the clad side of joints in steel clad with low carbon nickel-chromium-molybde¬num alloys.

APPLICATIONS
This highly versatile corrosion-resistant electrode is most commonly used in chemical process applications such as ferric and cupric chlorides, solvents, chlorine, sea water and brine solutions, acetic acids, mineral acids and wet chlorine gas.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	Balance
C	0.02 max.
Mn	1.0 max.
Fe	4.0-7.0
S	0.03 max.
Cu	0.50 max.
P	0.04 max.
Cr	14.5-16.5
Mo	15.0-17.0
W	3.0-4.5
V	0.35 max.
Co	2.5 max.
Si	0.20 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....100,000
Elongation in 2" (%).....25

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....60-80 amps
1/8 (3.2mm).....80-110 amps
5/32 (4.0mm).....105-135 amps
3/16 (4.8mm).....125-165 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

† Washington Alloy Nickel Based and Cobalt-Based Alloys can he certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of Inquiry.

Nickel-Based Alloy Flux Coated Electrodes

WASHINGTON ALLOY 187
AWS/SFA5.6 Class ECuNi

DESCRIPTION
Washington Alloy 187 is a 70% copper -30% nickel flux-coated electrode designed for welding wrought or cast forms of 70/30, 80/20 and 90/10 copper-nickel alloys. This electrode is also used for many dissimilar applications such as joining nickel-copper Monel® 400, R-405 and K500 or high nickel alloy 200 to the copper-nickel alloys.

APPLICATIONS
The most popular use of Washington Alloy 187 would involve marine applications where it offers excellent resistance to the corrosive effects of salt water. Also used for welding the clad side of copper-nickel clad steel.

TYPICAL WELD METAL CHEMISTRY (%)

*Ni	29.0-33.0
Mn	1.00-2.50
Fe	0.40-0.75
Si	0.50 max.
Cu	Balance
Ti	0.50 max.
Pb	0.02 max.
P	0.020 max.
Other (total)	0.50 max.

*Includes Cobalt (Co)

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....50,000 min.
Yield strength (psi).....20,000 min.
Elongation in 2" (%).....30

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....50-75 amps
1/8 (3.2mm).....75-110 amps
5/32 (4.0mm).....110-145 amps
3/16 (4.8mm).....145-185 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

WASHINGTON ALLOY 117
AWS A5.11 Class ENiCrCoMo-1
UNS W86117

DESCRIPTION
Washington Alloy 117 is a nickel-chromi¬um-cobalt-molybdenum flux-coated electrode designed for shielded metal-arc welding of Inconel® 617 to itself or to dissimilar metals such as Inconel® 600, 601 and Incoloy® 800 HT. The weld deposits of Washington Alloy 117 have excellent mechanical stability, oxidation and corrosion resistance as well as good stress rupture properties at temperatures above 1500°F up to 2100°F.

APPLICATIONS
Washington Alloy 117 is commonly used to weld cast alloys such as HK-40, HP and HP-45 modified. Excellent for joining Inconel® 617 to steel in high temperature applications. Washington Alloy 117 is used in the aerospace industry for engine components, after-burners, turbine seals; heat-treating equipment and many other high temperature ser¬vice applications.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	Balance
Cr	21.0-26.0
Mo	8.0-10.0
Cu	0.50 max.
Fe	5.0 max.
*Cb	1.0 max.
C	0.05-0.15
Mn	0.30-2.50
P	0.03 max.
S	0.015 max.
Si	0.75 max.
Co	9.0-15.0
Other (totals)	0.50 max.

*Includes Tantalum (Ta)

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....90,000 min.
Elongation in 2" (%).....25 min.

AVAILABLE SIZES AND OPERATING RANGES (DCELECTRODE POSITIVE)
3/32 (2.4mm).....60-80 amps 22-24 volts
1/8 (3.2mm).....80-110 amps 22-24 volts
5/32 (4.0mm).....105-135 amps 23-25 volts
3/16 (4.8mm).....125-165 amps 24-26 volts

WELDING PROCEDURES
All positions for 3/32 and 1/8.
5/32 and 3/16 for flat position only.

WASHINGTON ALLOY 132
AWS/SFA5.11 Class ENiCrFe-1
†AMS 5684

DESCRIPTION
Washington Alloy 132 is a nickel-chromium-iron flux-coated electrode designed primarily for welding Inconel® 600 and Incoloy® 825. Common ASTM base metals that can be joined are ASTM B163, B166, B167 and B168.

APPLICATIONS
Washington Alloy 132 offers corrosion resistance over a wide range of environments ranging from cryogenic temperatures to approximately 1500°F (820°C). This allows Washington Alloy 132 to be used in the chemical and food processing industries as well as for heat exchangers and evaporators. The most common use of this electrode would be for welding the clad side of joints in steel clad with Inconel® 600 and for surfacing steel.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	62.0 min.
C	0.08 max.
Mn	3.5 max.
Fe	11.0 max.
S	0.015 max.
Si	0.75 max.
Cr	13.0-17.0
Cu	0.50 max.
*Cb	1.5-4.0
P	0.03 max.

*Includes Tantalum (Ta): 0.30 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile strength (psi).....80,000 min.
Yield strength (psi).....40,000 min.
Elongation in 2" (%).....30 min.

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....70-90 amps
1/8 (3.2mm).....100-135 amps
5/32 (4.0mm).....130-135 amps
3/16 (4.8mm).....190-220 amps

WELDING PROCEDURES
Flat, horizontal, vertical, overhead.

† Washington Alloy Nickel Based and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. II is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy Flux Coated Electrodes

WASHINGTON ALLOY 135

DESCRIPTION

Washington Alloy 135 is a nickel-iron-chromium flux-coated electrode used primarily for welding Incoloy® 825 to itself or to other similar base metals such as nickel-iron-chromium-molybdenum-copper alloys.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	35.0-40.0
C	0.08 max.
Mn	1.25-2.50
Fe	Balance
S	0.03 max.
Si	0.75 max.
Cu	1.0-2.50
Cr	26.5-30.5
Mn	2.75-4.50
P	0.03 max.
Others (total)	0.50 max.

MINIMUM MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)

Tensile strength (psi).....85,000.
Elongation in 2* (%).....30.

WASHINGTON ALLOY "B"

AWS/SFA5.11 Class ENiCrFe-4
UNS W86134

DESCRIPTION

Washington Alloy "B" is a nickel-chromium-iron flux-coated electrode very similar to Washington Alloy "A", however Washington Alloy "B" offers two distinct features that are not available with Washington Alloy "A". Washington Alloy "B" offers a higher yield and tensile strength and it is formulated to operate with AC current, a feature that will allow Washington Alloy "B" to combat magnetic arc blow.

APPLICATIONS

Washington Alloy "B" is designed for shielded metal arc welding of 9% nickel steel such as ASTM A333, A334, A353, A522 and A553. However it can also be used for joining Incoloy® 800 to itself or to high nickel alloys 200 and 201. For joining Incoloy® 800 to 9% nickel steels or to nickel-copper Monel® 400 and K-500.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	60.0 min
C	0.20 max.
Mn	1.0-3.5
Fe	12.0 max.
S	0.02 max.
Si	1.0 max.
Cr	13.0-17.0
Mo	1.0-3.5
*Cb	1.0-3.5
Cu	0.50 max.

Includes Tantalum (Ta): 0.30 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)

Tensile strength (psi).....95,000 min.
Elongation in 2" (%).....20 min.

AVAILABLE SIZES AND OPERATING RANGES (AC/DC+ ELECTRODE POSITIVE)

3/32 (2.4mm).....70-90 amps
1/8 (3.2mm).....100-135 amps
5/32 (4.0mm).....130-180 amps
3/16 (4.8mm).....190-220 amps

WELDING PROCEDURES

Flat, horizontal, vertical, overhead.

WASHINGTON ALLOY B-2 FC

AWS/SFA5.11 Class ENiMo-7
UNS W80665

DESCRIPTION

Washington Alloy B-2 FC is a nickel-molybdenum flux-coated electrode developed specifically for welding similar base metals such as Hastelloy® B-2 to itself or to steel and nickel alloys. Common base metals that can also be welded would include ASTM B333, B335, B619, B622 and B626 all of which have UNS number N10665. Washington Alloy B-2 has a controlled low level of carbon, iron and cobalt which together with the nickel and molybdenum gives this electrode excellent resistance to pitting and stress corrosion cracking commonly caused by acids. AP

PLICATIONS

The most common application of Washington Alloy B-2 would be in the chemical processing industries on parts exposed to all concentrations and temperatures of hydrochloric acid. It is also used on parts subjected to sulphuric, phosphoric and acetic acids. Washington Alloy B-2 should not be used in the presence of cupric or ferric salts which may develop where iron or copper bearing alloys have come in contact with acids.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	Balance
Mo	26.0-30.0
C	0.02 max.
Mn	1.75 max.
Fe	2.25 max.
Si	0.2 max.
Co	1.0 max.
Cr	1.0 max.
W	1.0 max.
P	0.04 max.
S	0.030 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)

Tensile strength (psi).....100,000 min.
Hardness.....Rockwell B-98 avg.
Elongation in 2" (%).....25 min.

AVAILABLE SIZES AND OPERATING RANGES (DC ELECTRODE POSITIVE)

3/32 (2.4mm).....60-80 amps 22-24 volts
1/8 (3.2mm).....80-110 amps 22-24 volts
5/32 (4.0mm).....105-135 amps 23-25 volts
3/16 (4.8mm).....125-165 amps 24-26 volts

WELDING PROCEDURES

Flat position only.

† Washington Alloy Nickel Based and Cobalt-Based Alloys can he certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification require¬ments at the time of inquiry.

Nickel-Based Alloy Flux Coated Electrodes

WASHINGTON ALLOY X FC
AWS/SFA5.11 Class ENiCrMo-2
AMS 5799 UNS W86002

DESCRIPTION
Washington Alloy X FC is a nickel-chromium-molybdenum electrode developed for shielded metal-arc welding of similar base metals such a Hastelloy® X to themselves or to stainless steels, carbon steels and low alloy steels. Washington Alloy X FC offers an exceptional combination of oxidation, corrosion and thermal shock resistance. This electrode exhibits high temperature strength and prevents weld metal fatigue at temperature as high as 1100ºF

APPLICATIONS
Washington Alloy X FC is commonly used in the chemical process industry for retorts, muffles, catalyst support grids, furnace baffles. It is also used for engine tailpipes, turbine blades, afterburner components, nozzle vanes, cabin heaters and other aircraft related parts.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	Balance
Cr	20.5-23.0
Mo	8.0-10.0
W	0.20-1.0
P	0.04 max.
Si	1.0 max.
Co	0.50-2.50
Fe	17.0-20.0
Mn	1.0 max.
C	0.05-0.15
S	0.03 max.
Cu	0.50 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)

Tensile Strength (psi).....95,000 min.
Rockwell hardness.....B 92 avg.
Elongation in 2” (%).....20

AVAILABLE SIZES AND OPERATING RANGES (DC+ELECTRODE POSITIVE)
3/32 (2.4 mm).....60-80 amps 22-24 volts
1/8 (3.2 mm)….....80-110 amps 22-24 volts
5/32 (4.0 mm)….....105-135 amps 23-25 volts
3/16 (4.8 mm)….....125-165 amps 24-26 volts

WELDING PROCEDURES
Flat position only.

WASHINGTON ALLOY W FC
AWS/SFA5.11 Class ENiMo-3
AMS 5787

DESCRIPTION
Washington Alloy W FC is a nickel-molybdenum flux-coated electrode designed specifically for welding Hastelloy® W it itself or to a variety of other alloys used in high temperature service applications. Washington Alloy WFC is excellent for joining dissimilar combinations of cobalt, nickel and iron-base alloys.

APPLICATIONS
Washington Alloy W FC is most commonly used for jet engine repair and maintenance, gas turbine parts and rotor hubs. This electrode will provide good mechanical properties up to 1800ºF, however it does exhibit poor oxidation resistance above 1400ºF and it should not be used for service applications in excess of 750 hours.

TYPICAL WELD META CHEMISTRY (%)

Ni	Balance
Mo	23.0-27.0
Cr	2.5-5.5
Fe	4.0-7.0
Si	1.0 max.
W	1.0 max.
C	0.12 max.
Mn	1.0 max.
P	0.04 max.
S	0.03 max
Co	2.5 max.
V	0.60 max.
Cu	0.50 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile Strength (psi).....100,000 min.
Elongation in 2” (%).....25 min.

AVAILABLE SIZED AND OPERATING RANGES (DC+ELECTRODE POSITIVE)
3/32 (2.4 mm)….....60-80 amps 22-24 volts
1/8 (3.2 mm)….....80-110 amps 22-24 volts
5/32 (4.0 mm)….....105-135 amps 23-25 volts
3/16 (4.8 mm)….....125-165 amps 24-26 volts

WELDING PROCEDURES
Flat position only.

WASHINGTON ALLOY C22®
AWS A5.11 Class ENiCrMo-10
UNS W86022

DESCRIPTION
Washington Alloy C22® coated electrodes have excellent dissimilar welding characteristics when joining various combinations of alloys C22, 625, 825 and many other nickel-chromium-molybdenum and stainless steel alloys. Commonly used for overlay work and for cladding of steel, Washington Alloy C22 weld deposits offer better overall resistance to weld metal corrosion than other nickel-chromium-molybdenum alloys, such as C276, C4 and 625. Outstanding resistance to pitting, crevice-corrosion and stress-corrosion cracking.

APPLICATIONS
Washington Alloy C22® coated electrodes are commonly used in applications involving ferric and cupric chlorides, hot contaminated media-both organic and inorganic, chlorine, formic and acetic acids, acetic anhydride, sea-water, brine solutions and many other chemical-processing applications.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	Balance
Cr	20.0-22.5
Mo	12.5-14.5
Fe	2.0-6.0
W	2.5-3.5
Co	2.5 max.
C	0.02 max
Mn	1.0 max
Si	0.2 max.
Cu	0.5 max
V	0.35 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile Strength (psi).....115,000
Elongation in 2” (%).....40
Hardness, Rb.....100

AVAILABLE SIZES AND OPERATING RANGES (DCEP) (DC+)
3/32 (2.4mm).....50-75 amps
1/8 (3.2mm).....75-100 amps
5/32 (4.0mm).....80-140 amps
3/16 (4.8mm).....125-150 amps
C-22® trademark of Haynes International

† Washington Alloy Nickel Base and Cobalt-Based Alloys can be certified to most commercial and aircraft specifications, however material supplied to both ASME and MIL specifications are considered non-standard and must be tested to the applicable specification. Such testing will necessitate additional charges to the buyer. It is the responsibility of the buyer to state these ASME or MIL specification requirements at the time of inquiry.

Nickel-Based Alloy Flux Coated Electrodes

WASHINGTON ALLOY G30®
AWS A5.11 Class ENiCrMo-11
UNS W86030

DESCRIPTION
Washington Alloy G30® coated electrodes are used for welding alloys of similar composition (G30) including predecessor alloys G and G3, which G30® replaced. Washington Alloy G30® is commonly used for overlaying on steel and various dissimilar combinations of low alloy steel, carbon steel, stainless and nickel alloys in parts exposed to phosphoric, sulfuric, various nitric acid solutions and many other environments containing highly oxidizing acids.

APPLICATIONS
Washington Alloy G30® coated electrodes are commonly found being used in various acid service applications, nuclear fuel reprocessing, nuclear waste reprocessing, pesticide and fertilizer producers.

TYPICAL WELD METAL CHEMISTRY (%)

Ni	Balance
Cr	28.0-31.5
Fe	13.0-17.0
Co	5.0 max.
Mo	4.0-6.0
W	1.5-4.0
Cu	1.0-2.4
Cb+Ta	0.3-1.5
C	0.03 max.
Mn	1.5 max.
Si	1.0 max.

TYPICAL MECHANICAL PROPERTIES OF WELD DEPOSIT (as welded)
Tensile Strength (psi).....85,000 min.
Elongation in 2” (%).....25 min

AVAILABLE SIZES AND OPERATING RANGES (DC+ELECTRODE POSITIVE)
3/32 (2.4 mm).....40-65 amps
1/8 (3.2mm).....6.-90 amps
5/32 (4.0mm).....90-125 amps
3/16 (4.8 mm).....125-160 amps
G30® is a trademark of Haynes International

SPECIAL PURPOSE ELECTRODES

ARMORWELD 307

AC/DC ± (Straight or Reverse Polarity)
A 19% Chrome/9% Nickel Flux-coated Electrode

APPLICATION

Armorweld 307 is designed to produce moderate strength-crack resistant weld deposits in armor plate and between dissimilar steels such as 14% manganese steel to carbon steel forgings or castings. THE PERFECT ELECTRODE TO USE ON "DIFFICULT TO WELD STEELS." Excellent for joining wear resistant steel plates of high tensile strength, for welding stainless steel to carbon steel and for building up rails. Commonly used in mining and dredging equipment as well as within steel manufacturing facilities.

FEATURES

Armorweld 307 deposits offer excellent toughness and corrosion resistance. Weld deposits remain crack-resistant without any preheat or postheat treatment. Heat resistance up to 1460°F. Impact properties remain strong down to -150°F. Weld deposits are non-magnetic and they are machinable in the "as-welded" condition, however Armorweld 307 deposits do work-harden (up to RC52) when put into service. Beautiful welds with AC current!

TYPICAL WELD METAL CHEMISTRY (%)

Hardness (as welded).....200 HB
Hardness (work-hardened).....500 HB
Tensile Strength.....93,000 psi
Yield Strength.....68,000 psi
Elongation in 2".....40%

AVAILABLE SIZES AND RECOMMENDED AMPERAGE

3/32 (2.4 mm).....65-70 Amps
1/8 (3.2 mm).....95-120 Amps
5/32 (4.0 mm).....110-160 Amps
3/16 (4.8 mm).....150-190 Amps

*TENSILEWELD

APPLICATIONS

Tensileweld is the ultimate AC-DC electrode to use where high strength and porosity-free welds are required. Weld deposits are impact, abrasion, heat and corrosion resistant. Tensileweld is especially formulated to weld dissimilar steels; high carbon, tool and die steels; stainless steels; spring and coil steels; pressure vessels and aircraft steels. It is the perfect electrode to use where the alloy content of the base metal is unknown. Typical applications would include the underlayment of hardfacing alloys in mining applications, rebuilding shafts and agitator blades in turbines, framed, cast steel parts and gears.

PROCEDURES

Clean the work area. Thick sections should be beveled. A preheat of 400ºF is recommended for carbon and cast steels. AC or DC reverse polarity is used. Maintain a short arc, slightly inclined in the direction of movement and use stringer beads. Peening is recommended.

CHARACTERISTICS

Tensileweld has a high deposition rate. Weld deposits are smooth, ductile, porosity-free and take on a shiny appearance.

TYPICAL WELD META CHEMISTRY (%)

Tensile strength.....Up to 120,000 psi
Yield strength.....Up to 90,000 [so
Elongation in 2".....Up to 30%
Hardness.....200 Brinell

RECOMMENDED AMPERAGE (AC OR DC+)

Size	3/32	1/8	5/32	3/16
Amp.	40-90	75-125	100-150	140-240

PACKAGING.

6-10 lb. tubes in 60 lb. master carton.

*Also available in 36" straightened and cut lengths for TIG applications.

ALUMINUM 345

Extruded Maintenance & Repair Electrode
AWS/SFA 5.3 E4043 DC+ (Reverse Polarity)
UNS A94043

DESCRIPTION AND APPLICATIONS

An extruded aluminum electrode used for low temperature production and maintenance welding of cast and wrought aluminum sheets, plates, castings and extrusions.

Typical applications include tanks, pipes, appliances, refrigeration equipment, irrigation equipment, automobile parts and parts found in the laundry, chemical and food processing industries.

An all position electrode that produces dense and porosity-free machinable weld deposits. Color match and corrosion resistance of the weld deposit is excellent. Tensile strength is approximately 34,000 psi.

PROCEDURES

Clean the area to be welded. Large or heavy sections should be beveled to a 60 or 75 vee. Align the parts to be welded by tacking the joint(s). Preheating the larger sections to 350ºF will allow for a flatter bead as well as reducing the required amperage. Using DC+ reverse polarity, maintain a short arc length while tilting the electrode in the direction of travel. The weaving technique is not recommended because of the faster travel speed required when welding aluminum. Allow the part to cool, then remove all slag before making multiple passes. You may want to use a stainless steel wire brush and warm water to remove any flux residue. Many times a 10% sulphuric acid solution is used in the warm water. This will give the weld deposit a cleaner, more polished appearance.

SIZE	RECOMMENDE AMPERAGE (DC+)
3/32" (2.4 mm) × 14" (350 mm)	50-85 amps
1/82" (3.2 mm) × 14" (350 mm)	85-140 amps
5/32" (4.0 mm) × 14" (350 mm)	110-165 amps

PACKAGING

5 lb. tubes / 30 lb. master cartons or 1 lb. mini-paks.

SPECIAL PURPOSE ELECTRODES

USA CHAMFER ROD
AC/DC- (Straight Polarity)

APPLICATION
USA Chamfer Rods are used for gouging, beveling and veeing out of excess metal in ferrous and nonferrous materials. This rod is most commonly used for removing old weld metal and sharp edges prior to subsequent welding operation. USA Chamfer Rods may be used with little or no oxygen/air present.

PROCEDURES AND CHARACTERISTICS
USA Chamfer Rods may be used with either AC or DC (straight polarity) on any welding machine. Use the recommended amperage and hold the electrode at t low angle, pushing it rapidly forward, while applying slight pressure on the work. One pass will produce a clean groove, removing material equal to the diameter of the chamfer rod. Deeper grooves may be obtained by making multiple passes. USA Chamfer Rods produce a “blowing action” which removes all unwanted material (including dirt, grease, oil, etc.) from the base metal. It requires no gases or special equipment such as air compressors.

RECOMMENDE AMPERAGE (AC OR DC-)

Size	3/32	1/8	5/32	3/16
Amp.	120	170	230	350

PACKAGING
All sizes are packaged in 50 lb. cartons.

USA CUTROD

APPLICATIONS
USA Cutrod is a fast-working electrode used for cutting and piercing all metals including austenitic steels and cast iron. This electrode is frequently used for removing rivets and bolts, enlarging openings, trimming metals, etc.

PROCEDURES AND CHARACTERISTICS
USA Cutrod may be used with AC or DC (straight polarity) on most welding machines. Using the recommended amperage, hold the electrode at a 45° angle, strike the arc and use a “sawing” technique to cut through the base metal. Be sure to keep the arc gap as short as possible. To pierce holes, simply hold the electrode vertical, strike the arc and push through the base metal, removing the electrode immediately once the hole is made. The size of the hole may be increased by moving the electrode in a circular motion. USA Cutrod does not require gases or special equipment such as air compressors.

RECOMMENDED AMPERAGE (AC OR DC-)

Size	3/32	1/8	5/32	3/16
Amp.	120	170	230	300

PACKAGING
All sizes are packaged in 50 lb. cartons.

ALU-ZINC

DESCRIPTION AND APPLICATIONS
For repair of zinc-based metals, pot metal, white metals and aluminum.

Washington Alloy Alu-Zinc is a self-fluxing, low temperature joining alloy that can be used with oxy-acetylene or the TIG process, using argon as the shielding gas and AC (high frequency). It is excellent to use for new fabrication, maintenance or repair work. Flux is not necessary on accessible joints.

Common uses include: aluminum windows, doors, furniture, boats, engine heads, motor housings, power mowers, farm and dairy equipment, blocks and crankcases, vacuum cleaners, carburetors, gears and pumps, jigs and fixtures, dies and matchplates, trophies and ornaments, models and patterns, antique car parts and Kirksite dies.

PROCEDURES
Remove all dirt, plating, scale or oxides from the metal surface. Preheat to 400°F+/-. Then turn the torch at an angle, using the side of the flame to continue the heat build-up, making sure that both sides of the joint are the same temperature. Begin to touch the rod to the joint area. Continue the heat build-up until the rod begins to flow, which should be around 730°-740°F. As the rod flows into the joint, make sure to use the rod end to break up any surface skin that will most likely develop. Use a circular motion or a dipping motion to firmly rub the rod into the joint. Failing to do so may prevent the fusion of the base metal and the filler metal. After the joint is repaired, allow the part to cool at room temperature. Do now quench.

Clean up: After the repair has cooled, use a stainless steel brush or warm water to remove any surface residue. The clean, dry joint can now be plated or painted to match the original finish.

SPECIFICATIONS
Elastic Limit.....33,000 psi
Tensile Strength.....39,000 psi
Brinnel-500 kg load.....100
Melting range.....715 -735 F

PACKAGING
Available sizes: 1/8×18 — 5 lb. tubes.

USA FLUXCORED ALUMINUM
Tubular Torch Alloy

APPLICATIONS
An all-position, oxyacetylene welding or brazing rod used in repairing broken or cracked aluminum extrusions or castings. Typical applications would include building-up machinable deposits or worn or broken parts, model work, mold/die changes and thin sheet metal.

CHARACTERISTICS
Fluxcored aluminum is one of the most versatile torch rods. The self-contained flux offers protection from handling and moisture. A broad operating temperature range and excellent color match makes this alloy suitable for many applications. It offers good plasticity, high strength and is readily machinable.

PROCEDURES
Remove any plating, dirt, grease or surface corrosion from the area to be welded or brazed. Sand and clean the weld area thoroughly. The gap to be welded should not exceed 1/8”. Bevel heavy sections to form a 60° to 75° V-notch Using a slightly carburizing flame, heat the work area by keeping the flame 1” to 2” from the weld area. Continue to heat the weld area while occasionally touching the fluxcored aluminum rod to this area under the tourch flame. Do this until small amounts of alloy are deposited and the filler metal starts to flow through the gap of the heated weld area. Be sure that each drop of filler metal flows out and bonds to the base metal, but do not melt the base metal. Allow the weld part to cool and wash away the flux residue with warm water and a stiff brush.

SPECIFICATIONS
Liquidus.....1100ºF
Tensile Strength.....32,000 spi
Color Match.....Good
(Not to be anodized)

PACKAGING
Available sizes: 3/32 ×32, 1/8 × 32, 3/16 × 32; — 2lb. tubes/10 lb. master cartons or 1 lb. mini-packs.

Special Purpose Electrodes

RAINIER 1G AND 1G FC
Torch/Neutral Flame

DESCRIPTION
A general purpose rod for brazing cast iron, steel, copper, brass, bronze and galvanized iron.

APPLICATIONS
Rainier 1G and 1G FC is designed for torch brazing of ferrous and non-ferrous metals such as cast iron, copper alloys and steel to themselves or each other. Galvanized parts can be brazed with no damage to the zinc coating. Excellent for yellow brass and bronze castings. Recommended for “rush jobs” or temporary applications involving dissimilar metals or where rust is present.

FEATURES
The chemical analysis of Rainier 1G and 1G FC is formulated to produce sound, porosity free deposits with a minimum of fuming. Deposits are strong, easily machined and work hardened with use.

SPECIFICATIONS
Tensile strength (psi).....Up to 72,000
Elongation(%).....Up to 26
Brinell hardness.....120
Working temperature.....1450ºF to 1650ºF
Color match.....Good on brass/bronze
Machinability.....Excellent

AVAILABLE SIZES

(in.)	1/ 16	3/32	1/8	5/32	3/16	1/4
(mm)	1.6	2.4	3.2	4.0	4.8	6.0

PACKAGING
1 lb. packs, 5 lb. packs, 10 lb. tubes.

PROCEDURES
Clean joint area. Bevel crack or heavy sections. Utilizing a slightly oxidizing flame, preheat the part to be brazed. Dip Rainier 1G into bronze brazing flux and then back to the joint area. Apply the torch, keeping it in constant motion so as to not overheat the base metal. The molten drops of Rainier 1F (and flux) will follow the heat of the torch flame. Keep adding Rainier 1G (and flux), one molten drop at a time until the joint is filled. When using Rainier 1G FC, additional flux is not required. Removal of flux residue between passes is not necessary. Allow the joint to cool slowly and remove slag with a chipping hammer and wire brush

RAINIER 2G AND 2G FC
Torch/Neutral Flame

DESCRIPTION
High strength — thin flowing brazing rod for all ferrous and non-ferrous metals.

APPLICATIONS
Rainier 2G and 2G FC is used to produce high strength (up to 100,000 psi), wear-resistant deposits on close-fitted joints such as found in sheet metal work. Excellent for repairing small parts as in broken drill bits, attaching carbide tips, repairing mill cutters or radiators. Rainier 2G and 2G FC is commonly used as a replacement alloy for more expensive silver brazing alloys. Other uses include bicycle repairs, furniture, ornamental railings and for joining galvanized and stainless steel parts.

FEATURES
Rainier 2G and 2G FC is an excellent choice for quick inexpensive repair jobs where high strength and crack-resistant joints are needed. Rainier 2G and 2G FC wets out very smooth under relatively low brazing temperatures and solidifies rapidly when the torch is turned away. Deposits are easily machined and work hardened when used. Rainier 2G and 2G FC is also used to build up surfaces.

SPECIFICATIONS
Tensile strength (psi).....Up to 100,000
Elongation(%).....Up to 28
HB hardness.....Up to 220
Working temperature.....1300ºF to 1750ºF
Remelt temperature.....1750ºF (minimum)
Machinability.....Excellent

AVAILABLE SIZES

(in.)	1/ 16	3/32	1/8	5/32	3/16	1/4
(mm)	1.6	2.4	3.2	4.0	4.8	6.0

PACKAGING
1 lb. packs, 5 lb. packs, 10 lb. tubes.

PROCEDURES
Clean joint area. Bevel heavy sections. Thin joints may be brazed without preparation other than usual cleaning. Since Rainier 2G or 2G FC is a thin flowing alloy — a joint clearance of .001” to .003” will maximize the deposit strength. Cover the joint area with No. 2 Flux. Utilizing a slightly oxidizing (neutral) flame, preheat the part to be brazed until the flux is liquefied. Hold Rainier 2G to ht flame cone, adding enough alloy to fill the joint. If the base metal turns red, remove the torch and allow it to cool before proceeding. No. 2 Flux is not required if using Rainier 2G FC. Remove slag with a chipping hammer and wire brush.

COLUMBIA 7G
Meets AWS A5.8 Class BCuP-2
Torch/Neutral Flame, Propane

DESCRIPTION
Self-fluxing, copper to copper brazing rod.

APPLICATION
Columbia 7G is a fast and easy to use phosphorus-copper brazing rod designed for close fitting joints of only .001” to .0015” wide in copper, brass or bronze parts. Excellent for tube and pipe joints in plumbing, air conditioning and refrigeration applications. Also used in the repair of stranded or solid electrical conductors. Columbia 7G is not intended for use on steel or alloys containing more than 30% nickel.

FEATURES
Columbia 7G contains just the proper balance of phosphorus and copper which act as self-fluxing agents and provide for excellent capillary action in tight fitting joints. No special preparation to use, no clean-up problems later. Economy-speed-strength-ductility are the features that make Columbia 7G one of the most widely used brazing alloys.

GENERAL CHEMISTRY

P	7.25
Cu	Balance

SPECIFICATIONS
Tensile strength (psi).....Up to 40,000
Elongation in 2” (%).....19
Melting range.....Solidus 1310 F
Flow Point 1350 F
Liquidus:1460 F

AVAILABLE SIZES

(in.)	.050×1/8	1/16	3/32	1/8
(mm)	1.4×3.2	1.6	2.4	3.2

PACKAGING
1 lb. packs, 5 lb. packs, 10 lb. tubes.

PROCEDURES
Clean the joint area. The joint clearance should not exceed .0015”. Flux in not necessary in copper to copper joint, however flux should be used on brass or bronze. Utilizing a neutral (slightly oxidizing) flame and a large torch tip, preheat the joint area to a dull red color. Apply Columbia 7G by melting off a drop at a time. Remove the torch as soon as the joint is filed. Do not remelt the deposit Clean the deposit with hot water and a stiff brush. A bright copper color can be obtained by dipping the part in a solution of 10% sulfuric acid/90% water. Rinse in hot water.

Special Purpose Electrodes

COLUMBIA 8G
Meets AWS A5.8 Class BCuP-3
Torch/Neutral Flame, Propane

DESCRIPTION
Economical phos-copper-silver brazing alloy.

APPLICATIONS
Columbia 8G is designed for moderately fitted joints of .002”-.003” clearance in copper to copper and copper to brass or bronze. Common applications involve tubing or pipes of copper radiators, air conditioners, refrigerators, plumbing, marine and electrical components. Not to be used on ferrous metals.

FEATURES
Columbia 8G is an economical alternative to 15% silver alloys. The 5% silver content of Columbia 8G allows for a lower brazing temperature and higher ductility. High corrosion and heat resistance. Excellent electrical conductivity. Deposits may be tinned or electroplated by dipping.

GENERAL CHEMISTRY

Ag	5
P	6
Cu	Balance

SPECIFICATIONS
Tensile strength (psi).....Up to 45,000
Elongation in 2” %).....23-25
Melting range.....Solidus 1190^0 F
Flow Point 1350^0 F
Liquidus: 1495^0 F

AVAILABLE SIZES

(in.)	.050×1/8	1/16	3/32	1/8
(mm)	1.4×3.2	1.6	2.4	3.2

PACKAGING:
1 lb. packs, 5 lb. packs, 10 lb. tubes.

PROCEDURES
Clean the joint area. The joint clearance should not exceed .003”. Flux is not necessary in copper to copper joints, however flux should be used on brass or bronze and heavy sections. Utilizing a neutral (slightly oxidizing) flame and a large torch tip, preheat the joint area to a dull red color. Apply Columbia 8G by melting off a drop at a time. Remove the torch as soon as the joint is filled. Do not remelt the deposit. Clean the deposit with hot water and a stiff brush. A bright copper color can be obtained by dipping the part in a solution of 10% sulfuric acid - 90% water. Rinse in hot water.

COLUMBIA 9G
Torch/Neutral Flame, Propane

DESCRIPTION
Phos-copper-silver alloy for poor fit-ups.

APPLICATIONS
Columbia 9G is very similar to Columbia 8G, however it does contain more silver (6%). The increased silver content allows for a slightly lower operating temperature and makes Columbia 9G more suitable for varying or “greater than recommended” clearances of .002”-.003”. Most commonly used in copper to copper and copper to brass or bronze tubing or pipes such as found in radiators, air conditioners, refrigerators, plumbing, marine and electrical components. Not to be used on ferrous metals.

FEATURES
Columbia 9G is basically a more versatile alloy than Columbia 8G. Subsequently Columbia 9G would be the better choice of filler metal. Extremely ductile with high thermal and electrical conductivity. Corrosion resistant. Deposits may be tinned or electroplated by hot dipping.

GENERAL CHEMISTRY

Ag	6
P	6
Cu	Balance

SPECIFICATIONS
Tensile strength (psi).....Up to 45,000
Elongation in 2” (%).....23-25
Melting range.....Solidus 1190 F

AVAILABLE SIZES

(in.)	.050×1/8	1/16	3/32	1/8
(mm)	1.4×3.2	1.6	2.4	3.2

PACKAGING:
1 lb. packs, 5 lb. packs, 10 lb. tubes.

PROCEDURES
Clean the joint area. The joint clearance should not exceed .003”. Flux is not necessary in copper to copper joint, however flux should be used on brass or bronze and heavy sections. Utilizing a neutral (slightly oxidizing) flame and a large touch tip, preheat the joint area to a dull red color. Apply Columbia 9G by milting of a drop at a time. Remove the torch as soon as the joint is filled. Do not remelt the deposit. Clean the deposit with hot water and a stiff brush. A bright copper color can be obtained by dipping the part in a solution of 10% sulfuric acid – 90% water/ Rinse in hot water.

COLUMBIA 10G
Meets AWS A5.8 Class BCuP-6
Torch/Neutral Flame, Propane

DESCRIPTION
All purpose – 15% silver brazing alloy.

APPLICATIONS
Columbia 10G is the most popular and versatile of the phosphorus-copper-silver brazing alloys. In addition to joining copper to copper and copper to brass or bronze, Columbia 10G may also be used to braze silver, tungsten and molybdenum. This alloy is most commonly used in the commercial and domestic plumbing industry where some municipalities require a 15% silver alloy. Other uses include radiators, air conditioners, refrigerators, marine and electrical components. Not recommended for use on steel or alloys containing more than 10% Nickel.

FEATURES
Columbia 10G is excellent on joints with a clearance of .001”-.005”. The higher silver content and lower phosphorus content give Columbia 10G higher ductility and a lower working temperature range. Good vibration and shock resistance. Medium to high tensile strength.

GENERAL CHEMISTRY

Ag	15
P	5
Cu	80

SPECIFICATIONS
Melting range.....Solidus 1190^0 F
Flow Point 1300^0 F
Liquidus: 1475^0 F

AVAILABLE SIZES

(in.)	.050×1/8	1/16	3/32	1/8
(mm)	1.4×3.2	1.6	2.4	3.2

PACKAGING:
1 lb. packs, 5 lb. packs, 10 lb. tubes.

PROCEDURES
Clean the joint area. The joint clearance should not exceed .006”. Flux is not necessary in copper to copper joints, however flux should be used on brass or bronze as well as tungsten and molybdenum applications. Flux should also be used on heavy sections. Utilizing a neutral (slightly oxidizing) flame and a large torch tip, preheat the joint area to a dull red color. Apply Columbia 10G by melting off a drop at a time. Remove the torch as soon as the joint is filled, do not remelt the deposit. Clean the deposit with hot water and a stiff brush. A bright copper color can be obtained by “hot-dipping” the part in a solution of 10% sulfuric acid - 90% water. Rinse in hot water.

Special Purpose Electrodes

COLUMBIA 11G & 11G FC
Torch/Neutral Flame, Propane

DESCRIPTION
High strength silver brazing alloy for ferrous and nonferrous metals.

APPLICATIONS
Columbia 11G is a 35% cadmium free silver alloy designed for general purpose brazing of ferrous and nonferrous metals such as carbon steels, stainless steels, nickel, Monel®, nickel silver, copper, brass and bronze. Commonly used on machine shop small fixtures, instruments and delicate parts. Recommended for electrical, air conditioning, heating and ventilating work.

FEATURES
Columbia 11G has a wide operating range between melting and flow points. This feature creates a sluggish flow. Making Columbia 11G suitable for loose fit-ups and large fillets. Columbia 11G offers high strength and ductility. Excellent on small parts and dissimilar metal combinations. Contains no cadmium. More economical than Columbia 12G.

GENERAL CHEMISTRY

Ag	35
Zn	33
Cu	Balance

SPECIFICATIONS
Tensile strength (psi).....65,000
Melting range.....Solidus 1125^0 F
Liquidus: 1195^0 F
Color (as brazed).....Brassy, yellow brass

AVAILABLE SIZES

(in.)	1/32	3/64	1/16	3/32	1/8
(mm)	0. 8	1.2	1.6	2.4	3.2

PACKAGING:
Coils — all diameters. 18” lengths — 1/16, 3/32, 1/8.

PROCEDURES
Clean the joint area. For maximum strength deposits maintain a joint clearance of not more than .005”. Clamp the parts to maintain alignment. Cover the area thoroughly with silver brazing flux (additional flux is not required when using Columbia 11G FC). Utilizing a neutral (slightly oxidizing) flame, preheat the part broadly until the flux liquifies. Apply Columbia 11G by melting off a drop at a time. Remove the torch as soon as the joint is filled. Do not remelt the deposit. Allow the part to cool slowly then clean the deposit with warm water.

COLUMBIA 12G & 12G FC
Meets AWS A5.8 Class Bag-5
Torch/Carburizing Flame, Propane

DESCRIPTION
Thin flowing silver alloy for ferrous, nonferrous and dissimilar metals.

APPLICATIONS
Columbia 12G is a 45% cadmium free silver alloy used for general purpose brazing of iron, steel, nickel, stainless steel, alloy steel, copper, brass, bronze, dissimilar alloys, silver, etc. Columbia 12G is excellent for tight fitting joints and delicate parts where a thin flowing capillary action is required. Performs well on lap joints, “T” joint, flange joints and butt joints. Ideal on light gauge metal. Not to be used on aluminum, magnesium or zinc die cast.

FEATURES
Columbia 12G offers excellent fluidity and super capillary action on highly alloyed metals. All joints will have superior strength, ductility and nice appearance. Columbia 12G has the lowest working temperature of the silver brazing alloys.

GENERAL CHEMISTRY

Ag	45
Cu	30
Zn	25

SPECIFICATIONS
Tensile strength (psi).....Up to 60,000
Melting range.....Solidus 1225^0 F
Liquidus: 1370^0 F
Color (as brazed).....Yellow white

AVAILABLE SIZES

(in.)	1/32	3/64	1/16	3/32	1/8
(mm)	0.8	1.2	1.6	2.4	3.2

PACKAGING:
Coils — all diameters. 18” length in 1/16, 3/32, 1/8.

PROCEDURES
Clean the joint area. Maximum strength deposits can be obtained by keeping the joint clearance less than .003” wide. Clamp the parts to maintain alignment. Cover the area thoroughly with silver brazing flux Columbia 12G FC). Utilizing a slightly carburizing flame, preheat the part broadly until the flux liquefies. Apply Columbia 12G by melting off a drop at a time. Remove the torch as soon as the joint is filled. Do not remelt the deposit. Allow the part to cool slowly then clean the deposit with warm water.

COLUMBIA 13G & 13G FC
Meets AWS A5.8 Class BAg-7
Torch/Carburizing Flame, Propane

DESCRIPTION
Premium silver brazing rod for delicate steel parts.

APPLICATIONS
Columbia 13G is a cadmium free 56% silver brazing alloy developed primarily for use in the food and dairy industry. Columbia 13G provides high strength joints in ferrous and nonferrous metals such as carbon steels, copper alloys, nickel alloys, stainless steel and high speed steels (where higher brazing temperatures could be damaging to the base metal). Commonly used in tubing instruments and control devices of laboratory apparatus. Do not use on aluminum, magnesium and zinc die cast alloys.

FEATURES
Columbia 13G is a low melting, thin flowing and non-toxic alloy. Deposits will be a close color match on stainless steel. Columbia 13G will minimize stress corrosion on nickel or nickel base alloys at low brazing temperatures. Joints will have the maximum strengths offered by any of the silver brazing alloys. Resists pitting.

GENERAL CHEMISTRY

Ag	56
Cu	22
Zn	17
Sn	5

SPECIFICATIONS
Tensile strength (psi).....Up to 65,000
Melting range.....Solidus 1145^0 F
Liquidus: 1205^0 F
Electrical conductivity.....Good
Color (as brazed).....White

AVAILABLE SIZES

(in.)	1/32	3/64	1/16	3/32	1/8
(mm)	0.8	1.2	1.6	2.4	3.2

PACKAGING:
Coils — all diameters. 18” lengths in 1/16, 3/32, 1/8

PROCEDURES
Clean the joint area. Maximum strength deposits can be obtained by keeping the joint clearance less than .003” wide. Clamp the parts to maintain alignment. Cover the area thoroughly with silver brazing flux (additional flux is not required when using Columbia 13G FC). Utilizing a slightly carburizing flame, preheat the part broadly until the flux liquefies. Apply Columbia 13G by melting off a drop at a time. Remove the torch as soon as the joint is filled. Do not remelt the deposit. Allow the part to cool slowly. Clean the deposit with warm water.

Special Purpose Electrodes

COLUMBIA 14G
Torch, Propane, Soldering Iron Furnace

DESCRIPTION
Acid core, cadmium free-lead free general purpose silver bearing solder.

APPLICATIONS
Columbia 14G is a low temperature silver bearing solder used for joining stainless steel, Monel®, cast iron, nickel, copper, brass and bronze. Columbia 14G is ideal for stainless steel food handling equipment where a good color match and conformance to FDA requirements is necessary. Ideal for electrical work and instrument assembly where higher conductivity (than that offered by lead-tin solders) is required. Common applications include stainless steel tanks, sinks, pipes, tubing and jewelry. Not to be used on aluminum, magnesium or zinc die cast alloys.

FEATURES
Columbia 14G contains no lead, cadmium, zinc or antimony. Deposits are bright and shiny — will not discolor or tarnish. Columbia 14G offers higher tensile strength than lead-tin solders. Deposits are corrosion resistant and can be chrome plated.

SPECIFICATIONS
Tensile strength (psi).....Up to 15,000
Working temperature.....430ºF
Color match.....Good on stainless steel
Corrosion resistance.....Good
Electrical conductility.....Excellent

AVAILABLE SIZES

(in.)	3/64	1/16	3/32	1/8
(mm)	1.2	1.6	2.4	3.2

PACKAGING:
1 lb., 5lb., 20 lb. spools.

PROCEDURES
Clean the joint area. Although Columbia 14G is self-fluxing, the use of additional flux will improve flowing. Heat indirectly with just about any heating method. Keep the torch (or other heating source) in constant motion and back from the workpiece. Melt off the solder and draw through the joint with continued heating. Remove the heating source as soon as the joint is filled and a bright shiny deposit is visible. Allow the part to coop slowly and remove the flux residue with warm water.
Note: use a soft carburizing flame if torch brazing and be sure there is no contamination from other solders if using a soldering iron.

CASCADE 15A
Arc AC/DC+ (Reverse Polarity)
All-Positions

DESCRIPTION
High strength, non-nickel cast iron electrode.

APPLICATIONS
Cascade 15A is the most economical electrode for repairing cast iron parts where machinability of the weld deposit is not required. Commonly used on ornamental iron, gears, motor housings, machine parts, farm equipment and large frames. Excellent for castings impregnated with oil, grease, chemicals and other contaminants.

FEATURES
Cascade 15A performs well in any position. Weld deposits are non-porous and have a tensile strength of approximately 65,000 psi. The weld deposit color will be grey cast iron. Cascade 15A deposits are non-machinable.

SPECIFICATIONS
Tensile strength (psi).....65,000
Yield Strength (psi).....50,000
Brinell hardness.....300
Deposit.....Magnetic
Color match.....Grey cast iron

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32	3/16
(mm)	2.4	3.2	4.0	4.8
Amps	60-90	90-130	120-160	150-200

PROCEDURES
If possible, clean the joint area. Bevel or gouge out heavy sections. Preheating is not required, however it is useful in relieving stress within the weld deposit in parts greater than ½" thick. Using AC or DC+ (reverse polarity), hold the electrode 15 off vertical tilted toward the direction of travel The arc length should be between 1/8" to 3/16". Use stringer beads or the weaving technique. Holding the arc over the molten deposited metal, follow the pool but do not allow the arc to lead or get ahead of the molten pool. If the part is less than ¼" thick use a 1" bead, ¼: to ½" use a 2" bead, over ½" use a 3" to 4" bead. Extinguish the electrode by whipping the arc back over the deposited mental. Peen the weld deposit with a blunt instrument to relieve stress and prevent the spread of cracks on the part. Re-strike the arc on the previously deposited weld metal. On thin or complex shaped parts use the skip weld technique. Always use an electrode diameter that is small enough to permit at least two passes.

Note: If there is cracking of the part, make stopholes at both ends of the joint. Do not let the part become too hot during welding. Remove slag often. Gradual cooling of the weld metal is strongly recommended.

CASECADE 17A
Arc AC/DC- (Straight Polarity)
All-Position

DESCRIPTION
Fully-machinable cast iron electrode for repair welding of thin sections.

APPLICATIONS
Cascade 17A is a high nickel electrode used for cladding, buildup and joining all grades of cast iron to itself or dissimilar metals such as low alloy and carbon steels, stainless steels, iron, copper, Monel®, etc. Excellent for repairing and "cold welding" cracked or porous thin sections where maximum machinability of the weld deposit is required. Common uses include engine blocks, machinery parts, frames, gears and pulleys.

FEATURES
Cascade 17A is an all-position electrode which produces porosity-free, non-cracking weld deposits that will match the color of cast iron. When properly used, the arc will penetrate through dirt and oil as well as over slag.

SPECIFICATIONS
Tensile strength (psi).....Up to 50,000
Yield strength (psi).....Up to 40,000
Brinell hardness.....Approximately 160
Elongation (%).....Approximately 30
Color match.....Excellent on cast iron

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32	3/16
(mm)	2.4	3.2	4.0	4.8
Amps	40-80	80-120	100-140	120-170

PROCEDURES
Clean the work area. Preheating is not required, however it is useful in relieving stresses and to increase machinability of the weld deposit in parts greater than 1/2" thick. 200°F is an acceptable preheat temperature. Using AC or DC- (straight polarity), hold the electrode 15° off vertical tilted toward the direction of travel. The arc length should be between 1/8" to 3/16". Use stringer beads or the weaving technique. Holding the arc over the molten deposited metal, follow the pool but do not allow the arc to lead or get ahead of the molten pool. If the part is less than 1/4" thick use a 1" bead, 1/4" to 1/2" use a 2" bead, over 1/2" use a 3" to 4" bead. Extinguish the electrode by whipping the arc back over the deposited metal. Peen the weld deposit with a blunt instrument to relieve stress and prevent the spread of cracks on the part. Re-strike the arc on the previously deposited weld metal. On thin or complex shaped parts use the skip weld technique. Always use an electrode diameter that is small enough to permit at least two passes.

Note: If there is cracking of the part, make stopholes at both ends of the joint. Do not let the part become too hot during welding. Remove slag often. Gradual cooling of the weld metal is strongly recommended.

Special Purpose Electrodes

CASCADE 17T & 17M
Meets AWS A5.15 Class ERNi-CI
TIG/MIG

DESCRIPTION
High nickel alloy bare wire for TIG or MIG cast iron welding.

APPLICATIONS
Cascade 17T and 17M are the TIG (17T) or MIG (17M) equivalents to Cascade 17A. Developed primarily tor automatic and semi-automatic welding of ductile, malleable or gray cast iron to itself or to dissimilar metals such as low alloy and carbon steel, stainless steel, iron, copper, Monel®, etc. Cascade 17T and 17M are excellent for the buildup of worn parts, repairing machining errors or defective castings where maximum machinability of the deposit is required.

FEATURES
Cascade 17T and 17M can be used in any position. Produces high quality welds with a minimal amount of effort. Weld deposits are strong, dense and fully machinable. Color will match that of cast iron.

SPECIFICATIONS
Tensile strength (psi).....Up to 70,000
Yield strength (psi).....Up to 46,000
Brinell hardness.....150
Elongation (%).....Approximately 12
Reduction of area(%).....Approximately 20

AVAILABLE SIZES

(in.)	.035	.045	1/16	3/32	1/8
(mm)	0.9	1.2	1.6	2.4	3.2

PACKAGING:
10 lb. and 30 lb. spools — .035, .045
1/16. 36" straight lengths — .035, .045, 1/16, 3/32, 1/8.

PROCEDURES
Clean the joint area. Bevel heavy sections. Preheating is not required, however it is useful in relieving stresses and to increase machinability of the weld deposit in parts greater than 1/2" thick. 600°F is an acceptable preheat temperature. Use DC- (straight polarity) with the oscillating technique and DC+ (reverse polarity) with the stringer bead technique. The oscillating technique will produce the lowest weld metal dilution. When using the stringer bead technique, be sure to strike the arc on the edge of previously deposited weld metal. This will reduce dilution. Be sure to use flux. Do not let the part become too hot during welding. Remove slag often. Gradual cooling of the weld metal is recommended.

CASCADE 18A
Arc AC/DC+ (Reverse Polarity)
All-Position

DESCRIPTION
Premium cast iron electrode for heavy sections.

APPLICATIONS
Cascade 18A is for general maintenance welding of cast iron, malleable iron and ductile iron to themselves or dissimilar metals such as wrought alloys or high nickel alloys. Commonly used on motor blocks, gear housings, machine parts and frames. Excellent for filling holes and building up missing or worn heavy sections. Cascade 18A is recommended for "meehanite" and "Ni-Resist" alloys.

FEATURES
Cascade 18A is an all-position electrode that produces machinable, high density and crack-resistant weld deposits. Especially suited for welding dirty, oil-soaked castings of unknown composition.

SPECIFICATIONS
Tensile strength (psi).....Up to 80,000
Yield Strength (psi).....Up to 60,000
Brinell hardness.....Approximately 200
Elongation in 2" (%).....Approximately 20
Color match.....Good

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32	3/16
(mm)	2.4	3.2	4.0	4.8
Amps	40-70	80-110	100-140	120-170

PROCEDURES
Clean the work area. Preheating is not required, however it is useful in relieving stresses and to increase machinability of the weld deposit in parts greater than ½" thick, 200^0 F is an acceptable preheat temperature. Using AC or DC- (straight polarity), hold the electrode 15 off vertical tilted toward the direction of travel. The arc length should be between 1/8" to 3/16" Use stringer beads or the weaving technique. Holding the arc over the molten deposited metal. Peen the weld deposit with a blunt instrument to relieve stress and prevent the spread of cracks on the part. Re-strike the arc on the previously deposited weld metal. On thin complex shaped parts use the skip weld technique. Always use an electrode diameter that is small enough to permit at least two passes.

Note: If there is cracking of the part, make stopholes at both ends of the joint. Do not let the part become too hot during welding. Remove slag often. Gradual cooling of the weld metal is strongly recommended.

CASECADE 17 ANC
Arc AC/DC- (Straight Polarity)
All-Position

DESCRIPTION
Non-conductive coating cast iron electrode

APPLICATIONS
Cascade 17 ANC is similar to Cascade 17A, however a special non-conductive coating eliminates the problem of accidental side arcing when welding through limited access holes or in confined areas. Commonly used for cladding, build-up and joining all grades of cat iron to itself or dissimilar metals such as low alloy and carbon steels, stainless steels, iron, copper, monel®, etc. Excellent for producing fully machinable weld deposits on engine blocks, pump housings, end bells and other "hard-to-reach" worn or broken parts.

FEATURES
The non-conductive coating of Cascade 17 ANC makes this electrode the primary choice for repairing castings that are in deep holes or out-of-position. Cascade 17 ANC produces porosity-free, non-cracking weld deposits that will match the color of cast iron. When properly used the soft, stale arc will penetrate through dirt and oil. Excellent on cracked or porous thin sections.

SPECIFICATIONS
Tensile strength (psi).....Up to 65,000
Elongation (%).....Approximately 30
Brinell hardness.....Approximately 175
Color match.....Excellent on cast iron

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32
(mm)	2.4	3.2	4.0
Amps	35-75	50-120	75-140

PROCEDURES
Clean the work area. Preheating is nor required, however it is useful in relieving stresses and to increase machinability of the weld deposit in parts greater than ½" thick. 200 F is an acceptable preheat temperature. Using AC or DC- (straight polarity), hold the electrode 15 off vertical tilted toward the direction of travel. The arc length should be between 1/8" to 3/16". Use stringer beads or the weaving technique. Holding the arc over the molten deposited metal, follow the pool but do not allow the arc to lead or get ahead of the molten pool. If the part is less than ¼" thick use a 1" bead, ¼" to ½" use a 2" bead, over ½" use a 3" to 4" bead. Extinguish the electrode by whipping the arc back over the deposited metal. Peen the weld deposit with a blunt instrument to relieve stress and prevent the spread of cracks on the part. Re-strike the arc on the previously deposited weld metal. On thin or complex shaped parts use the skip weld technique. Always use an electrode diameter that is small enough to permit at least two passes.

See note on previous column.

Special Purpose Electrodes

SUPER 100
Arc AC/DC± (Straight or Reverse Polarity)
All-Position

DESCRIPTION
General purpose — deep penetrating mild steel electrode for low carbon steel.

APPLICATIONS
Super 100 is a thinly-coated mild steel electrode designed for deep penetrating, pass-over-pass welding without excessive slag interference. Excellent over rust, oil, dirt, grease and cement or where poor groove fit-ups are a problem. Super 100 is most commonly used on pipes, storage tanks, automobile and truck frames, bridges, building structures, shipbuilding, galvanized steel, farm implements and many other mild steel uses.

FEATURES
The special coating of Super 100 was designed for low amperage settings on AC machines, however it will produce high strength, non-porous welds with either AC or DC (straight or reverse polarity). The strong arc force and “fast-freeze” weld deposit make Super 100 excellent for vertical-up or down and overhead pipe welding. Super 100 has good arc stability even at higher amperage settings when greater deposition efficiency is desired. Slag-removal is easy.

SPECIFICATIONS
Tensile strength (psi).....Up to 78,000
Yield strength (psi).....Up to 64,000
Elongation in 2” (%).....Approximately 25

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32	3/16
(mm)	2.4	3.2	4.0	4.8
Amps	35-80	60-110	90-145	120-180

PROCEDURES
Clean joints always provide the best welding conditions. AC or DC (reverse polarity for deep penetration, straight polarity for a more shallow penetration and flatter bead). An arc length or approximately 1/8” should be maintained ahead of the weld puddle. Flat and horizontal welding should be done by holding the electrode at a slight angle in the direction of travel and using a slight back and forth whipping motion.

Overhead welding should be done in a manner similar to flat and horizontal but a slight circular motion should be used in the molten metal.

Vertical-down welding should be performed using stringer beads or a slight weave. The weld puddle will be kept in place by pointing the electrode arc upward into the puddle.

Vertical-up welding should be done by using the shelf or step method where welding is done by adding layer on top of layer. Do not use the whipping motion, but move the electrode slowly while pointing the arc force upward.

SPEEDWELD 300
Arc AC/DC ± (Straight or Reverse Polarity)
All-Position

DESCRIPTION
High speed-high deposition mild steel electrode for carbon steel.

APPLICATIONS
Speedweld 300 is designed for high-speed, high deposition welding of mild and low carbon steel where strength, appearance and weld integrity is critical. Excellent for dissimilar gauges and poor fit-ups in sheets, plates, beams, angles and channels. Commonly used on ornamental iron, railing, furniture, automobile bodies, storage tanks, machine parts, sheet metal and structural steel for building.

FEATURES
The unique coating of Speedweld 300 gives a spatter-free, quiet arc that will produce x-ray quality weld deposits. Speedweld 300 is a favorite among fabricators of ornamental iron railings and furniture because of the smooth bead contour which usually requires painting. Operating at relatively low amperage makes Speedweld 300 suitable for thin sheet metal applications where heat distortion must be kept to minimum. Speedweld 300 can be used on either AC or DC machines.

SPECIFICATIONS
Tensile strength (psi).....Up to 76,000
Yield Strength (psi).....Up to 65,000
Elongation in 2” (%).....Approximately 25
Penetration.....Medium

AVAILABLE SIZES AND AMPERAGE

(in.)	1/16	5/64	3/32	1/8	5/32	3/16
(mm)	1.6	2.0	2.4	3.2	4.0	4.8
Amps	20-50	25-80	40-100	60-140	110-210	120-240

PROCEDURES
Clean joints always provide the best welding conditions. AC or DC (straight or reverse polarity) may be used. DC reverse polarity will produce the deepest penetration. DC straight polarity deposits will be similar to those produced by AC current. An arc length of 1/8” should be maintained ahead of the weld puddle. Flat and horizontal welding should be done by holding the electrode at an angle 20 -45 from perpendicular in the direction of travel and using a slight back and froth whipping motion.

For vertical-down welding use higher current settings with stringer beads or a slight weave technique. The weld puddle will be kept in place by pointing the electrode arc upward into the puddle.

Vertical-up welding should be done using lower current settings and the shelf or step method where welding is done by adding layer on top of layer. Do not use the whipping motion, but move the electrode slowly while pointing the arc force upward.

Overhead welding should also be done using lower current settings and in a manner similar to flat and horizontal but with a slight circular motion in the molten metal.

Special Purpose Electrodes

SUPER 500
Arc AC/DC± (Straight or Reverse Polarity)
All-Position

DESCRIPTION
High performance mild steel electrode for mild, low alloy and medium carbon steel.

APPLICATIONS
Super 500 is the easiest-to-use, all-position electrode designed to operate at lower amperage and with lower open-circuit AC voltage (DC straight or reverse polarity may be also use). Super 500 is excellent for painted or galvanized surfaces and light sheet metal work. Ideal for joining dissimilar gauges or where poor fit-up is a problem. Commonly used to fill holes and build-up over-machined or worn parts. More common uses include sheets, plates, angle iron, beams, pipes and machine parts. Excellent for repairing auto-mobile or truck bodies and farm implements.

FEATURES
Super 500 has a wide operating range. Low amperage settings with the smaller diameter electrodes eliminate warpage and distortion when welding thin sections. Higher amperage settings with the larger diameter electrodes allow for medium penetration and welding over rust, oil and grease. Super 500 has great re-strike capability which makes it excellent for short spot welds. A soft steady arc and good wetting action allows for a smoother bead appearance with fine ripples making Super 500 truly superior maintenance and repair electrode.

SPECIFICATIONS
Tensile strength (psi).....Up to 83,000
Yield strength (psi).....Up to 67,000
Elongation in 2" (%).....Approximately 24

AVAILABLE SIZES AND AMPERAGE

(in.)	1/16	5/64	3/32	1/8	5/32	3/16
(mm)	1.6	2.0	2.4	3.2	4.0	4.8
Amps	20-25	25-60	35-80	65-125	90-160	120-210

PROCEDURES
Clean joint always provide the best welding conditions. AC is best for preventing arc blow. DC+ (reverse polarity) produces deep penetration; DC- (straight polarity) should be used on thinner gauges. An arc length of approximately 1/8" should be maintained ahead of the weld puddle. Flat and horizontal welding should be done by holding the electrode at a slight angle in the direction of travel and using a gentle back and forth whipping motion.

Overhead welding should be done in a manner similar to flat and horizontal but a slight circular motion should be used in the molten metal.

Vertical-down welding should be performed using stringer beads or a slight weave. The weld puddle will be kept in place by pointing the electrode arc upward into the puddle.

Vertical-up welding should be done by using the shelf or step method where welding is done by adding layer on top of layer. Do not use the whipping motion, but move the electrode slowly while pointing the arc force upward. Slag is easily removed with a chipping hammer.

SUPER 700
Arc AC/DC+ (Reverse Polarity)
All-Position

DESCRIPTION
Premium high strength, low hydrogen electrode for high stress steels.

APPLICATIONS
Super 700 was designed for all-position welding of crack sensitive steels such as "free-machining" steels that contain high levels of sulfur. Ideal for joining cold rolled steel, enameling steel, carbon steel, low and medium alloy high tensile steels. Super 700 is commonly used in structural steel fabrication of beams, angles, channels, plates, pipes and other structures where high stress may exist. Super 700 is often used as an inexpensive alternative to high cost alloys.

FEATURES
Super 700 is specially formulated to produce deposits that are dense, crack-free, ductile and x-ray quality. Preheating is not a requirement to prevent underbead cracking, thereby elimination this costly time consuming process. Super 700 has a very quiet arc and very little spatter with either AC or DC+ (reverse polarity). High deposition efficiency and easy slag removal.

SPECIFICATIONS
Tensile strength (psi).....Up to 80,000
Yield Strength (psi).....Up to 68,000
Elongation in 2" (%).....Approximately 30-40
Penetration .....Medium

AVAILABLE SIZES AND AMPERAGE

(in.)	3/32	1/8	5/32	3/16	¼
(mm)	2.4	3.2	4.0	4.8	6.0
Amps	50-110	100-150	130-200	210-280	300-375

PROCEDURES
Clean the work area of all contaminants. Bevel heavy sections to a 60 Vee. DC+ (reverse polarity) is a recommended, however an AC machine with sufficient open circuit voltage can be used. Using a short arc length, hold the electrode at a slight angle in the direction travel. A slight weaving technique may be used, but not to exceed 3 times the diameter of the electrode. Do not use the whipping technique since it will cause porosity in the weld metal. A straight forward progression is recommended for all positions. Remove slag between passes, but allow for high carbon steels to cool slowly before removing slag.

TOOL, DIE & MOLD STEELS
GTAW (TIG) WIRES

WASHINGTON ALLOY 4130
Heat Treatable Low Alloy Steel
AISI/SAE 4130 (No AWS Class)

DESCRIPTION
Washington Alloy 4130 is a chromium-molybdenum low alloy GTAW (TIG) wire that produces dense, heat-treatable deposits having high tensile strength and medium elongation. Washington Alloy 4130 weld deposits match the hardening characteristics of the base metal. Weld deposits are approximately 32-36 Rockwell C as applied, and can be readily machined and then heat-treated producing a hardening up to Rockwell C 42-45 using proper procedures.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600° F, then:

	Tempered at 1150° F	Tempered at 950° F
Yield Point (psi)	168,000	188,000
Tensile Strength (psi)	190,000	200,000

TYPICAL WELD METAL CHEMISTRY (%)
(GTAW Welded with DCSP, 100% Argon Shield Gas)

C	0.25
Mn	1.25
Si	0.40
P	0.013
S	0.015
Cr	0.50
Ni	1.30
Mo	0.20

TYPICAL APPLICATIONS
Washington Alloy 4130 is commonly used to weld low-alloy heat-treatable steels such as AISI/SAE 4130 and 8630, as well as steel castings with comparable hardening characteristics. Typical applications are for tool and die block construction and repair, construction and repair of tools, dies and molds having similar chemistries, as well as welding of oil-field piping and valve equipment, rolled high tensile plate, and foundry repair of high-tensile castings. Washington Alloy 4130 also responds well to flame hardening procedures.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to 50 lb. master carton.

Vacuum Melted AMS (Aerospace) Grade 4130 is also available upon request.

WASHINGTON ALLOY 4140
Heat Treatable Low Alloy Steel
AISI/SAE 4140 (No AWS Class)

DESCRIPTION
Washington Alloy 4140 is a chromium molybdenum low alloy flux-cored GTAW (TIG) Wire with slightly higher carbon than Washington Alloy 4130. Washington Alloy 4140 produces dense, heat-treatable deposits having higher tensile strength and somewhat lower elongation. Washington Alloy 4140 weld deposits match the hardening characteristics of the base metal. Weld deposits are approximately 36 Rockwell C as applied, and can be heat-treated producing a hardening up to Rockwell C 46 with proper procedures.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600° F, then:

	Tempered at 1150° F	Tempered at 950° F
Yield Point (psi)	157,000	195,000
Tensile Strength (psi)	180,000	220,000

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.35
Mn	0.80
Si	0.50
P	0.012
S	0.014
Cr	0.75
Mo	0.33

TYPICAL APPLICATIONS
Washington Alloy 4140 is commonly used to weld low-alloy heat-treatable AISI/SAE 4140 steel as well as steel castings with comparable hardening properties where the weld must match the heat-treating characteristic of the base metal. Typical applications are for build-up and repair of dies, forgings, and castings having similar chemistries, as well as welding of oil-field piping and valve equipment, and rolled high tensile plate made from medium carbon, low alloy base metals such as AISI 4140 steel, when post-weld heat treatment or flame hardening is required.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

WASHINGTON ALLOY 4340
Heat Treatable Low Alloy Steel
AISI/SAE 4340 (No AWS Class)

DESCRIPTION
Washington Alloy 4340 is a chromium-molybdenum low alloy flux-cored GTAW (TIG) wire that produces dense, shock resistant, heat treatable deposits having high tensile strength, medium elongation, and good compressive strength. Washington Alloy 4340 weld deposits match the hardening characteristics of the AISI/SAE 4340 base metal. Weld deposits are approximately 44 – 48 Rockwell C as applied. The weld deposits can be heat treated producing hardness of up to Rockwell C 52 using proper procedures.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600°F, then:

	Tempered at 1150°F	Tempered at 950°F
Yield Point (psi)	168,000	250,000
Tensile Strength (psi)	200,000	289,000

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.35
Mn	0.85
Si	0.50
P	0.011
S	0.014
Cr	0.78
Ni	1.80
Mo	0.25

TYPICAL APPICATIONS
Washington Alloy 4340 is used to weld low alloy heat treatable steels such as AISI/SAE 4340 and 4330, as well as steel castings with comparable hardening characteristics. Typical applications are for medium hard, tough weld deposits and include welding of forgings, castings, plastic molds, composite dies, die casting dies, crank shafts, gears, axles and for build up under harder weld deposits. Washington Alloy 4340 also responds well to flame hardening procedures.

AVAILABLE SIZES
.035 x 36
.045 x 36
.063 (1/16) x 36”
.093 (3/32) x 36”
.125 (1/8) x 36”

PACKING
10 lbs. tubes, 5 tubes to a 50 lbs. master carton.

TOOL, DIE & MOLD STEELS
GTAW (TIG) WIRES

WASHINGTON ALLOY 6150
Heat Treatable Low Alloy Steel
AISI/SAE 6150 (No AWS Class)

DESCRIPTION
Washington Alloy 6150 is a chromium molybdenum-vanadium-carbon medium alloy GTAW (TIG) wire that produces dense, heat-treatable deposits having higher tensile strength and slightly lower elongation than the AISI4100 series wires. Washington Alloy 6150 weld deposits match the hardening characteristics of the AISI 6150 base metal. Weld deposits are approximately 48 Rockwell C as applied, and can be heat-treated producing hardness up to Rockwell C 57 with proper procedures.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600° F, then:

	Tempered at 1150° F
Yield Point (psi)	160,000
Tensile Strength (psi)	190,000

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.50
Mn	0.85
Si	0.48
P	0.011
S	0.013
Cr	0.85
Mo	0.38
V	0.20
Cu	0.15

TYPICAL APPLICATIONS
Washington Alloy 6150 is commonly used to weld medium alloy heat-treatable AISI/SAE 6150 steels as well as steel castings with comparable hardening characteristics where the weld must match the heat-treating characteristics of the base metal. Typical applications are for build-up and repair of stamping dies (including GM 190, Chrysler NP 2088, Ford M3A76A grades), forgings, and castings made from medium carbon, medium alloy steels (such as AISI 6150) when post-weld heat treatment or flame hardening is required.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to 50 lb. master carton.

WASHINGTON ALLOY 8620
Heat Treatable Low Alloy Steel
AISI/SAE 8620 (No AWS Class)

DESCRIPTION
Washington Alloy 8620 is a low alloy chromium-molybdenum-nickel-carbon low alloy GTAW (TIG) wire that produces dense, shock-resistant heat-treatable deposits having very high tensile strength, medium elongation, and good compressive strength. Washington Alloy 8620 weld deposits match the hardening characteristics of the AISI/SAE 8620 base metal. Weld deposits are approximately 25-30 Rockwell C as applied, and can be heat-treated producing hardness up to Rockwell C 42 with proper procedures.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600° F, then:

	Tempered at 1150° F
Yield Point (psi)	92,000
Tensile Strength (psi)	108,000

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.20
Mn	0.81
Si	0.25
P	0.011
S	0.014
Cr	0.51
Ni	0.52
Mo	0.22
Cu	0.21

TYPICAL APPLICATIONS
Washington Alloy 8620 is designed to join, build-up or underlay prior to hard facing low-alloy heat-treatable AISI 8620 steel components, as well as steel castings and forgings with similar analysis and hardening characteristics. Typical applications are for medium hard, tough weld deposits and include welding of forgings, castings, and plastic molds and for build-up under harder weld deposits, particularly those with higher carbon contents.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

WASHINGTON ALLOY AH-2
Air Hardening Tool Steel
AISI/SAE A-2 (No AWS Class)

DESCRIPTION
Washington Alloy AH-2 is a high carbon, high chromium air-hardening tool steel alloy GTAW (TIG) wire that produces dense, heat-treatable deposits which respond to the hardening procedures for AISI type A-2 tool steel. The weld deposits are resistant to high abrasion, mild impact and wear. Washington Alloy AH-2 weld deposits match the hardening characteristics of AISI A-2 base metal and can also be used for joining and building-up of AISI A-2 through A-8 Tool Steel parts. Weld deposits are approximately 38-42 Rockwell C as applied, and can be multiple heat-treated, annealed, drawn or tempered.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600^0 F, then:

	Tempered at 1150^0 F	Tempered at 950^{0}F
Yield Point (psi)	130,000	175,000
Tensile Strength (psi)	150,000	200,000

*Due to the many proprietary A-2 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.55
Mn	0.50
Si	2.95
P	0.011
S	0.013
Cr	9.50
Mo	0.38
V	0.20

TYPICAL APPLICATIONS
Washington Alloy AH-2 is commonly used for repairs and alterations to air-hardening tool steel punches, blanking dies, forming dies, coining dies, forming dies, and for fabrication of composite dies and up-grading wear areas on lower alloys.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

Tool, Die and Mold Steels

WASHINGTON ALLOY D-2
Air Hardening Tool Steels
AISI/SAE D-2 (No AWS Class)

DESCRIPTION
Washington Alloy D-2 is a high carbon, high chromium air-hardening tool steel ally GTAW (TIG) wire that produces dense, fine-grained, heat-treatable deposits with resistance to abrasion and mild impact. Washington Alloy D-2 weld deposits match the hardening characteristics of AISI type D-2 tool steel. Washington Alloy D-2 can also be used for joining, and building-up A-8, D-2, D-3 and D-4 tool steels. Weld deposits are approximately 58-60 Rockwell C as applied, and can be multiple heat-treated, annealed, drawn or tempered.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600° F, then:

	Tempered at 900° F	Tempered at 450⁰ F
Yield Point (psi)	160,000	195,000
Tensile Strength (psi)	180,000	225,000

*Due to the many proprietary D-2 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	1.55
Mn	0.60
Si	0.95
P	0.011
S	0.013
Cr	12.00
Mo	0.80
V	0.85

TYPICAL APPLICATIONS
Washington Alloy D-2 is commonly used for repairs ad alterations to air-hardening tool steel cold-working shears, tool steel punches, slitter knives, blanking dies, extrusion dies, trimming dies, coining dies, forming dies, and for fabrication of composite dies using lower alloy based and fro upgrading wear areas on lower alloys.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to 50 lb. master carton.

WASHINGTON ALLOY OH-1
Oil Hardening Tool Steel
AISI/SAE OH-1 (No AWS Class)

DESCRIPTION
Washington Alloy 4140 is a chromium molybdenum low alloy flux-cored GTAW (TIG) Wire with slightly higher carbon than Washington Alloy 4130. Washington Alloy 4140 produces dense, heat-treatable deposits having higher tensile strength and somewhat lower elongation. Washington Alloy 4140 weld deposits match the hardening characteristics of the base metal. Weld deposits are approximately 36 Rockwell C as applied, and can be heat-treated producing a hardening up to Rockwell C 46 with proper procedures.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1600⁰ F, then:

	Tempered at 1150⁰ F	Tempered at 950⁰ F
Yield Point (psi)	157,000	195,000
Tensile Strength (psi)	180,000	220,000

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.35
Mn	0.80
Si	0.50
P	0.012
S	0.014
Cr	0.75
Mo	0.33

TYPICAL APPLICATIONS
Washington Alloy 4140 is commonly used to weld low-alloy heat-treatable AISI/SAE 4140 steel as well as steel castings with comparable hardening properties where the weld must match the heat-treating characteristic of the base metal. Typical applications are for build-up and repair of dies, forgings, and castings having similar chemistries, as well as welding of oil-field piping and valve equipment, and rolled high tensile plate made from medium carbon, low alloy base metals such as AISI 4140 steel, when post-weld heat treatment or flame hardening is required.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

WASHINGTON ALLOY WH-1
Water Hardening Tool Steel
AISI/SAE WH-1 (No AWS Class)

DESCRIPTION
Washington Alloy WH-1 is a high carbon-chromium-vanadium water-hardening tool steel alloy GTAW (TIG) wire that produces dense, fine-grained, heat-treatable deposits with resistance to abrasion and mild impact in cold-working service. Washington Alloy WH-1 weld deposits match the hardening characteristics of AISI type W-1 tool steel. Typically, Washington Alloy WH-1 weld deposits utilize a “differential hardening characteristic” to form a hard, wear-resistant surface or “case”, and a softer, shock-resistance core. Washington Alloy WH-1 can also be used for joining and building-up AISI W-1 through W-5 grades of water-hardening tool steels. Weld deposits are approximately 58-60 Rockwell C as applied, and can be multiple heat-treated, annealed, drawn or tempered.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, post weld re-heat, oil quenched at 1450⁰ F, then:

	Tempered at 900⁰ F	Tempered at 450⁰ F
Yield Point (psi)	140,000	175,000
Tensile Strength (psi)	160,000	195,0000

*Due to the many proprietary W-1 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	1.00
Mn	0.40
Si	0.95
P	0.011
S	0.013
Cr	0.50
V	0.20

TYPICAL APPLICATIONS
Washington Alloy WH-1 is commonly used for repairs and alterations to water-hardening tool steels primarily in tempers 9-11 used on cold-working blanking dies, trimming dies, coining dies, forming dies, trimming dies, coining dies, forming dies, press-brake forming tools and for fabrication of composite dies using lower alloy bases and for upgrading wear areas on lower alloys.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

Tool, Die and Mold Steels

WASHINGTON ALLOY M-2
High Speed Tool Steels
AISI/SAE M-2 AWS A5.13 Class RFe5A

DESCRIPTION
Washington Alloy M-2 is a carbon-chromium-tungsten high-speed tool steel alloy GTAW (TIG) wire that produces dense, fine-grained heat-treatable deposits with resistance to abrasion, frictional wear and mild impact. Washington Alloy M-2 weld deposits retain maximum hardness up to operating temperatures of 1,100°F. Washington Alloy M-2 weld deposits correspond to the same hardening procedures as AISI type M-2 tool steel. Washington Alloy M-2 can also be used for joining, and building-up AISI M-1 through M-44 types of high-speed tool steel. Weld deposits are approximately 61-63 Rockwell C as applied, and can be multiple heat-treated, annealed, drawn or tempered.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, then quenched at 2200^0 F, and then:

	Tempered at 1,200^0+ F	Tempered at 850^0 F
Yield Point (psi)	160,000	195,000
Tensile Strength (psi)	180,000	225,000

*Due to the many proprietary M-2 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.75
Mn	0.60
Si	0.80
P	0.011
S	0.013
Cr	5.50
Mo	4.50
V	1.80
W	6.60

TYPICAL APPLICATIONS
Washington Alloy M-2 is commonly used for repairs and alterations to high-speed tool steel shear blades, cutting dies and similar tool steel shear blades, cutting dies and similar tools where cutting edge retention is critical. Washington Alloy M-2 is also used for fabrication of composite dies using lower alloy bases and for upgrading wear areas on lower alloys.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to 50 lb. master carton.

WASHINGTON ALLOY H-12
Hot Work Tool Steel
AISI/SAE H-12 (No AWS Class)

DESCRIPTION
Washington Alloy H-12 is a 5% chromium hot working tool steel alloy GTAW (TIG) wire that produces dense, fine-grained, heat-treatable deposits with resistance to abrasion and mild impact in hot or cold-working service. Washington Alloy H-12 weld deposits match the hardening characteristics of AISI type H-12 tool steel. Weld deposits are approximately 52-54 Rockwell C as applied, and can be multiple heat-treated, annealed, drawn or tempered.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, then quenched in oil at 1850 F, then:

	Tempered at 1000^0 F	Tempered at 500^0 F
Yield Point (psi)	198,000	205,000
Tensile Strength (psi)	230,000	295,000

*Due to the many proprietary H-12 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.35
Si	0.95
P	0.011
S	0.013
Cr	5.50
Mo	1.50
V	0.20
W	1.50

TYPICAL APPLICATIONS
Washington Alloy H-12 is adapted for repairs and alterations to all AISI “H” Series tool steels used on hot-working blanking dies, and press-brake forming tools. Tools used for cold cutting an trimming have superior resistance to chipping when welded with Washington Alloy H-12. Washington Alloy H-12 can be used for heavy build-up, if necessary

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

WASHINGTON ALLOY H-13
Tungsten-Free Hot Work Tool Steel
AISI/SAE H-13 (No AWS Class)

DESCRIPTION
Washington Alloy H-13 is a 5% chromium, tungsten-free hot work tool steel alloy GTAW (TIG) wire that produces dense, fine-grained, heat-treatable deposits with resistance to abrasion, frictional wear and mild impact in water-cooled hot working service. Washington Alloy H-13 weld deposits retain maximum hardness with continuous operating temperatures of 1,000°F. Washington Alloy H-13 is not as susceptible to brittleness common to grades H20-H26 when used at the normal working hardness of RC 45 to 55. Likewise, the higher alloy content of H20 through H26 types make them unsuitable for water-cooled service. Washington Alloy H-13 weld deposits correspond to the same hardening procedures as AISI type H-13 tool steel. Weld deposits are approximately 54-57 Rockwell C as applied, and can be multiple heat-treated, annealed, drawn or tempered.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, then quenched in oil at 1925^0 F, then:

	Tempered at 1,200^0 F	Tempered at 850^0 F
Yield Point (psi)	180,000	225,000
Tensile Strength (psi)	210,000	300,000

*Due to the many proprietary H-13 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%)
(Welded with DCSP, 100% Argon Shield Gas)

C	0.35
Si	0.25
P	0.011
S	0.013
Cr	5.30
Mo	1.50
V	1.00

TYPICAL APPLICATIONS
Washington Alloy H-13 is especially adapted to hot die work of all kind, particularly for white metal (aluminum, magnesium, and Zinc) extrusion dies and die-casting dies, forging dies, mandrels and hot shears.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

Tool, Die and Mold Steels

WASHINGTON ALLOY P-20
Low Carbon Mold Steel
AISI/SAE P-20 (No AWS Class)

DESCRIPTION
Washington Alloy P-20 is a specially formulated premium alloy tool steel wire that produces dense, fine-grained, heat-treatable deposits on pre-hardened AISI P-20 plastic mold steels. Outstanding characteristics of Washington Alloy P-20 weld deposits are its machinability, polishability, and excellent texturing capability. Additionally, Washington Alloy P-20 provides uniform chrome plating properties. The deposits are nitridable and also provide excellent flame hardening characteristics. Washington Alloy P-20 weld deposits are approximately 31 RC (290/325 BHN) as applied, and can be carburized (flame hardened) to 58 RC with almost no hardness drop-off across the entire width and depth of the weld. Washington Alloy P-20 responds to ion nitriding that provides high hardness of 60 RC with no distortion or dimensional changes of large molds or deep cavities.

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
Yield Point (psi)	140,000*
Tensile Strength (psi)	160,000*

*Due to the many proprietary P-20 mold steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%) (Welded with DCSP, 100% Argon Shield Gas)

C	0.35
Mn	1.50
Si	0.40
P	0.011 max.
S	0.003 max.
Cr	1.80
Ni	1.00
Mo	0.50

TYPICAL APPLICATIONS
USA P-20 is commonly used for repairs and alterations to standard, premium and modified grades of pre-hardened AISI P-20 plastic mold steels for dies, molds, and holder blocks used in compression or injection molding of ABS, thermosetting, SMC, GMT, Flax PP and transparent melts.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to 50 lb. master carton.

WASHINGTON ALLOY M-250
Maraging Tool Steel
AISI/SAE Maraging 250 (No AWS Class)

DESCRIPTION
Washington Alloy M-250 is a nickel-chrome-molybdenum alloy GTAW (TIG) wire. It is specially formulated to produce an as-welded hardness of Rockwell C 30-32 which allows for complete machining operations prior to maraging (age hardening). After machining, finished parts are slowly re-heated to 1,750 F and, following a rapid cooling in air, subjected to maraging at 900 F for three hours producing a hardness of Rockwell C 48-52

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
PWHT: fully annealed, welded, then quenched in oil at 1850^0 F, then:

Yield Point (psi)	95,000*
Tensile Strength (psi)	120,000*

*Due to the many proprietary maraging tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%) (GTAW Welded with DCSP, 100% Argon Shield Gas)

C	0.009
Mn	0.040
Si	0.020
Cr	1.00
Ni	18.110
Mo	4.870
P	0.004
Zr	0.005
Al	0.090
B	0.002
Co	7.900
H	0.0001
N	0.0029
O	0.001
S	0.001
Ti	0.480

TYPICAL APPLICATIONS
Washington Alloy M-250 is commonly used for repairs, build-up and alterations to hot working dies made from all grades of maraging steels for aluminum, magnesium and zinc die casting dies, rubber injection molding dies and molds, forging dies and holder blocks.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

WASHINGTON ALLOY S-7
Shock Resisting Tool Steel
AISI/SAE S-7 (No AWS Class)

DESCRIPTION
Washington Alloy S-7 is carbon-silicon-chromium-tungsten-molybdenum alloy GTAW (TIG) wire that produces a dense, fine-grained structure with high strength and ductility even in hardness up to Rockwell C 60. The deposit is completely heat-treatable using AISI S-7 procedures. Washington Alloy S-7 deposits retain their hardness in working environments up to 600° F. The hardness of Washington Alloy S-7 as welded is Rockwell C 54-57

TYPICAL MECHANICAL PROPERTIES (Stress Relieved)
Yield Point (psi)	110,000*
Tensile Strength (psi)	165,000*

*Due to the many proprietary S-7 tool steel formulations available, always contact the tool steel manufacturer for recommendations on heat treatment procedures.

TYPICAL WELD METAL CHEMISTRY (%) (Welded with DCSP, 100% Argon Shield Gas)

C	0.50
Mn	0.80
Si	1.50
Cr	1.50
Mo	0.50
W	2.50

TYPICAL APPLICATIONS
Washington Alloy S-7 is primarily used for repair, build-up and alterations to blanking dies, bending dies, trimmer dies, and coining dies. Washington Alloy S-7 deposits perform extremely well on medium hot (600^0 F) and cold work applications where repetitive high shock loading and metal-to-metal wear is present such as rivet sets, heading dies, hammer faces, punches and shear blades and chisel points.

AVAILABLE SIZES
.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING
10 lb. tube, 5 tubes to a 50 lb. master carton.

Tool, Die and Mold Steels

WASHINGTON ALLOY TENSILEWELD TIG

For Joining Tool Steels and Dissimilar Steels

DESCRIPTION

Washington Alloy Tensileweld TIG is a chromium-nickel alloy wire that produces a unique austenitic-ferritic structure that has dense. Fine-grained delta ferrite in a rich austenitic matrix. This results in extremely crack-resistant, tough welds having very high strength (up to 122,000 psi) coupled with up to 35% elongation. The deposits are readily machined having a hardness of 22-23 RC (236 BHN). The weld deposits are non heat-treatable but work-harden and provide resistance to heat, corrosion, abrasion, and impact. Washington Alloy Tensileweld can be used for joining, and building-up all AISI types of tool steels. Washington Alloy Tensileweld TIG is an excellent underlay (buffer layer) for harder deposits.

TYPICAL MECHANICAL PROPERTIES (As Welded)

Yield Point (psi)	90,000
Tensile Strength (psi)	122,000
Elongation in 2” (%)	35
Hardness (RC)	23 RC

TYPICAL WELD METAL CHEMISTRY (%)

(Welded with DCSP, 100% Argon Shield Gas)

C	0.12
Mn	1.70
Si	0.50
Cr	29.5
Ni	9.50

TYPICAL APPLICATIONS

Washington Alloy Tensileweld TIG is commonly used for repairs and alteration to steel casting, forgings, gears, tools and dies, shear blades. Washington Alloy Tensileweld is often used for structural repairs to tools and dies with only the top two or three passes being made of the matching tool steel base metal. In applications where dissimilar steels are to be welded, Washington Alloy Tensileweld performs flawlessly, every time.

AVAILABLE SIZES

.035 × 36”
.045 × 36”
.063 (1/16”) × 36”
.093 (3/32”) × 36”
.125 (1/8”) × 36”

PACKAGING

10 lb. tube, 5 tubes to 50 lb. master carton.

Tool, Die and Mold Steels – Weld Metal Selection

A.I.S.I./S.A.E. BASE METAL TYPE (PARTIAL LIST)	TYPICAL APPLICATIONS	PREHEAT RANGE FOR WELD REPAIRS	POST WELD HEAT TREAT-MENT	HARDNESS AS WELDED	WELD METAL GTAW BARE ROD
Low Alloy High Tensile, Cr-Mo SAE 4130 heat Treatable Steel, SAE 4118, SAE 6140, Forgings, Castings, Plastic Molds, Dies.	Welding and overlaying Medium and High Carbon Steels, Chrome Moly Steels, Bandsaw, Blades, etc. –GM 190, Chrysler NP 2088, Ford M3A76A, Stamping Dies.	Up to ½ inch thick – 300^0 F ½ to 1.0 inch thick – 400^0 F over 1 inch thick – 450^0 F	Use 4130 Procedures	36-38 RC, hard as welded-Flame hardens to 45-47 RC, also responds to 4130 Heat Treatment.	Washington Alloy 4130
Low Alloy High Tensile, Cr-Mo SAE 4140 Hat Treatable steel, SAE 4135, SAE 4142, Forgings, Castings, Plastic Molds, Dies.	Welding and overlaying Medium and High Carbon Steels, Chrome Moly Steels, 4100 and 4300 series – GM 190, Chrysler NP 2088, for M3A76A, Stamping Dies	Up to ½ inch thick – 350^0 F ½ to 1.0 inch thick – 450^0 F Over 1 inch thick – 500^0 F	Use 4140 Procedures	44-48 RC, hard as welded – Flame hardens to 55 RC, also responds to 4140 Heat Treatment.	Washington Alloy 4140
Low Alloy High Tensile, Cr-Mo SAE 4340 Heat Treatable Steel, SAE 4320, 4300 series Forgings, Castings, Plastic Molds, Dies.	Welding and overlaying Medium and High Carbon Steels, Chrome Moly Steels, SAE 4300 series – GM 190, Chrysler NP 2088, Ford M3A76A, Stamping Dies	Up to ½ inch thick – 550^0 F 1\2 to 1.0 inch thick -550^0 F Over 1 inch thick – 550^0 F	Use 4340 Procedures	47-49 RC, hard as welded-Flame Hardens to 55 RC, also responds to 4340 Heat Treatment.	Washington Alloy 4340
Low Alloy High Tensile, C, Cr, V SAE 6150 Heat Treatable Steel, SAE 4100, 4300 series Forgings, Castings, Plastic Molds, Dies.	Welding and overlaying Medium and High Carbon Steels, Chrome Moly Steels, SAE 6150 series – GM 190, Chrysler NP 2088, Ford M3A76A, Stamping Dies	Up to ½ inch thick – 550^0 F 1\2 to 1.0 inch thick -550^0 F Over 1 inch thick – 550^0 F	Use 6150 Procedure	47-49 RC, hard as welded-Fame hardens to 55 RC, also responds to 6150 Heat Treatment	Washington Alloy 6150
Low Alloy High Tensile, Cr, Mo, Ni SAE 8620 Heat treatable Steel, SAE 8600 series Forgings, Casting, Plastic Molds, Dies.	Welding and overlaying Medium and High Carbon Steels, Chrome Moly Steels, SAE 6150 series – GM 190, Chrysler NP 2088, Ford M3A76A, Stamping Dies	Up to 1\2 inch thick –200^0 F 1\2 to 1.0 inch thick–300^0 F Over 1 inch thick–350^0 F	Use 8620 Procedures	47-49 RX, hard as welded – Flame hardens to 55 RC, also responds to 8620 Heat Treatment.	Washington Alloy 8620
Alloy Tool Steels Ni, Co, Mo types Maraging 250 solution Heat Treatable Steels for repair or composite fabrication of Dies, Molds, mandrels, Dummy Blocks, etc.	Welding and overlaying all types of Tool Steels, deposits are in solution treated condition. Further heat treatment (aging) at 950 F harden up to 49 RC. Using Maraging 250 procedures, hardness of up to 58 RC with excellent polishability.	Preheating is not required welding Maraging Steels, however, preheat other steels according to their recommended pre-heats.	Aging at 900-950 °F at 3 hr. per inch of thickness. Use Maraging 250 Procedures.	30-32 RC as welded. Solution Heat Treats at 900-950 F for 3 hours up to 55-58 RC, also responds to Maraging 250 Procedures.	Washington Alloy Maraging 250
Dissimilar Tool Steels – High Strength, crack resistant, non-heat treatable, Austenitic-Ferritic alloy with excess Delta Ferrite.	Welding Dies and Tools where further heat treatment is not used. Excess Delta Ferrite causes carbon pick up from some steels increasing hardness to advantage.	Up to 1\2 inch thick–200^0 F 1\2 to 1.0 inch thick–300^0 F Over 1 inch thick – 350^0 F	Stress relieve at preheat temperature for 1 hr. per inch of thickness, then slow cool.	22-23 RC as welded. May pick up carbon from some Steels increasing hardness (first pass) substantially.	Washington Tensileweld TIG
Low Carbon Steel – For machinable deposits on Low Carbon Steels, Added Mn, Si, Ti, and Al provide increased deoxidizing properties.	Welding deposits are dense, free from porosity, machinable with excellent appearance. Triple deoxidized filler metal with 83,000 psi tensile and 27.5% elongation.	Preheat other steels according to their recommended preheats.	Stress relieve at preheat temperature for 1 hr. per inch of thickness, then slow cool.	15-16 RC as welded.	Washington Alloy ER70S-2
Corrosion Resisting Mold Steels, Precipitation Hardening Stainless Steel Mold bases, Cavities for Plastics and Rubber Molds, even With Corrosive PVC plastics	Welding deposits have uniform hardness in all dimension, excellent toughness, corrosion resistance and compressive strength. Welds are shrinkage free, and free from decarburization and scale.	No preheat is required when welding Precipitation Hardening Stainless Steels. Welds should be stress relieved for 1 hr. per inch of thickness	Preheat to 925^{0}F for 1 hr. per inch of thickness. Slow cool in mica to reduce stresses.	38-42 RC as welded. Use 17-4 PH Procedures.	Washington Alloy 17-4 PH

Tungsten Electrodes

2% THORATED **EWTH-2** **10 Pieces Each**	**TTU 2% TUNGSTEN 03**	.040 X 7
	TTU 2% TUNGSTEN 04	1/16 X 7
	TTU 2% TUNGSTEN 05	3/32 X 7
	TTU 2% TUNGSTEN 06	1/8 X 7
	TTU 2% TUNGSTEN 07	5/32 X 7
	TTU 2% TUNGSTEN 08	3/16 X 7"

RARE EARTH **EWG** **10 Pieces Each**	**TTU 3TH 04**	1/16 X 7
	TTU 3TH 05	3/32 X 7
	TTU 3TH 06	1/8 X 7

PURE TUNGSTEN **EWP** **10 Pieces Each**	**TTU P/T 03G**	.040 X 7
	TTU P/T 04G	1/16 X 7
	TTU P/T 05G	3/32 X 7
	TTU P/T 06G	1/8 X 7
	TTU PT 07G	5/32 X 7

2% CERIATED **EWCE-2** **10 Pieces Each**	**TTU C/T 03**	.040 X 7
	TTU C/T 04	1/16 X 7
	TTU C/T 05	3/32 X 7
	TTU C/T 06	1/8 X 7
	TTU C/T 07	5/32 X 7

2% LANTHANUM **EWLA-2** **10 Pieces Each**	**TTU L/T 03**	.040 X 7
	TTU L/T 04	1/16 X 7
	TTU L/T 05	3/32 X 7
	TTU L/T 06	1/8 X 7

1 1/2% LANTHANUM **EWLA-1.5** **10 Pieces Each**	**TTU GL/T 03**	.040 X 7
	TTU GL/T 04	1/16 X 7
	TTU GL/T 05	3/32 x 7
	TTU GL/T 06	1/8 X 7
	TTU GL/T 07	5/32 X 7

ZIRCONATED **EWZR-1** **10 Pieces Each**	**TTU Z/T 03**	.040 X 7
	TTU Z/T 04	1/16 X 7
	TTU Z/T 05	3/32 X 7
	TTU Z/T 06	1/8 X 7
	TTU Z/T 07	5/32 X 7
	TTU Z/T 08	3/16 X 7"

Helmets & Helmet Parts/Accessories

AUTO DARKENING HOOD	**WA H700**	BLACK 2 X 4 AUTO DARKENING
	WA H700/LS	SILVER 2 X 4 AUTO DARKENING
	WA H700/S	GUN METAL 2 X 4 AUTO DARKENING
	WA H700MB	MATTE BLACK 2 X 4 AUTO DARKENING
	WA H800	BLACK 4 X 5 AUTO DARKENING
	WA H800D	BLACK 4 X 5 DIGITAL AUTO DARKENING

LIFT FRONT HELMET	**WA H750**	2 X 4 1/4 LIFT FRONT HELMET
	WA H754	4 1/2 X 5 1/14 LIFT FRONT HELMET

REPLACEMENT FILTERS	**WA H700-ADF PRO**	2 X 4 AUTO DARKENING REPLACEMENT FILTER
	WA H800-ADF	4 X 5 AUTO DARKENING REP;LACEMENT FILTER

REPLACEMENT LENS	**WA H700-IL**	INNER COVER LENS FOR H700
	WA H700-OL	OUTER COVER LENS FOR H700
	WA H700-OL/3	3 PACK OUTER COVER LENS FOR H700
	WA H700-L/KIT	5 OUTER LENSE & 2 INNER LENS KIT FOR H700
	WA H800-IL	INNER COVER LENSE FOR H800
	WA C215	4 1/2 X 5 1/4 OUTER COVER PLATE FOR H800

FILTER PLATE **2" X 4 1/4"**	**WA FP24-4**	FILTER PLATE 2 X 4 1/4" SHADE 4
	WA FP24-5	FILTER PLATE 2 X 4 1/4" SHADE 5
	WA FP24-8	FILTER PLATE 2 X 4 1/4" SHADE 8
	WA FP24-9	FILTER PLATE 2 X 4 1/4" SHADE 9
	WA FP24-10	FILTER PLATE 2 X 4 1/4" SHADE 10
	WA FP24-11	FILTER PLATE 2 X 4 1/4" SHADE 11
	WA FP24-12	FILTER PLATE 2 X 4 1/4" SHADE 12
	WA FP24-13	FILTER PLATE 2 X 4 1/4" SHADE 13
	WA FP24-14	FILTER PLATE 2 X 4 1/4" SHADE 14

FILTER PLATE **4 1/2" X 5 1/4"**	**WA FP45-8**	FILTER PLATE 4 1/2 X 5 1/4 SHADE 8
	WA FP45-9	FILTER PLATE 4 1/2 X 5 1/4 SHADE 9
	WA FP45-10	FILTER PLATE 4 1/2 X 5 1/4 SHADE 10
	WA FP45-11	FILTER PLATE 4 1/2 X 5 1/4 SHADE 11
	WA FP45-12	FILTER PLATE 4 1/2 X 5 1/4 SHADE 12
	WA FP45-13	FILTER PLATE 4 1/2 X 5 1/4 SHADE 13
	WA FP45-14	FILTER PLATE 4 1/2 X 5 1/4 SHADE 14

Helmets & Helmet Parts/Accessories

MAGNIFYING LENS	**WA ML-75**	MAGNIFYING LENS .075 DIOPTGER (2 X 4 1/4)
	WA ML-100	MAGNIFYING LENS 1.00 DIOPTGER (2 X 4 1/4)
	WA ML-125	MAGNIFYING LENS 1.25 DIOPTGER (2 X 4 1/4)
	WA ML-150	MAGNIFYING LENS 1.50 DIOPTGER (2 X 4 1/4)
	WA ML-175	MAGNIFYING LENS 1.75 DIOPTGER (2 X 4 1/4)
	WA ML-200	MAGNIFYING LENS 2.00 DIOPTGER (2 X 4 1/4)
	WA ML-225	MAGNIFYING LENS 2.25 DIOPTGER (2 X 4 1/4)
	WA ML-250	MAGNIFYING LENS 2.50 DIOPTGER (2 X 4 1/4)
	WA ML-275	MAGNIFYING LENS 2.75 DIOPTGER (2 X 4 1/4)
	WA ML-300	MAGNIFYING LENS 3.00 DIOPTGER (2 X 4 1/4)

HELMET ACCESSORIES	**WA H700-HG**	REPLACEMENT HEADGEAR FOR H700 & H800
	WA H700-HD	HARD HAT ADAPTER
	WA H700-MK	MOUNT KIT FOR H700 HEAD GEAR
	WA H800-RK	H800 ADF RETAINING KIT
	WA H754 ASSEMBLY	4 1/2 X 5 1/4 FLIP UP ASSEMBLY FOR H754
	WA H754 HG	H754 REPLACEMENT HEAD GEAR

Ground Clamps & Electrode Holders

GROUND CLAMPS J: Jackson Style L: Lenco Style T: Tweco Style		
	WA ECM 30R	250 AMP MAGNETIC GROUND CLAMP
	WA ECM 50R	400 AMP MAGNETIC GROUND CLAMP
	WA GC200J	J-200 AMP GOUND CLAMP
	WA GC200L	L-200 AMP BRASS GROUND CLAMP
	WA GC200T	T-200 AMP BRASS GROUND CLAMP
	WA GC300J	J-300 AMP BRASS GROUND CLAMP
	WA GC300L	L-300 AMP BRASS GROUND CLAMP
	WA GC300T	T-300 AMP BRASS GROUND CLAMP
	WA GC500J	J-500 AMP BRASS GROUND CLAMP
	WA GC500L	L-500 AMP BRASS GROUND CLAMP
	WA GC500T	T-500 AMP BRASS GROUND CLAMP
	WA GL300L	L-300 AMP STEEL GROUND CLAMP
	WA GL400L	L-400 AMP STEEL GROUND CLAMP
	WA GL500L	L-500 AMP STEEL GROUND CLAMP
	WA GCWG60C	GROUND CLAMP C-CLAMP

ELECTRODE HOLDERS J: Jackson Style L: Lenco Style T: Tweco Style B: Bernard Style		
	WA EH200J	J-200 AMP ELECTRODE HOLDER
	WA EH200L	L-200 AMP ELECTRODE HOLDER
	WA EH200SK	200 AMP ELECTRODE HOLDER
	WA EH200T	T-200 AMP ELECTRODE HOLDER
	WA EH250L	L-250 AMP ELECTRODE HOLDER
	WA EH250T	T-250 AMP ELECTRODE HOLDER
	WA EH300J	J-300 AMP ELECTRODE HOLDER
	WA EH300L	L-300 AMP ELECTRODE HOLDER
	WA EH300T	T-300 AMP ELECTRODE HOLDER
	WA EH350L	L-350 AMP ELECTRODE HOLDER
	WA EH350T	T-350 AMP ELECTRODE HOLDER
	WA EH400B	B-400 AMP ELECTRODE HOLDER
	WA EH500L	L-500 AMP ELECTRODE HOLDER
	WA EH500T	T-500 AMP ELECTRODE HOLDER
	WA EH600B	B-600 AMP ELECTRODE HOLDER

Accessories

BRUSHES	**WA WIRE BRUSH BR**	WIRE BRUSH W/ BRASS WIRE
	WA WIRE BRUSH SS	WIRE BRUSH W/ STAINLESS STEEL WIRE
	WA WIRE BRUSH ST	WIRE BRUSH W/ STEEL WIRE

CABLE CONNECTOR	**WA CC100**	4-1 CABLE CONNECTOR SET
	WA CC100-F	CABLE CONNECTOR 4-1 FEMALE
	WA CC100-M	CABLE CONNECTOR
	WA CC300	1/0 - 4/0 CABLE CONNECTOR SET
	WA CC300-F	CABLE CONNECTOR 2MBP FEMAILE
	WA CC300-M	CABLE CONNECTOR 2MBP MALE
	WA CC400	3/0 - 4/0 CABLE CONNECTOR SET
	WA CC400-F	CABLE CONNECTOR 4MBP FEMALE
	WA CC400-M	CABLE CONNECTOR 4MBP MALE

CHIPPING HAMMERS	**TU CHIPG B.**	CHISEL & BRUSH W/ SPRING HANDLE
	TU CHIPG S.	CHISEL & PICK CHIPPING HAMMER
	TU CHIPG S2	CROSS-CHISEL & PICK W/ SPRING HANDLE
	TU CHIPG W.	CHISEL & PICK W/ WOODEN HANDLE
	WA CHIPG HMR	PLASTIC CHIPPING HAMMER W/ BRUSH
	WA CHWH-20	CONE & CHISEL W/ WOODEN HANDLE - LARGE

CABLE LUG	**WA CL 10-20**	1/0 - 2/0 INTERNAL SOLDER ON
	WA CL 30-40	3/0 - 4/0 INTERNAL SOLDER ON
	WA CL-TE-10F	CABLE LUG TE-10F
	WA CL-TE-1AF	CABLE LUG TE-1AF
	WACL-TE-20F	CALBE LUG TE-20F
	WA CL-TE-2AF	CABLE LUG TE-2AF
	WA CL6-2	INTERNAL SOLDER ON TERMINAL
	WA CLH-L	3/0 - 4/0 CALBE LUG HAMMER ON LARGE
	WA CLH-M	1/0 -2/0 CABLE LUG HAMMER ON MEDIUM
	WA CLH-S	6-2 CABLE LUG HAMMER ON SMALL
	WA CLS-L	3/0 - 4/0 CALBE LUG SOLDER ON LARGE
	WA CLS-M	1/0 -2/0 CABLE LUG SOLDER ON MEDIUM
	WA CLS-S	6-2 CABLE LUG SOLDER ON SMALL

Accessories

CHEMICALS	**WC ANT SPAT 01**	16 OZ AEROSOL ANTI-SPATTER
	WC GREEN SPAT 02	SPATTER SPATTER 1 GALLON
	WC GREEN SPAT 03	SPATTER SPATTER 5 GALLON
	WC NOZ DIP 01	16 OZ NOZZLE DIP
	WC SPRAY GALV 01	12 OZ SPRAY GALVANIZING

CYLINDER CAPS (24 EACH PER CASE)	**WA CCACT**	ACETYLENE COURSE THREAD
	WA CCAFT	ACETYLENE FINE THREAD
	WA CCOCT	OXYGEN COURSE THREAD
	WA CCOFT	OXYGEN FINE THREAD

CYLINDER/MIG CARTS	**WA CYT-14CH**	CYLINDER TROLLY CYT-14CH
	WA CYT-8CH	CYLINDER TROLLEY CYT-8CH
	WA MIG-CARTS	MIG CART BLU W/O HANDLE
	WA MIG-PLASMA CARTS	MIG PLASMA CART

FLOW GAUGES	**WA FG1530**	FLOW GAUGE 1.5" DOUBLE SCALE, 30 cfh
	WA FG1550	FLOW GAUGE 1.5" DOUBLE SCALE, 50 cfh
	WA FG230	FLOW GAUGE 2" DOUBLE SCALE, 30 cfh
	WA FG250	FLOW GAUGE 2" DOUBLE SCALE, 50 cfh
	WA FG2530	FLOW GAUGE 2.5" DOUBLE SCALE, 30 cfh
	WA FG2550	FLOW GAUGE 2.5" DOUBLE SCALE, 50 cfh

GOGGLES	**WG 209**	SHADE 5 (2 X 4 1/4" LIFT FRONT)
	WG SG231	CLEAR PERFORATED, SAFTETY GOGGLES
	WG SG234	CLEAR VENTED, SAFTEY GOGGLES

GOUGING TORCH	**TG K1000A**	GOUGING TORCH WITH 7' CABLE

HOSE	**WA TH 05R 25**	GRADE R TWIN HOSE: 25'
	WA TH 05R 50	GRADE R TWIN HOSE: 50'
	WA TH 05R 100	GRADE R TWIN HOSE: 100'

Accessories

MACHINE COUPLING	**WA MCM8-F**	MACHINE COUPLING M-8 FEMALE
	WA MCM8-M	MACHINE COUPLING M-8 MALE
	WA MCM10-F	MACHINE COUPLING M-10 FEMALE
	WA MCM10-M	MACHINE COUPLING M-10 MALE
	WA MCM12-F	MACHINE COULING M-12 FEMALE
	WA MCM12-M	MACHINE COUPLING M-12 MALE

MAGNETIC HOLDERS	**WA MAG-M**	MEDIUM MAGNETIC HOLDER
	WA MAG-L	LARGE MAGNETIC HOLDER
	WA MI-EHS-M	MAGNETIC ELECTRODE HOLDER STAND
	WA MI-MTS-M	MAGNETIC MIG TORCH HOLDER STAND
	WA MI-TTS-M	MAGNETIC TIG HOLDER STAND

PLIERS/WRENCHES	**WA MIG PLIER**	MIG WELDING PLIERS
	WA TW-5	TANK WRENCH 5
	WA TW-20	TANK WRENCH 20
	WA TW-250	TANK WRENCH 250
	WA WR1013	TEN MOUTH WRENCH

PRESSURE GAUGES	**WA PG1530**	1 1/2" X 30 PSI
	WA PG15100	1 1/2" X 100 PSI
	WA PG15200	1 1/2" X 200 PSI
	WA PG15400	1 1/2" X 400 PSI
	WA PG154000	1 1/2" X 4000 PSI
	WA PG15 LENS	1 1/2" LEXAN GAUGE COVER
	WA PG230	2" X 30 PSI
	WA PG2100	2" X 100 PSI
	WA PG2200	2" X 200 PSI
	WA PG2400	2" X 400 PSI
	WA PG24000	2" X 4000 PSI
	WA PG2 LENS	2" LEXAN GAUGE COVER
	WA PG2530	2 1/2" X 30 PSI
	WA PG25100	2 1/2 X 100 PSI
	WA PG25200	2 1/2 X 200 PSI
	WA PG25400	2 1/2 X 400 PSI
	WA PG254000	2 1/2 X 4000 PSI
	WA PG25 LENS	2 1/2" LEXAN GAUGE COVER

Accessories

ROD OVENS	**WA EQ 20Si**	20 LB ROD OVEN
	WA EQ-50SI	50 LBS ROD OVEN
	WA EQ 50SiW	50 LBS ROD OVEN W/ WHEELS

SOAPSTONE	**TU SOAPSTONE 01**	FLAT SOAPSTONE
	TU SOAPSTONE 03	ROUND SOAPSTONE
	TU SOAPSTONE 04	SQUARE SOAPSTONE
	WA FLAT HOLDER	FLAT SOAPSTONE HOLDER
	WA ROUND HOLDER	ROUND SOAPSTONE HOLDER

SPARK LIGHTERS	**WA FL308**	TRIPLE FLINT LIGHTER
	WA FL308R	TRIPLE FLINT RENEWAL
	WA SPARKLIGHTER-S	SPARKLIGHTER SINGLE FLINT
	WA FL508R	SINGLE FLINT RENEWAL 5 PACK
	WA MI-SL-PIEZO	ELECTRONIC STRIKER (LIGHTNIN' BUG)
	WA SPARK STICK	ZAP STICK W/ LANYARD
	WA SPARK STICK RP	ZAP STICK RETAIL PACK (20 SPARK STICKS)

TIP CLEANERS	**WA TIP STD**	STANDARD TIP CLEANER
	WA TIP L	LONG TIP CLEANER
	WA TIP KING	KING TIP CLEANER
	WA TIP CLEAN ASST RP	TIP CLEANER RETAIL PACK (24 STD, 20 KING, 20 LONG)