LAWSON Products

WELDING TECHNICAL GUIDE

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LAWSON Products

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Technical Data And Critical Specifications

Get the technical information and support you need to use our welding products more effectively and efficiently.

We Bring You:

- General Purpose and Maximum Performance welding products
- A complete line of welding accessories
- Access to our Welding Technical Team (1.800.843.0763)

Our Trusted Brands:

CERTANIUM
A LAWSON BRAND
General Purpose

Cronatron™
A LAWSON BRAND
Maximum Performance

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Maintenance Welding Guide

Base Metal: Carbon Steel

Welding Alloys:			Certanium® General Purpose		Cronatron Maximum Performance		
Process	AWS Class	Dia. (Inches)	Part No.	Pkg. Qty. (Lbs.)	Cronatron Product	Part No.	Pkg. Qty. (Lbs.)
MIG	ER70S-6	.023	41752	2			
		.023	41753	11			
		.030	41754	2	331M	CW5129	2
		.030	41755	11	331M	CW5130	10
		.030	41756	30	331M	CW5131	33
		.035	41757	11	331M	CW5132	2
		.035	41758	30	331M	CW3777	10
		.035			331M	CW3308	33
		.045	41759	11	331M	CW3778	10
		.045	41760	30	331M	CW3309	33
		.052	41761	45			
		1/16	41762	45	331M	CW3310	33
	E71T-11	.023	41763	2			
		.030	41764	2			
		.030	41765	10			
		.030	41766	25			
		.035	41767	10	331M-FC	CW5907	10
		.035	41768	25	331M-FC	CW5908	25
		.045	41769	10	331M-FC	CW5909	2
		.045	41770	25	331M-FC	CW5911	25
		.052	41771	25			
		1/16	41772	25	331M-FC	CW5914	25
TIG	ER70S-3	.035			321T	CW1010	2
		1/16	41773	5	321T	CW1011	10
		3/32	41774	10	321T	CW1008	10
		1/8	41775	10	321T	CW1007	10

Stick Electrodes

Applications	Cronatron Alloys																
	311	315	321	338	340	375	333	3330	777	3880	3881	377	3990	3000	3010	349	383
Carbon and Alloy Steels																	
Low Carbon/Mild Steel (.05 – .30 Carbon) Angle Iron, Channels, I Beams, Plates	1		2	1		3	3										
Medium Carbon Steels (.30 – .45 Carbon) Axles, Cams, Crankshafts		2			2	3										1	
High Carbon Steels (.45 – 1.0 Carbon) Rails, Bearings, Blades						2	1	1									
Alloy Steels																	
e.g. AISI 4130, 4140, 4340, 4350					2											1	
Cast Steel																	
Buckets, Cheek Plates, Asphalt Equipment		1			2		1	1									
Galvanized Steel																	
Duct Work, Angle Iron, Channels	2			1													
Dissimilar Steels																	
Carbon/Alloy Steels to Stainless Steel					2		1	1						3			
Manganese Steel																	
Hammers, Liners, Frogs							2	2	1								
Stainless Steels																	
300 Series (18Cr-8Ni) 302, 304, 308, 316 (and all "L" Grades)										1	1			2	2		3
Corrosion-Resistant and High Temperature Alloys																	
310, 330												1		2	2		
Carpenter 20													1				
Inconels														2	1		
Hastalloys														2	1		
400 Series Stainless					1												

1 = Primary, 2 = Secondary, 3 = Alternate ( ) Indicates discontinued; use crossover products

Gas Tungsten Arc (TIG) Wires

Applications	Cronatron Alloys								
	321T	315T	333T	340T	3000T	3010T	3880T	349T	383T
Carbon and Alloy Steels									
Low Carbon/Mild Steel (.05 – .30 Carbon) Angle Iron, Channels, I Beams, Plates	1	2	2	3					
Medium Carbon Steels (.30 – .45 Carbon) Axles, Cams, Crankshafts		2	2	1					
High Carbon Steels (.45 – 1.0 Carbon) Rails, Bearings, Blades		3	1	2	3				
Alloy Steels									
e.g. AISI 4130, 4140, 4340, 4350		3	2	2				1	
Cast Steel									
Buckets, Cheek Plates, Asphalt Equipment		2	1						
Galvanized Steel									
Duct Work, Angle Iron, Channels	1								
Dissimilar Steels									
Carbon/Alloy Steels to Stainless Steel			1	2	3	3			
Manganese Steel									
Hammers, Liners, Frogs			1						
Stainless Steels									
300 Series (18Cr-8Ni) 302, 304, 308, 316 (and all "L" Grades)					2	2	1		3
Corrosion-Resistant and High Temperature Alloys									
310, 330					1	2			
Inconels					2	1			
Hastalloys					2	1			
400 Series Stainless				1					

1 = Primary, 2 = Secondary, 3 = Alternate ( ) Indicates discontinued; use crossover products

Solid MIG Wires

Applications	Cronatron Alloys								
	321M	329M	331M	333M	340M	375M	3880M	665M	383M
Carbon and Alloy Steels									
Low Carbon/Mild Steel (.05 – .30 Carbon) Angle Iron, Channels, I Beams, Plates	1		1						
Medium Carbon Steels (.30 – .45 Carbon) Axles, Cams, Crankshafts	2		2			1			
High Carbon Steels (.45 – 1.0 Carbon) Rails, Bearings, Blades		3		1		2			
Alloy Steels									
e.g. AISI 4130, 4140, 4340, 4350		3		2		1			
Cast Steel									
Buckets, Cheek Plates, Asphalt Equipment	2	3	2	2		1			
Galvanized Steel									
Duct Work, Angle Iron, Channels	1	3	2					1	
Dissimilar Steels									
Carbon/Alloy Steels to Stainless Steel		2		1					
Manganese Steel									
Hammers, Liners, Frogs		2		1					
Stainless Steels									
300 Series (18Cr-8Ni) 302, 304, 308, 316 (and all "L" Grades)							1		2
Duplex Stainless Steel (Boilers, Kilns, Furnaces)									
Ferralium 255, Sandvik 2205		3		2					

1 = Primary, 2 = Secondary, 3 = Alternate ( ) Indicates discontinued; use crossover products

MIG Flux Core Wires

Applications	Cronatron Alloys							
	311M-FC	329M-FC	375M-FC	376M-FC	7109M-FC	7770M-FC	7940M-FC	3880M-FC
Carbon and Alloy Steels								
Low Carbon/Mild Steel (.05 – .30 Carbon) Angle Iron, Channels, I Beams, Plates	1		1	1			2	
Medium Carbon Steels (.30 – .45 Carbon) Axles, Cams, Crankshafts			1	2				
High Carbon Steels (.45 – 1.0 Carbon) Rails, Bearings, Blades		1						
Alloy Steels								
e.g. AISI 4130, 4140, 4340, 4350			1					
Cast Steel								
Buckets, Cheek Plates, Asphalt Equipment	2		1	2				
Galvanized Steel								
Duct Work, Angle Iron, Channels	2	1				2		
Dissimilar Steels								
Carbon/Alloy Steels to Stainless Steels		1						
Manganese Steel								
Hammers, Liners, Frogs		3			1	2		
Stainless Steels								
300 Series (18Cr-8Ni) 302, 304, 308, 316 (and all "L" Grades)		2						1
Duplex Stainless Steel (Chemical Processing)								
Ferralium 255, Sandvik 2205		1						

1 = Primary, 2 = Secondary, 3 = Alternate ( ) Indicates discontinued; use crossover products

Copper, Brass and Bronze

	Arc		TIG		Gas			
	Cronatron Alloys							
Base Metal	**625**	**667**	**665T**	**625T**	**44**	**45**	**30F**	**23F**
Aluminum Bronze	1		2	1				
Copper	2	1	2	2	1	1		2
Phosphor Bronze			1		2	2	2	
Silicon Bronze	2		1	2	2	1	2	
Naval (Yellow) Bronze	1		2	1		2	1	
Manganese Bronze	1			1			2	
Naval Gun Metal "G" Bronze	1			1			2	
Red Brass	2		2	2		2		1
Cupro-Nickel	1		2	1		2	2	
Nickel-Aluminum Bronze	1		2	1			2	
Cast Iron				2			1	2
Carbon Steel				2			1	2
Stainless Steel				2			2	

1 = Preferred, 2 = Alternate ( ) Indicates discontinued; use crossover products

Brazing

Higher Temperature, Higher Strength Applications	Cronatron Alloys								
	41F	42	43F	44	45, 46SP, 47SP			40F*/B	
Instrumentation, Electrical Appliances, Controls and Switches, Piping, Pattern and Trim Work, Kitchen Utensils, Heat Affected Stainless Steel	1	1	1			1	2	1	1
Electrical Conductors, Bronze and Brass Castings, Valves and Elbows, Tool Repair, Metal Furniture. Connections Needing High Electrical Conductivity	1	1	1			2	1	1	2
Food Processing and Handling Equipment, Heat Exchange Tubing, Flexible Hose, Mixing Vats and Tanks, Dairy and Heat Exchange Tubing. Filing Gaps and Poor Fit Joints						2	2	1	2
Food and Beverage, Dairy Equipment, Hospital Equipment. Surgical Instruments, Laboratory Apparatus, I Dental Instruments. Drug and Chemical; Pill Molds, Mixing Vats, Wire Mesh Screens, Miscellaneous Applications; Water Tanks, Bread Slicers, Carts and Conveyors						2	1	1	1
Anywhere a Shim Type Silver Solder is Needed. Carbide Tool Tipping, Copper Tubing, Kitchen Utensils, Dairy and Bakery Equipment, Electrical, etc.		1						1	
Copper to Copper, Copper Bus Bars, Plumbing and Refrigeration				2	1				

*1 = Preferred, 2 = Alternate *Cadmium-Free C = Flux Cored F = Flux Coated ( ) Indicates discontinued; use crossover products*

CARBON STEELS

Alloy Selector Guide and Welding Procedures

Low, Medium, High Carbon Steels

Cronatron™ A LAWSON BRAND

T = TIG
M = MIG
FC = Flux Core
M-MC = Metal Core

Stick Electrodes

A	311	(78,000 PSI)	Low Hydrogen	19
A	311-1	(81,500 PSI)	Low Hydrogen	20
B	315	(86,500 PSI)	Low Hydrogen	21
A	321	(76,000 PSI)	Extra Penetration	26
A	338	(80,000 PSI)	Excellent at Vertical or Overhead	24
C	375	(133,400 PSI)		22, 23

MIG Wires

A	311M-FC	(81,000 PSI)		20
A	321M	(76,000 PSI)		26
A	331M	(86,000 PSI)		25
A	331M-FC	(90,600 PSI)		25
B	375M	(110,000 PSI)		23
C	375M-FC	(105,000 PSI)		23
A	376M-FC	(76,000 PSI)	(No Gas) DCSP	25

TIG Wires

A	315T	(111,000 PSI)		21
A	321T	(76,000 PSI)		26

Gouging/Chamfering, Rods

	1100			18

Certanium®

Stick Electrodes

A	701 AC/DC	(90,000 PSI)	Excellent at Vertical or Overhead	25
B	704	(101,000 PSI)	Low Hydrogen	21

Bead Profiles and Techniques

Desired Bead Profile	Fillet welds should be slightly concave with smooth transitions. Avoid excessive travel speed.
Technique	Multiple torch angles and weave techniques are acceptable.
Helpful Hints	Drag/Pull technique provides maximum penetration.
Preheat	Hold at stated preheat temperature for one hour per one inch thickness.
Base Metal ID	Carbon greatly affects the hardness of steel. Therefore, a low carbon steel can easily be filed while a high carbon steel would be difficult. All carbon steels are strongly magnetic as opposed to stainless steels.

Alloy Selector Guide and Welding Procedures

Low, Medium, High Carbon Steels

Group	Description	Common Metal Grades
A	Low Carbon/Mild Steels (C = 0% to 0.2%)	A3-1>2, A27, A36, A53, A105, A106, A131, A134, A135-A>B, A139, A161, A178-A>C>D, A179, A181-60>70, A192, A204, A209, A210, A211, A214, A216, A226, A242, A250, A252, A266, A328, A414, A441, A537, A556, A557, A562, A570, A572, A573, A587, A660, A662, A694, A696, A737, A765, A841, A850, 1010, 1020
B	Medium Carbon Steels (C = 0.2% to 0.5%)	A3-3, A82, A184, A185, A333, A334, A335, A350, A356, A420, A533, A575, A588, A656, A660, A675, A678, A706, A727, A734, A735, A738, A739, A827, 1030, 1040, T-1 (Fillet Welds)
C	High Carbon/High Strength Steels (C = 0.5% to 1.2%)	A148, A225, A288, A372, A469, A470, A514, A517, A519, A521, A533, A649, A709, A724, A782, 1050, 1060, T-1 (Butt Welds)

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
A – Low Carbon Steels	<1"	70	N/A	N/A	N/A	Excellent weldability. For thick sections, AWS (American Welding Society) recommends a stress relief PWHT (postweld heat treatment) of 1,150°F for an hour per inch of thickness.
	1" – 2"	100	N/A	N/A	N/A	
	>2"	150	N/A	N/A	N/A	
B – Medium Carbon Steels	<1"	200	N/A	200	N/A	Good weldability when proper preheat is used. Amount of proper preheat is also affected by alloying elements such as Mn; the higher the alloy percentage, the higher the preheat that is needed. A typical stress relief is 1,150°F held for one hour per one inch of base metal followed by a slow cool.
	1" – 2"	300	Stress Relief	300	N/A	
	>2"	400	Stress Relief	400	N/A	
C – High Carbon Steels	<1"	400	N/A	400	N/A	Poor weldability. Easily susceptible to cracking. Controlling hydrogen (use hotbox) and using proper preheat is critical to success. A typical stress relief is 1,150°F held for one hour per one inch of base metal followed by a slow cool.
	1" – 2"	500	Stress Relief	500	N/A	
	>2"	600	Stress Relief	600	N/A	

For optimal operating parameters, refer to tech sheets.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

CUTTING and GOUGING Alloys/ MILD STEEL Alloys

PROBLEM SOLVER

Cronacut Eagle™ 1100

Cutting and Gouging Electrode

PROBLEM:

Need to cut or gouge metal without access to a cutting system

- Often in maintenance welding and repair you have to cut, gouge or pierce a hole quickly and you don't have access to a plasma, oxy-fuel or carbon arc cutting system

High noise levels from carbon arc gouging

- When using a carbon arc gouging system, they can be very noisy and require all nearby personnel to wear hearing protection

SOLUTION:

Quick Cutting or Gouging

- The Cronatron 1100 cutting and gouging electrode simply attaches to your normal stick welding stinger and removes or cuts metal cleanly and efficiently without having to drag additional equipment around with you

Minimal Arc Noise

- Quickly remove cracks, cut and gouge with significantly lower noise levels. The Cronatron 1100 doesn't need compressed air making it a much quieter alternative

APPLICATIONS

- All types of metals including steel and cast iron
- Weld preparation
- Light demolition
- Scrap recovery
- Removing cracks
- Gouging
- Cutting

Cronacut Eagle™ 1100 Electrode

The ultimate cutting, gouging, piercing, chamfering and grooving electrodes for any type of metal, including stainless steel, Monel®, cast iron and aluminum. Completely outclasses ordinary gouging and cutting electrodes.

Superior Advantages

- Provides straight, smooth cuts and efficient metal removal
- Prevents slag pileup and sticking
- Produces a ready-to-weld, clean, carbon-free surface
- Operates with standard welding machines

Usage Procedure

Use AC or DC straight polarity only. Point the electrode in the direction of travel and ignite the arc. For shallow chamfers, move quickly along line of cut. To obtain a deeper groove, make successive passes 1/2 the diameter of the electrode. For piercing, place rod in desired position and allow the blasting effect of electrode to penetrate metal.

Polarity: AC or DC Straight

Dia. (Inches)	Amps	Part No.
3/32	100 – 175	**CW1907A**
3/32	100 – 175	**CW1907**
1/8	125 – 200	**CW1906A**
1/8	125 – 200	**CW1906***
5/32	200 – 300	**CW1905A**
5/32	200 – 300	**CW1905**
3/16	300 – 450	**CW1904A**
3/16	300 – 450	**CW1904**
1/4	350 – 600	**CW3433A**
1/4	350 – 600	**CW3433**

Available in Assortment LP813. See page 56.

CARBON STEEL Alloys, Controlled Hydrogen

PROBLEM SOLVER

Cronatron 311

Carbon Steel Controlled Hydrogen Electrodes and Wires

PROBLEM:

Poor performing low hydrogen electrodes

- Hydrogen damage caused by moisture pick-up
- Loss of control over weld deposit due to fingernailing resulting from eccentric coating
- Slag inclusions on multi-pass welds
- Porosity when welding contaminated steels
- In-service cracking of welds

SOLUTION:

Cronatron 311 Carbon Steel Controlled Hydrogen Electrodes and Wires

- Moisture-resistant coating reduces hydrogen damage
- Concentric coating produces no fingernailing
- Slag remelts and rises to the top, eliminating the chance of slag inclusion
- Special fluxing agents are designed for optimum performance on dirty, rusty and contaminated steels
- High elongation and tensile strength resists cracking

APPLICATIONS

- Free machining or high sulfur steels
- Agricultural equipment
- Truck bodies and frames
- Pipes, flanges, channels, tubes and shafts

For everyday maintenance of mild and low-alloy steels

311 Electrode

Easy-to-use, all-position electrodes are fully machinable and designed to resist underbead cracking. For use in a variety of applications for everyday maintenance of mild and low-alloy steels.

Superior Advantages

- Fully machinable
- Resists cracking due to high elongation
- Easy slag removal saves time
- Moisture-resistant coating
- Meets or exceeds low-hydrogen requirements

Typical Applications

- Use on free-machining or high sulfur steels
- Agriculture equipment
- Structural members
- Truck bodies and frames
- Pipes, flanges, channels, tubes and shafts
- Holding tanks, steel vessels

Usage Procedure

For electrodes, maintain close arc or contact technique on horizontal fillets. On heavy section joining, bevel or chamfer use a "V" groove for safe, strong, lasting welds.

Tensile Strength: 78,000 PSI
Yield Strength: 65,000 PSI
Elongation: 30%
Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 70	**CW1852B**
3/32	50 – 70	**CW1852**
3/32	50 – 70	**CW1852A**
1/8	85 – 120	**CW1055B**
1/8	85 – 120	**CW1055***
1/8	85 – 120	**CW1055A**
5/32	115 – 150	**CW1054B**
5/32	115 – 150	**CW1054**
5/32	115 – 150	**CW1054A**
3/16	145 – 175	**CW1851B**
3/16	145 – 175	**CW1851**
3/16	145 – 175	**CW1851A**
1/4	170 – 225	**CW1850B**
1/4	170 – 225	**CW1850**
1/4	170 – 225	**CW1850A**

Available in Assortment LP812. See page 56.

Popular Carbon Steel Alloys and Part Numbers

Welding Alloys:			Certanium® General Purpose		Cronatron Maximum Performance		
Process	AWS Class	Dia. (Inches)	Part No.	Pkg. Qty. (Lbs.)	Cronatron Product	Part No.	Pkg. Qty. (Lbs.)
Stick	E6013	1/16			338	CW1860	5
		5/64			338	CW1060B	5
		5/64			338	CW1060	10
		3/32			338	CW1059	10
		1/8	41778	10	338	CW1058	10
		5/32			338	CW1057	10
		3/16			338	CW1056	10
	ER6011	3/32	41780	5	321	CW1811	25
		1/8	41781	1	321	CW1810	25
		1/8	41782	10	321	CW1810A	50
		5/32	41783	10	321	CW1809	25
	ER6010	3/32	41784	5			
		1/8	41785	1			
		1/8	41786	10			
		5/32	41787	10			
		3/32			311*	CW1852	25
		1/8	41790	10	311*	CW1055	25
		5/32	41793	50	311*	CW1054	25
		3/16			311*	CW1851	25
		1/4			311*	CW1850	25

**Not an AC electrode.*

Base Metal: Cast Iron, Dissimilar or Unknown Steel, Gouging, High Strength Carbon

Welding Alloy:			Cronatron Maximum Performance		
Base Metal	Process	Dia. (Inches)	Cronatron Product	Part No.	Pkg. Qty. (Lbs.)
Cast Iron	MIG	.035	211M-FC	CW2065	10
		.035	211M-FC	CW2066	33
		.045	211M-FC	CW2057	10
		.045	211M-FC	CW2058	33
		1/16	211M-FC	CW2059	33
	TIG	1/16	211T	CW1901	2
		1/16	211T	CW1902	2
		3/32	211T	CW1903	2
	Stick	3/32	211	CW1035	5
		1/8	211	CW1034	5
		5/32	211	CW1033	5
Dissimilar or Unknown Steel	MIG	.035	333M	CW1787	10
		.035	333M	CW1936	25
		.045	333M	CW1786	10
		.045	333M	CW1937	25
	TIG	.035	333T	CW1993	2
		1/16	333T	CW1898	2
		3/32	333T	CW1899	2
		1/8	333T	CW1900	2
	Stick	1/16	333	CW1877	5
		3/32	333	CW1049	5
		1/8	333	CW1048	5
		5/32	333	CW1047	5
		3/16	333	CW1046	5
Gouging	Stick	3/32	1100	CW1907	10
		1/8	1100	CW1906A	5
		1/8	1100	CW1906	10
		5/32	1100	CW1905	10
		3/16	1100	CW1904	10
		1/4	1100	CW3433	10
High-Strength Carbon Steel	MIG	.035	375M	CW5147	2
		.035	375M	CW1933	33
		.045	375M	CW1934	33
		1/16	375M	CW1935	44
		.045	375M-FC	CW2060	10
		.045	375M-FC	CW2061	33
		1/16	375M-FC	CW2062	33
	Stick	3/32	375	CW1053	10
		1/8	375	CW1052	10
		5/32	375	CW1051	10

CARBON STEEL Alloys, Controlled Hydrogen

Usage Procedure

For electrodes, maintain close arc or contact technique on horizontal fillets. On heavy section joining, bevel or chamfer a "V" groove for safe, strong, lasting welds.

311-1* Electrode

Tensile Strength: 81,500 PSI

Yield Strength: 69,000 PSI

Elongation: 32%

Polarity: DC Reverse

Impact Properties: As welded at –50°F (–46°C), 104 ft./lb.

Dia. (Inches)	Amps	Part No.
3/32	70 – 100	**CW9365B**
3/32	70 – 100	**CW9365**
3/32	70 – 100	**CW9365A**
1/8	90 – 160	**CW9364B**
1/8	90 – 160	**CW9364**
1/8	90 – 160	**CW9364A**
5/32	130 – 220	**CW9366B**
5/32	130 – 220	**CW9366**
5/32	130 – 220	**CW9366A**

*311-1 is only available in Canada and meets or exceeds Canadian Welding Bureau specifications.

311M-FC MIG Wire

Tensile Strength: 81,000 PSI

Yield Strength: 72,000 PSI

Elongation: 29%

Gas: 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.035	**CW1762**
.035	**CW1763**
.045	**CW1764**
.045	**CW1765**
1/16	**CW1766**

High-Strength Carbon Steel Controlled Hydrogen Electrodes and Wires

Maintenance engineered, all-position, high-strength, hydrogen-controlled electrodes and wires for difficult weldments of low carbon, low alloy and cast steels.

Superior Advantages

- Versatile – joins a wide variety of carbon and low alloy steels, can be used in all positions
- Strong – produces tough welds with high impact strength and elongation

Usage Procedure

For electrodes, use AC or DC reverse polarity. Use close arc with either stringer or weave technique.

For vertical welds, use rapid weave and hesitate over each crater before extinguishing arc.

Typical Applications

- Heavy equipment repairs – buckets, liners, pins, etc.
- Structural members – H-beams, frames, angle iron
- Mild and low-alloy steels – chains and chain links
- Pipes and pipe flanges
- Rear end housings and spring block hangers

Certanium® 704 Electrode

Low Hydrogen electrode for welding high strength steels in the 80 to 90 ksi tensile range such as T-1, Hy80, cast steels, construction grades, buckets and loaders

Tensile Strength: 101,000 PSI

Yield Strength: 85,000 PSI

Elongation: 28%

Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	65 – 1 0	**P12656**
1/8	110 – 140	**P12657***
5/32	140 – 200	**P12658**

Available in Assortment LP812. See page 56.

315T TIG Wire

Tensile Strength: 111,000 PSI

Yield Strength: 95,000 PSI

Elongation: 22%

Polarity: DC Straight

Gas: 100% Ar

Dia. (Inches)	Part No.
1/16	**CW3067A**
1/16	**CW3067**
3/32	**CW3068A**
3/32	**CW3068**
1/8	**CW3069A**
1/8	**CW3069**

315 Electrode

Low Hydrogen electrode for repairs on low/medium carbon low alloy steels in the 70 to 80 ksi tensile strength such as structural steels, frames, cast steel housings, heavy equipment and I-beams

Tensile Strength: 86,500 PSI

Yield Strength: 72,000 PSI

Hardness: 235 BHN

Elongation: 29%

Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	70 – 110	**CW1510**
3/32	70 – 110	**CW1510A**
1/8	90 – 160	**CW1511**
1/8	90 – 160	**CW1511A**
5/32	120 – 210	**CW1512**
5/32	120 – 210	**CW1512A**
3/16	200 – 290	**CW1513**
3/16	200 – 290	**CW1513A**

CARBON STEEL Alloys, Controlled Hydrogen

PROBLEM SOLVER

Cronatron 375

Maximum Strength Carbon Steel Controlled Hydrogen Electrodes and Wires

PROBLEM:
Out-of-position repairs

- Lack of time or inability to disassemble parts or equipment for repair
- Need to make repairs in the overhead position

Weld cracks on high-strength steels

Porosity, spatter and slag inclusions

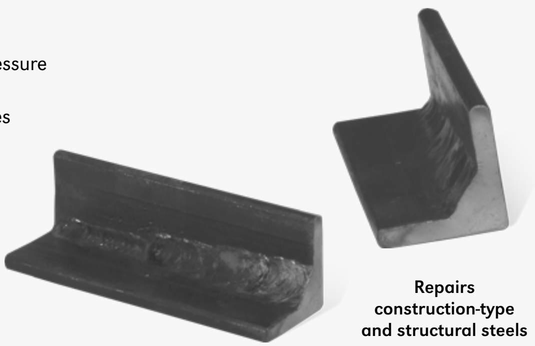
- Fatigue failures and/or cracking

SOLUTION:
Cronatron 375 Maximum Strength Carbon Steel Controlled Hydrogen Electrodes and Wires

- Can use in all-position welding
- Fast deposition rate
- High tensile strength provides crack-free welds, even on T-1, Hy 80 and Cor-Ten construction-type steels
- No slag inclusions between passes
- Spatter-free welds with no undercutting
- Moisture-resistant and hydrogen-controlled coating

APPLICATIONS

- Structural steel components
  - Bridges
  - "I" and "H" beams
- Heavy construction and earthmoving equipment
  - Dozer blades
  - Bucket teeth
  - Crane and shovel booms
- Boilers, vats, pressure tanks and pipes
- Tools and fixtures



Repairs construction-type and structural steels

Maximum Strength Carbon Steel Controlled Hydrogen Electrodes and Wires

Provides crack-free and porous-free welds on high-strength, carbon and cast steels.

Superior Advantages

- Saves Time
  - Fast deposition rate
  - Pass-over-pass with minimal slag chipping
- Easy To Use
  - All-position welding
  - Will not undercut or spatter

Provides crack-free and porous-free welds on high-strength, carbon and cast steels.

375 Electrode

Tensile Strength: 133,400 PSI

Yield Strength: 120,500 PSI

Elongation: 18%

Hardness: Rc 20-25

Polarity: DC Reverse

Usage Procedure

Use AC or DC reverse polarity with 375. Use close arc with either stringer or weave technique. For vertical welds, use rapid weave and hesitate over each crater before extinguishing arc.

Dia. (Inches)	Amps	Part No.
3/32	60 – 100	**CW1053**
1/8	100 – 130	**CW1052***
5/32	130 – 170	**CW1051**

Available in Assortment LP812. See page 56.

375M-FC MIG Wire

Tensile Strength: 105,000 PSI

Yield Strength: 93,000 PSI

Elongation: To 21%

Gas: 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.045	**CW2060**
.045	**CW2061**
1/16	**CW2062**

375M MIG Wire

Tensile Strength: 110,000 PSI

Yield Strength: 95,000 PSI

Elongation: 22%

Gas: 75% Ar, 25% CO_2 or 98% Ar, 2% O_2

Dia. (Inches)	Part No.
.035	**CW5147**
.035	**CW1933**
.045	**CW1934**
1/16	**CW1935**

CARBON STEEL Alloys, Premium

PROBLEM SOLVER

Cronatron 338

Premium Carbon Steel Electrodes and Wires

PROBLEM:

Difficult to reach, out-of-position repairs

- Lack of time or inability to disassemble parts or equipment for repair
- Need to make repairs in the overhead position

Time-consuming preparation on galvanized steels

- Removal of zinc coating required

Poor alloy operability with low-duty cycle A/C machines (buzz boxes)

- Low amperage does not have enough power to adequately run some alloys

SOLUTION:

Cronatron 338 Premium Carbon Steel Electrodes and Wires

- Fast freeze deposition allows welding in overhead and vertical positions
- Welds through dirt, rust and grease contamination
- Produces almost no spatter
- Resists zinc contamination and welding defects, even when welding on un-prepped galvanized steel
- 338 provides a more consistent, stable arc and prevents burn-through

Easy to use in nearly any position

APPLICATIONS

- Galvanized steels
  - Tanks and containers
  - Automotive parts
- Mild structural steels
- Sheet metals
- Door and window frames

338 Electrode

The E-Z Alloy Electrode. Safe, simple, all-position mild steel alloy. No preparations, just strike an arc and the electrode does all the work.

Tensile Strength: 80,000 PSI

Yield Strength: 70,000 PSI

Elongation: 29%

Polarity: AC or DC Reverse

Usage Procedure

Operates equally well with any power source or polarity. Excellent results with small, portable, low open-circuit voltage AC welders (“buzz boxes”). Use low amperage for thin metals; increase for thicker types or high-speed operations.

Dia. (Inches)	Amps	Part No.
1/16	25 – 35	**CW1860**
5/64	30 – 45	**CW1060B**
5/64	30 – 45	**CW1060**
3/32	40 – 90	**CW1059B**
3/32	40 – 90	**CW1059**
3/32	40 – 90	**CW1059A**
1/8	60 – 140	**CW1058B**
1/8	60 – 140	**CW1058***
1/8	60 – 140	**CW1058A**
5/32	95 – 170	**CW1057B**
5/32	95 – 170	**CW1057**
5/32	95 – 170	**CW1057A**
3/16	145 – 240	**CW1056B**
3/16	145 – 240	**CW1056**
3/16	145 – 240	**CW1056A**

Available in Assortments LP812 and LP851. See pages 56 and 58.

338 Carbon Steel Try-Pak

Description	Part No.
338 Electrode, 5 lbs. 1/8", 5/32" and 3/32", in AC34 Rack	**LP857**

Premium Carbon Steel Electrodes and Wires

Specially formulated for welding steel in typical maintenance applications where welding through dirty, rusty or scaled surfaces may be required. These products have premium operability designed to minimize prep time, weld out-of-position and provide stronger than typical weld repairs.

Superior Advantages

- Outstanding cleaning action
- High strength
- Excellent out-of-position
- Low spatter

Typical Applications

- Heavy equipment
- Structural steel
- Automotive
- Galvanized steel

Certanium® 701 AC-DC Electrode

For deeper penetration

Tensile Strength: 90,000 PSI

Yield Strength: 81,000 PSI

Elongation: 26%

Polarity: AC or DC Reverse

Usage Procedure

Operates equally well with any power source or polarity. Excellent results with small, portable, low open-circuit voltage AC welders ("buzz boxes"). Use low amperage for thin metals; increase for thicker types or high-speed operations.

Dia. (Inches)	Amps (Flat/Overhead)	Amps (Vertical)	Part No.
3/32	50 – 90	50 – 80	**P12798**
1/8	80 – 120	70 – 110	**P12804**
5/32	100 – 140	90 – 130	**P12807**
3/16	110 – 180	100 – 160	**P12815**

331M-FC MIG Wire

For all-position, multi-pass welding of carbon steels.

Tensile Strength: Up to 90,600 PSI

Yield Strength: Up to 82,700 PSI

Elongation: 26%

Gas: 75% Ar, 25% CO_2 or 100% CO_2

Dia. (Inches)	Part No.
.035	**CW5906**
.035	**CW5907**
.035	**CW5908**
.045	**CW5909**
.045	**CW5911**
1/16	**CW5914**

331M MIG Wire

Tensile Strength: 86,000 PSI

Yield Strength: 72,000 PSI

Elongation: 26%

Gas: 75% Ar, 25% CO_2 or 100% CO_2

Dia. (Inches)	Part No.
.030	**CW5129**
.030	**CW5130**
.030	**CW5131**
.035	**CW5132**
.035	**CW3777**
.035	**CW3308**
.045	**CW3778**
.045	**CW3309**
1/16	**CW3310**

376M-FC** MIG Wire

Self-shielded, all-position, flux cored wire for welding thin carbon steel and general-purpose mild steel repairs. Requires no shielding gas and is ideal for welding flat or out of position.

No Shielding Gas Required

Tensile Strength: 76,000 PSI

Elongation: To 29%

Polarity: **DC Straight**

Gas: None

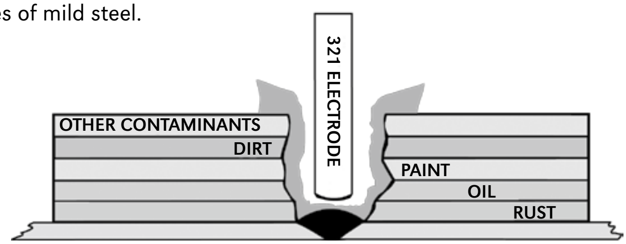
**376M-FC eliminates cold lapping and reduces distortion due to its ability to run at lower heat input and higher travel speeds.

Dia. (Inches)	Part No.
.030	**CW3713**
.030	**CW3100**
.035	**CW1793**
.035	**CW1792**
.035	**CW1770**
.045	**CW1771**
.045	**CW1772**
1/16	**CW1773**
5/64	**CW5261**

CARBON STEEL Alloys

Deep Penetrating Carbon Steel Electrodes and Wires

Formulated to cut through rust and other contaminants, providing solid, sound and dense weld deposits on all types of mild steel.



Superior Advantages
- Saves time – welds through all types of contaminants
- Deep penetrating for pipe root passes
- Produces strong, dense weld deposits

Typical Applications
- Sheet, plates, angles, beams, channels and joining of all mild steel structures
- Galvanized sheet
- Machinery and machine parts
- Automotive and truck bodies
- Pipes, tanks, containers

321 Electrode

Usage Procedure

Maintain a short arc to reduce heat buildup in the base metal and keep distortion to a minimum. Weaving is seldom necessary, except when welding vertical-up. Pass-over-pass can be deposited without chipping slag. Slag coverage chips off easily after cooling. Machine or grind to desired dimensions.

Tensile Strength: 76,000 PSI

Yield Strength: 66,000 PSI

Hardness: Rb 75-80

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	40 – 80	**CW1811**
3/32	40 – 80	**CW1811A**
1/8	75 – 125	**CW1810**
1/8	75 – 125	**CW1810A**
5/32	110 – 170	**CW1809**
5/32	110 – 170	**CW1809A**
3/16	140 – 215	**CW1808A**

321M MIG Wire

Tensile Strength: 76,000 PSI

Yield Strength: 66,000 PSI

Hardness: Rb 75-80

Gas: 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.024	**CW1796**
.024	**CW1782**
.030	**CW1797**
.030	**CW1783**
.030	**1480162**
.035	**CW1801**
.035	**CW1784**
.035	**CW1931**
.045	**CW1932**

321T TIG Wire

Tensile Strength: 76,000 PSI

Yield Strength: 66,000 PSI

Hardness: Rb 75-80

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1010**
1/16 x 36	**CW1011**
3/32 x 36	**CW1008**
1/8 x 36	**CW1007**

Alloy Selector Guide and Welding Procedures
Tool Steels

Cronatron™
A LAWSON BRAND

Stick Electrodes

B	344	Rc 59–63	29
C	345	Rc 54–58	30
F	349	Rc 33–36	30

TIG Wires

B	344T	Rc 59–63	29
C	345T	Rc 54–58	30
D	346T	Rc 56–62	29
F	349T	Rc 33–36	30

T = TIG

Bead Profiles and Techniques

Desired Bead Profile	Uniform tight stringer beads with adequate penetration.
Technique	Stringer beads should be used, with careful attention paid to eliminating notches and areas of stress concentration.
Helpful Hints	It is best to position the workpiece in the flat position with slight incline, welding up the incline. Peen between passes.
Preheat	Hold at stated preheat temperature for one hour per one inch thickness followed by a slow cool.
Base Metal ID	If unsure about the type of tool steel, it is safer to weld with 345 and use a higher than normal preheat.

Group	Description	Common Metal Grades
B	D/M-Series Tool Steels (High-Speed)	D2, M2, (Preheat 900°F to 950°F)
C	H-Series Tool Steels (Hot Work) S-Series Tool Steels (Shock Resistant) O-Series Tool Steels (Oil Hardening)	H11, H12, H13 (Preheat 700°F to 1,000°F) S1, S5, S7 (Preheat 500°F to 600°F) O1, O6 (Preheat 300°F to 400°F)
D	A-Series Tool Steels (Air Hardening)	A2, A4, A6 (Preheat 300°F to 400°F)
F	Chrome-Moly and Mold Steels	A217, 4130, 4140, 4340 (Preheat 450°F to 550°F)

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
B – D/M Series Tool Steels	<1"	900	900	Preheat Temp.	1,000	Tool steels have good weldability as long as proper preheat and welding procedures are followed. Tightly control interpass temperatures to prevent tempering base material. Refer to Cronatron's Tool Steel Chart for more details on temperatures and procedures.
	1" – 2"	950	950	Preheat Temp.	1,000	
	>2"	950	950	Preheat Temp.	1,000	
C – H Series Tool Steels	<1"	800	800	Preheat Temp.	1,000	
	1" – 2"	900	900	Preheat Temp.	1,000	
	>2"	1,000	1,000	Preheat Temp.	1,000	
C – S Series Tool Steels	<1"	500	500	Preheat Temp.	600	
	1" – 2"	550	550	Preheat Temp.	600	
	>2"	600	600	Preheat Temp.	600	
C – O Series Tool Steels	<1"	300	300	Preheat Temp.	400	
	1" – 2"	350	350	Preheat Temp.	400	
	>2"	400	400	Preheat Temp.	400	
D – A Series Tool Steels	<1"	300	300	Preheat Temp.	500	
	1" – 2"	400	400	Preheat Temp.	500	
	>2"	500	500	Preheat Temp.	500	
F – Chrome-moly and Mold Steels	<1"	400	400	Preheat Temp.	500	
	1" – 2"	450	450	Preheat Temp.	500	
	>2"	500	500	Preheat Temp.	500	

For optimal operating parameters, refer to tech sheets.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

Procedure data for various tool die/mold steels using CRONAWELD™, CRONATIG™ and CRONAMIG™ tool steel alloys

Recommended Alloy for SMAW & GMAW (2)	TIG Alloy Equivalent DCSP	AISI-SAE Designation (1)	Hardened Base Metal			Guidelines for Base Metal Heat Treatment (3)						
			Preheat °F (°C)	Postheat °F (°C)	Normal H Rc as Deposited	Annealing Temperature °F (°C)	Preheat °F (°C)	Postheat °F (°C)	Hardening Temperature °F (°C)	Quench Media	Normal Tempering Temperature °F (°C)	Resulting Hardness H Rc
Cronaweld 340 Cronamig 340M	Cronatig 340T (340Mit) (20T)	400 Series Stainless Steel	300/400 (149/204)	Slow Cool	40/42				According to Base Metal			40/42
Cronaweld 345 (4) (Cronamig 345M) (219)	Cronatig 345T (345Mit) (19T)	Shock-Resistant S1 S5 S7	500/600 (260/316)	500/600 (260/316)	52/56	S1-1,475 (802) S5-1,450 (788) S7-1,500/1,550 (816/843)	300/500 (149/260)	300/500 (149/260)	S1-1,750 (954) S5-1,600 (871) S7-1,725 (940)	Oil Oil Air or Oil	300/500 500 Minutes 400/425 DBL*	55/57 55/59 56/58
Cronaweld 344 (211)	Cronatig 344T (344Mit) (11T)	High-Speed Steel D2, M2	900/950 (482/510)	900/950 (482/510)	59/61	1,650 (899)	700/900 (371/482)	700/900 (371/482)	1,850 (1,010)	Air	900/925 DBL* (482/495)	58/60
Cronaweld 345 (Cronamig 345M) (219)	Cronatig 345T (345Mit) (19T)	Hot-Worked H11 H12 H13	700/1,000 (371/538)	500/1,000 (371/538)	52/58	H11-1,600 (871) H12-1,625 (885) H13-1,600 (871)	900/1,200 (482/649)	900/1,200 (482/649)	1,850 (1,010)	Air	1,000/1,150 DBL* (538/621)	40/50
(Cronaweld 346) (215)	Cronatig 346T (346Mit) (15T)	Air-Hardening A2, A4, A6	300/400 (149/204)	300/400 (149/204)	56/62	1,650 (899)	300/500 (149/260)	300/500 (149/260)	1,775 (968)	Air	350/400 DBL* (177/204)	59/60
Cronaweld 345 (4) (Cronamig 345M) (219)	Cronatig 345T (345Mit) (19T)	Oil-Hardening 01 06	300/400 (149/204)	300/400 (149/204)	56/62	01-1,450 (788) 06-1,425/1,450 (775/788)	300/400 (149/204)	300/400 (149/204)	01-1,475 (802) 06-1,450/1,500 (788/816)	Oil	300/450 (149/232)	61/63
Cronaweld 349 (720)	Cronatig 349T (349Mit) (72T)	Chrome-Moly and Mold Steels P20	450/550 (232/288)	450/550 (232/288)	33/36	1,400/1,450 (760/788)	450/550 (232/288)	450/550 (232/288)	1,500/1,600 (816/871)	Oil	900/1,100 (482/593)	29/35
Cronaweld 349	Cronatig 349T (349Mit)	Tool Steel Buildup and Joining	According to Base Metal	According to Base Metal	32/40				According to Base Metal			

DBL = Double Tempering   ( ) Former matching alloys, available through special orders.

NOTES:

(1) CRONATIG 345T is recommended when base metal analysis is unknown, since it is compatible with most tool steel types.

(2) When welding a cracked die or joining two pieces of tool steel together, the weld metal does not need to be of matching analysis or hardness (except at cutting edges or wear surfaces). It is often advisable to use a filler material of lower strength and higher ductility, leaving approximately 3/16" (4.8mm) for finishing with the required tool steel alloy. CRONAWELD 349/349T is widely recommended for this application as a shock absorber between the base metal and the finishing tool steel alloy. It is important that the cushion layer is thoroughly covered or premature wear will result.

(3) Heat-treating data are for guidelines only. Contact Cronatron's Engineering Department for actual heat-treating procedures. The properties listed in this chart are typical or average values based on laboratory tests conducted by the manufacturer. They are indicative only of the results obtained in such tests and should not be considered as guaranteed maximums or minimums. Materials must be treated under actual service to determine their suitability for a particular purpose.

4) 345 can be used for shock-resistant and oil-hardening tool steels, although the "as deposited" chemistry may not match the base metal.

Tool Steel Electrodes and Wires

A broad selection of premium alloys to use for nearly any tool steel application and repair.

Superior Advantages

- Crack-resistant
- Premium operability
- High wear resistance

Typical Applications

- Various tool steel repairs – specific alloy selection is dependent upon the type (or Series) of tool steel being repaired
- Forming dies, cutting tools and high impact tools

Repair and increase the service life of damaged and dull cutting edges with 344 and 345.

- **Rc 62 as deposited thru-hardness**
- **Excellent for tire shredders and paper cutter blades**

"D" and "M" Series

This alloy was formulated for welding the "D" and "M" Series, due to its very high percentage of carbon and alloy additions of chromium, molybdenum and vanadium. The deposits are air-hardenedable and require high preheat temperatures for welding types D-2, M-2.

Usage Procedure

Refer to Procedure Data table on page 28.

344 Electrode

Hardness: Rc 59-63

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 90	**CW1068**
1/8	80 – 120	**CW1067**
5/32	115 – 150	**CW1812**

344T TIG Wire

Hardness: Rc 59-63

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1982**
1/16 x 36	**CW1886**
3/32 x 36	**CW1887**

"A" Series, Medium Alloy Cold Work Steel

An air-hardening tool steel containing manganese, chromium, molybdenum and vanadium. These alloying elements provide deep air-hardening characteristics with minimal distortion. This alloy also has a high carbon content providing weld deposits with high wear resistance. Types: A2, 4, 6.

346T TIG Wire

Hardness: Rc 56-62

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1984**
1/16 x 36	**CW1892**

TOOL STEEL Alloys

Tool Steel Electrodes and Wires

A broad selection of premium alloys to use for nearly any tool steel application and repair.

Superior Advantages

- Crack-resistant
- Premium operability
- High wear resistance

Typical Applications

- Various tool steel repairs – specific alloy selection is dependent upon the type (or Series) of tool steel being repaired
- Forming dies, cutting tools and high impact tools

Universal and "H" Series, Chromium Hot Work Tool Steel

The principal elements in this alloy are chromium, tungsten, moly and vanadium. This chemistry provides an extremely tough deposit with deep air-hardening capabilities up to 12". Types: H11, 12, 13, S1, S7, 01, 06.

345 Electrode

Hardness: Rc 54-58

Polarity: AC or DC Straight

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW1864**
1/8	85 – 115	**CW1863**
5/32	110 – 130	**CW1862**

345T TIG Wire

Hardness: Rc 54-58

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.020 x 18	**CW4829***
.035 x 36	**CW1983**
1/16 x 36	**CW1888**
3/32 x 36	**CW1889**
5/32 x 36	**CW1891**

**Micro alloy size*

"P" Series, Mold Steels and Chrome-Moly Steels

This alloy was specially formulated for welding P-mold steels and most of the chrome-moly alloy steels. The primary alloying elements are chromium and molybdenum. The deposits are relatively soft but they do respond to post-weld heat treatment procedures similar to AISI 4130. Die-castings, injection molds and chrome-moly steels like AISI types 4130, 4140, 4340, 8620 and 8640.

349 Electrode

Tensile Strength: 89,700 PSI

Yield Strength: 73,400 PSI

Elongation: 26%

Hardness: Rc 33-36

Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW4852**
1/8	100 – 140	**CW4853**
5/32	130 – 180	**CW4854**

349T TIG Wire

Tensile Strength: 89,700 PSI

Yield Strength: 73,400 PSI

Elongation: 26%

Hardness: Rc 33-36

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.020 x 18	**CW4841***
.035 x 36	**CW1986**
1/16 x 36	**CW1979**
3/32 x 36	**CW1980**
1/8 x 36	**CW1981**

**Micro alloy size*

Alloy Selector Guide and Welding Procedures
Alloy Steels

Cronatron™ A LAWSON BRAND

Stick Electrodes

A	340	(140,000 PSI)	(Rc 40)	33
B	349	(89,700 PSI)	(Rc 33-36)	34
C	333*	(125,000 PSI)	(235 BHN)	57, 58

MIG Wires

A	340M	(140,000 PSI)	(Rc 40)	33
C	333M*	(125,000 PSI)	(235 BHN)	58

TIG Wires

A	340T	(140,000 PSI)	(Rc 40)	33
B	349T	(89,700 PSI)	(Rc 33-36)	34
C	333T*	(125,000 PSI)	(235 BHN)	58

See Dissimilar Steels Welding Alloys Section (All Weldable Steels)

Certanium®

Stick Electrodes

C	707*	(120,000 PSI)	(Rc 20-23)	59

MIG Wires

C	707M*	(120,000 PSI)	(Rc 20-23)	59

TIG Wires

C	707T*	(120,000 PSI)	(Rc 20-23)	59

See Dissimilar Steels Welding Alloys Section (All Weldable Steels)

Bead Profiles and Techniques

Desired Bead Profile	Fillet welds should be flat to slightly convex with smooth transitions.
Technique	Stringer beads are best.
Helpful Hints	Minimize heat input to decrease HAZ grain growth.
Preheat	Hold at stated preheat temperature for one hour per one inch thickness.

Group	Description	Common Metal Grades
A	Nickel Chrome-Moly Alloy Steels	43XX, 4340
B	Chrome-Moly Alloy Steels	A217, 41XX, 4130, 4140
C	Most 300 Series Stainless Steel and Dissimilar Steels	201, 202, 205, 301, 302, 304, 305, 308, 309, 310, Carbon Steels, Cast Steels

For optimal operating parameters, refer to the product page.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

ALLOY STEELS

Alloy Selector Guide and Welding Procedures

Alloy Steels

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
Group A – Nickel Chrome-Moly Alloy Steels	<1"	500	Depends	500	N/A	Easily susceptible to cracking. Controlling hydrogen (use hotbox) and using proper preheat is critical to success. A PWHT (Post Weld Heat Treatment) is sometimes done to regain optimal characteristics. A typical stress relief can be done at about 1,200°F and held for one hour per one inch of base metal, followed by a slow cool.
	1" – 2"	500	Depends	500	N/A	
	>2"	500	Depends	500	N/A	
Group B – Chrome-Moly Alloy Steels	<1"	200	Depends	200	N/A	Better weldability than Nickel Chrome-Moly steels but still susceptible to cracking. Controlling hydrogen (use hotbox) and using proper preheat is critical to success. A PWHT (Post Weld Heat Treatment) is sometimes done to regain optimal characteristics.
	1" – 2"	300	Depends	300	N/A	
	>2"	400	Depends	400	N/A	
Group C – Most 300 Series Stainless Steel and Dissimilar Steels	<1"	100	Depends	100	N/A	With the selection of Cronatron 333 or Certanium® 707, most alloyed steels, stainless steels, carbon steels and cast steels can be welded with little or no preheat. They can be welded to similar composition base materials as well as dissimilar composition base materials. A PWHT (Post Weld Heat Treatment) is rarely done since materials of varying chemistry would result in non-uniform characteristics.
	1" – 2"	200	Depends	200	N/A	
	>2"	300	Depends	300	N/A	

For optimal operating parameters, refer to the product page.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

400 Series Martensitic Stainless Steel Electrodes and Wires

The ultimate thermo-reactive welding alloy for use with 400 Series stainless steels, such as 410, 416 and 420. Can also be used on chrome-moly steels.

Superior Advantages

- Produces smooth, dense, porosity- and crack-free weld deposits
- Resistant to moderate corrosion and heat scaling (up to 1,200°F)
- Hard with excellent machinability
- Ideally suited for high temperature applications (up to 800°F)

Usage Procedure

Maintain a short arc with minimal weave.
Preheat as prescribed by base metal.

Typical Applications

- Tubular frames and roll bars
- Forging dies
- Fractured tools and blades
- Shaft buildup
- Bearing surfaces
- Metal-to-metal wear

340 Electrode

Tensile Strength: 140,000 PSI
Elongation: 25%
Hardness: Rc 40
Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW1028**
1/8	85 – 120	**CW1029**
5/32	95 – 140	**CW1030**

340T TIG Wire

Tensile Strength: 140,000 PSI
Elongation: 25%
Hardness: Rc 40
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1972**
1/16 x 36	**CW1973**
3/32 x 36	**CW1988**

340M MIG Wire

Tensile Strength: 140,000 PSI
Elongation: 25%
Hardness: Rc 40
Gas: 98% Ar, 2% O_2

Dia. (Inches)	Part No.
.035	**CW3430**
.045	**CW3431**

ALLOY STEELS

Chrome-Moly Alloy Steel Electrodes and Wires

Specially formulated for welding P-mold steels and most chrome-moly alloy steels.

Superior Advantages

- Crack-resistant
- Premium operability
- High wear resistance

Usage Procedure

Maintain a short arc with minimal weave.
Preheat as prescribed by base metal.

Typical Applications

- Die-casting dies
- Injection molds
- Compression molding of plastics and chrome-moly steels like AISI 4130, 4140, 8620 and 8640

349 Electrode

Tensile Strength: 89,700 PSI
Yield Strength: 73,400 PSI
Elongation: 26%
Hardness: Rc 33-36
Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW4852**
1/8	100 – 140	**CW4853**
5/32	130 – 180	**CW4854**

349T TIG Wire

Tensile Strength: 89,700 PSI
Yield Strength: 73,400 PSI
Elongation: 26%
Hardness: Rc 33-36
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.020 x 18	**CW4841***
.035 x 36	**CW1986**
1/16 x 36	**CW1979**
3/32 x 36	**CW1980**
1/8 x 36	**CW1981**

**Micro alloy size*

Alloy Selector Guide and Welding Procedures

Cast Irons

Cronatron™ A LAWSON BRAND

Stick Electrodes

A	211	(84,000 PSI)	36, 37
B	222	(65,000 PSI)	38
C	235	(60,000 PSI)	38

MIG Wires

A	211M-FC	(74,000 PSI)	37

TIG Wires

A	211T	(60,000 PSI)	37

Certanium®

Stick Electrodes

A	889SP	(84,000 PSI)	38

TIG Wires

A	89T	(73,300 PSI)	38

T = TIG
M = MIG
FC = Flux Core

Group	Description	Common Metal Grades
A	Best General Cast Iron Repair	For (Gray, Ductile, Malleable) Cast Irons.
B	Machinable	Weld Deposit is Easily Machinable.
C	Iron Adding	For Contaminated, Rusty or Burned Out Castings.

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
Group A – Joining or Repair of Gray, Ductile, Malleable Cast Irons	<1"	600	Depends	600	N/A	Most cast irons are generally weldable with the proper procedure and proper electrode. White or Ni-Hard castings are not weldable. After welding, a stress-relief can be used to improve ductility by heating casting to 1,200°F and holding for one hour per one inch of thickness. Always slow cool.
	1" – 2"	700	Depends	700	N/A	
	>2"	800	Depends	800	N/A	
Group B – Cast Irons with Machining	<1"	600	Depends	600	N/A	Higher preheats along with a slow cool will improve machinability.
	1" – 2"	700	Depends	700	N/A	
	>2"	800	Depends	800	N/A	
Group C – Iron Adding for Contaminated or Burned-Out Castings	<1"	600	Depends	600	N/A	When a casting is oily, contaminated or burned out, it helps to preheat and then weld with 235. The extra deoxidizers and cleansing agents will improve subsequent pass welding. This will help eliminate the contamination and add iron. It is best to weld the cover passes with a Group A or B product.
	1" – 2"	600	Depends	600	N/A	
	>2"	600	Depends	600	N/A	

For optimal operating parameters, refer to the product page.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

CAST IRON Alloys

PROBLEM SOLVER

Cronatron 211

Premium Cast Iron Electrodes and Wires

PROBLEM:

Repair welding of dirty, oily and contaminated cast iron

- Porosity
- Slag inclusion
- Cracking
- Machining required

Steel to cast iron welding

Out-of-the-way repairs required

- No pre-heat available
- Equipment dismantling required to reach repair site

SOLUTION:

Cronatron 211 Premium Cast Iron Electrodes and Wires

- Welds on all weldable cast irons, including grey, ductile, nodular and Meehanite®
- Provides porosity-free welds, even on dirty, oily or rusty cast iron
- Fully machinable
- Re-melting slag for pass-over-pass welding without slag inclusion
- Provides strong welds, even on steel to cast iron
- No pre-heat required for many repairs
- Perform all-position welding

APPLICATIONS

- Automotive and transportation
  - Transmission cases
  - Engine blocks and heads
- Machinery and moving parts
  - Gear teeth and bull wheels
  - Pulleys
  - Pump impellers
  - Pump housings
  - Bearing housings

Makes even the most difficult cast iron repairs easy

Premium Cast Iron Electrodes and Wires

All-position welding for any type of weldable cast iron repair and cast iron to steel.

Superior Advantages

- High strength welds
- Fully machinable
- Pass-over-pass welding to save time
- All-position welding may eliminate the need to dismantle equipment to perform repairs

Typical Applications

- Pump and bearing housings
- Cylinder blocks and heads
- Machine bases
- Manifolds and exhaust systems

211 Electrode

Usage Procedure

Use AC or DC reverse polarity. Generally, where a narrow, thin bead is desired, a straight polarity application is suggested.

Tensile Strength: Up to 84,000 PSI

Hardness: 185 – 240 BHN

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	55 – 95	**CW1035**
1/8	75 – 110	**CW1034***
5/32	120 – 150	**CW1033**

**Available in Assortments LP813 and LP851.* *See pages 56 and 58.*

211T TIG Wire

Soft, ductile (copper/nickel) TIG filler wire provides excellent elongation for crack sensitive cast iron repairs. Excellent machinability and sealing properties for repairs on cylinder heads, blocks and thin castings such as water jackets.

Tensile Strength: Up to 60,000 PSI

Hardness: 185 – 240 BHN

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1901**
3/32 x 36	**CW1902**
1/8 x 36	**CW1903**

211M-FC MIG Wire

Usage Procedure

Use direct current electrode positive (Reverse Polarity) with 98% argon/2% oxygen as the shielding gas. For best results, set wire amperage and adjust voltage for the smoothest operation. Some types of cast iron may need to be preheated prior to welding.

Tensile Strength: 74,000 PSI

Elongation: 12%

Hardness: Rb 87

Gas: 98% Ar, 2% O_2

Dia. (Inches)	Part No.
.035	**CW2065**
.035	**CW2066**
.045	**CW2057**
.045	**CW2058**
1/16	**CW2059**

CAST IRON Alloys

Premium Cast Iron Electrodes and Wires

All-position welding for any type of weldable cast iron repair and cast iron to steel.

Superior Advantages

- High strength welds
- Fully machinable
- Pass-over-pass welding to save time
- All-position welding may eliminate the need to dismantle equipment to perform repairs

Typical Applications

- Pump and bearing housings
- Cylinder blocks and heads
- Machine bases
- Manifolds and exhaust systems

Usage Procedure:

Remove grease, scale and other impurities from weld area. Bevel cracks or breaks (70° to 90° “V”). CRONACUT™ 1100 is the fastest and easiest method to prepare section for weld repairing. Use a short to medium arc at the lowest possible amperage for best results. Employ weaving technique or stringer beads. Peen to relieve stress. Remove slag between passes. Slow cooling to room temperature recommended.

Certanium® 889SP Electrode

For all cast irons – even steel to cast iron

Tensile Strength: Up to 84,000 PSI

Hardness: 180 – 222 BHN

Polarity: AC or DC Straight or Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 100	**P12001A**
3/32	60 – 100	**P12001**
1/8	85 – 120	**P12003A**
1/8	85 – 120	**P12003***
5/32	90 – 140	**P12006A**
5/32	90 – 140	**P12006**
3/16	120 – 170	**P12009A**
3/16	120 – 170	**P12009**

**Available in Assortment LP849. See page 25.*

889 Cast Iron Repair Pak

Description	Part No.
5 lbs. 1/8" 889SP Electrode, 2 lbs. 5/32" 889SP Electrode, 2 lbs. 1/8" 100 Electrode in AC34 Rack	**LP853**

235 Electrode

Iron-adding

235 is specifically formulated for welding on burned, rusty, corroded or otherwise contaminated cast iron parts not requiring machining.

Tensile Strength: 60,000 PSI

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/8	80 – 120	**CW1037**

Cronacast™ 222 Electrode

Easily machinable cast iron repairs

The high nickel content in 222 provides for easy machinability.

Tensile Strength: 65,000 PSI

Hardness: 170 – 200 BHN

Polarity: AC or DC Straight or Reverse

Dia. (Inches)	Amps	Part No.
3/32	40 – 75	**CW1861**
1/8	80 – 110	**CW1036**
5/32	100 – 140	**CW1835**

Alloy Selector Guide
Stainless Steels and Nickel Alloys

Cronatron™ A LAWSON BRAND

Stick Electrodes

B	333*	(125,000 PSI)		57, 58
B	3330*	(127,000 PSI)		60
B	3333*	(125,000 PSI)	Excellent at Vertical or Overhead	60
E	340	(140,000 PSI)		48
A4	377	(95,000 PSI)		45
A2	382	(82,000 PSI)		44
A1	383	(80,000 PSI)		41
C	3000	(100,000 PSI)		46
C	3010	(110,000 PSI)		46
A2	3880	(90,000 PSI)		43
A2	3881	(84,000 PSI)	Excellent at Vertical or Overhead, Low Carbon	42
A5	3990	(84,000 PSI)		47

MIG Wires

A3	329M	(95,000 PSI)	Low Carbon	44
A3	329M-FC	(95,000 PSI)	Low Carbon	44
B	333M*	(125,000 PSI)		58
E	340M	(140,000 PSI)		48
A2	3880M	(85,000 PSI)	Low Carbon	43
A2	3880M-FC	(90,000 PSI)	Low Carbon	43
A1	383M	(80,000 PSI)	Low Carbon	41

TIG Wires

B	333T*	(125,000 PSI)		58
E	340T	(140,000 PSI)		48
A1	383T	(80,000 PSI)		41
C	3000T	(100,000 PSI)		46
C	3010T	(110,000 PSI)		46
D	3220T	(109,000 PSI)		47
A2	3880T	(90,000 PSI)	Low Carbon	43
A2	3880T-C	(90,000 PSI)	Low Carbon	44

**See Dissimilar Steels Welding Alloys Section (All Weldable Steels)*

Certanium®

Stick Electrodes

A3	706**	(101,000 PSI)	81
B	707*	(120,000 PSI)	59
A6	710	(89,000 PSI)	45

MIG Wires

A3	706-FC**	(95,000 PSI)	81
B	707M*	(120,000 PSI)	59

TIG Wires

B	707T*	(120,000 PSI)	59

**See Dissimilar Steels Welding Alloys Section (All Weldable Steels)*

***See Hardfacing Alloys Section*

T = TIG
M = MIG
FC = Flux Core

Bead Profiles and Techniques

Desired Bead Profile	Uniform tight stringer beads with adequate penetration. Minimize base metal dilution. The weld bead should have convex profile.
Technique	Stringer beads should be used, with careful attention paid to eliminating notches, crater cracks and areas of stress concentration. Use backstep technique to avoid crater cracks.
Helpful Hints	Be extra cautious of notches and crater cracks.
Preheat	Austenitic keep cool (300 Series), Martensitic keep hot (400 Series).
Base Metal ID	Austenitic materials are non-magnetic to slightly magnetic. Martensitic materials are magnetic and harder than typical stainless steel.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

STAINLESS STEELS and NICKEL Alloys

Alloy Selector Guide

Stainless Steels and Nickel Alloys

Group	Description	Common Metal Grades
A1	200 and 300 Series – "Austenitic"	201, 202, 205, 301, 302, 304, 305, 308, 347, 348
A2	200 and 300 Series – "Austenitic"	201, 202, 205, 301, 302, 304, 305, 308, 316, 347, 348
A3	200 and 300 Series – "Austenitic"	309
A4	200 and 300 Series – "Austenitic"	310
A5	200 and 300 Series – "Austenitic"	Carpenter 20, 320, 321, 329
A6	200 and 300 Series – "Austenitic"	317
B	Dissimilar	Stainless Steels, Tool Steels, HSLA, Carbon Steels, Cast Steels, Unknown Steel
C	Nickel Alloys	Monel®, Inconel, Hastelloy
D	Duplex Stainless	329, 2205, Ferralium 255
E	Most 400 Series "Martensitic"	403, 410, 414, 420, 431
!!!	**CAUTION:** Call Lawson Engineering at 1-866-529-7664, when asked about welding these grades.	**303, 416, 440s**

Welding Procedures

Stainless Steels and Nickel Alloys

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
A – Austenitic – 200 and 300 Series Stainless	<1"	70°	N/A	N/A	225°	The easiest group of stainless steels to weld. Minimize base metal dilution by keeping heat input low. A wet rag can be immediately applied to weld area to keep interpass temperature low.
	1" – 2"	70°	N/A	N/A	225°	
	>2"	70°	N/A	N/A	225°	
B – Most Stainless and Dissimilar Steels	<1"	N/A	N/A	N/A	N/A	If there is any doubt as to the base metal composition or joining dissimilar grades together, use Cronatron 333 or Certanium 707®. Preheat is typically not necessary.
	1" – 2"	N/A	N/A	N/A	N/A	
	>2"	N/A	N/A	N/A	N/A	
C – Nickel Alloys	<1"	70°	N/A	N/A	400°	Moderately easy to weld, nickel alloys can be welded with little or no preheat. To weld properly, maintain a short arc length while using a slight drag angle along with a weave not to exceed 2 times the electrode diameter. Try to not overheat the base metal to minimize excessive grain growth.
	1" – 2"	70°	N/A	N/A	400°	
	>2"	70°	N/A	N/A	400°	
D – Duplex Stainless	<1"	100°	N/A	N/A	300°	Prevent rapid cooling after welding.
	1" – 2"	150°	N/A	N/A	300°	
	>2"	200°	N/A	N/A	300°	
E – Martensitic – 400 Series Stainless Steels	<1"	500°	Slow cool	500°	N/A	Difficult to weld because of the higher carbon content and susceptibility to cracking. A thorough preheat followed by a slow cool after welding yields the best success.
	1" – 2"	550°	Slow cool	550°	N/A	
	>2"	600°	Slow cool	600°	N/A	
CAUTION – Difficult to Weld Stainless Steels – 303, 416, 440s	<1"	N/A	N/A	N/A	N/A	The only way to weld these is to "butter" the mating surfaces while minimizing dilution and then join with 333 or 707. Even doing everything right, successful joining without cracking is difficult.
	1" – 2"	N/A	N/A	N/A	N/A	
	>2"	N/A	N/A	N/A	N/A	

For appropriate product selection, refer to previous page.

For optimal operating parameters, refer to tech sheets.

Popular Stainless Steel Welding Alloys and Part Numbers

Welding Alloys:			Certanium® General Purpose		Cronatron Maximum Performance		
Process	AWS Class	Dia. (Inches)	Part No.	Pkg. Qty. (Lbs.)	Cronatron Product	Part No.	Pkg. Qty. (Lbs.)
MIG	ER316L	.024			3880M	CW1795	2
		.030			3880M	CW1813	2
		.030			3880M	CW1778	10
		.035	41700	10	3880M	CW1814	2
		.035	41701	25	3880M	CW1775	10
		.035			3880M	CW1938	25
		.045	41702	10	3880M	CW1776	10
		.045	41703	25	3880M	CW1939	25
		1/16	41704	25	3880M	CW1777	10
	ER308L	.030			383M	CW5149	10
		.035	41712	10	383M	CW5151	2
		.035	41713	25	383M	CW5152	10
		.035			383M	CW5153	25
		.045	41714	10	383M	CW5155	10
		.045	41715	25			
		1/16	41716	25			
	ER309L	.035	41724	10			
		.035	41725	25			
		.045	41726	10			
		.045	41727	25			
		1/16	41728	25			
TIG	ER316L	.035			3880T	CW1989	2
		1/16	41705	10	3880T	CW1023	2
		3/32	41706	10	3880T	CW1022	2
		1/8	41707	10	3880T	CW1800	2
		5/32			3880T	CW3272	2
	ER308L	1/16	41717	10	383T	CW5175	2
		3/32	41718	10	383T	CW5176	2
		1/8	41719	10	383T	CW5177	2
	ER309L	1/16	41729	10			
		3/32	41730	10			
		1/8	41731	10			
Stick	E316L	3/32	41708	10	3881	CW1805	5
		1/8	41709	1	3881	CW1806	5
		1/8	41710	10	Try Pak	LP856	2 lbs. ea.*
		5/32	41711	10			
	E308L	5/64			383	CW2706	5
		3/32	41720	10	383	CW5172	5
		1/8	41721	1	383	CW5173	5
		1/8	41722	10			
		5/32	41723	10			
	E309L	3/32	41732	10			
		1/8	41733	1			
		1/8	41734	10			
		5/32	41735	10			

**Includes 1/8" and 3/32" diameters*

STAINLESS STEELS and NICKEL Alloys

Austenitic Stainless Steel Electrodes and Wires

Smooth-running, all-position alloys for joining the most common 200 and 300 Series stainless steel. Joins dissimilar grades of stainless including Series 200, 301, 302, 303, 304, 305 and 308 stainless, and CF-8, CF-3, CF-20 and HF castings.

Superior Advantages

- Minimal carbide precipitation
- Excellent corrosion and heat resistance
- All-position welding reduces the need to dismantle equipment
- Easy slag removal saves time

Typical Applications

- Piping and tubing
- Food and medical processing equipment
- Housings and impellers
- Tanks and vats

383 Electrode

Tensile Strength: 80,000 PSI
Elongation: 35%
Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 70	**CW5172**
1/8	85 – 115	**CW5173**
5/64	20 – 40	**CW2706**

383T TIG Wire

Tensile Strength: 80,000 PSI
Elongation: 35%
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW5175**
3/32 x 36	**CW5176**
1/8 x 36	**CW5177**

383M MIG Wire

Tensile Strength: 80,000 PSI
Elongation: 35%
Gas: 98% Ar, 2% O_2 or 90% He, 7.5% Ar, 2.5% CO_2

Dia. (Inches)	Part No.
.030	**CW5148**
.030	**CW5149**
.035	**CW5151**
.035	**CW5152**
.035	**CW5153**
.045	**CW5155**

SMART Tip

When welding on Austenitic or 300 series stainless steels, it is important to keep the base metal below 400°F (204°C).

PROBLEM SOLVER

3881 Electrode

Premium Austenitic Stainless Steel Electrodes

PROBLEM:

Difficult to reach, out-of-position repairs on stainless steel pipes, tanks and containers

- Lack of time or inability to disassemble parts or equipment for repair
- Need to make repairs in the overhead position

Carbide precipitation and corrosion

- Poor corrosion resistance
- Base/weld metal cracking

Repairs required on pipes with dripping water present

SOLUTION:

3881 Electrode Premium Austenitic Stainless Steel Electrodes

- Fast freeze deposition allows welding in overhead and vertical positions
- No slag inclusions or cracking when welding vertical-down
- High molybdenum content resists pitting corrosion
- Resists carbide precipitation (sensitization)
- 3881 will seal the joint as you weld vertical-down

APPLICATIONS

- Food processing equipment
  - Pipes
  - Fixtures
  - Tables
- Hospital equipment
- Storage containers
  - Tanks
  - Drums
  - Vats
  - Canisters

Deposits sound x-ray quality welds

X-ray quality welds, smooth-running in all positions for joining the most common grades of stainless steels including 303, 304, 307, 308, 309, 316, 317 and the low carbon "L" version of these alloys.

Superior Advantages

- Minimal carbide precipitation
- Excellent resistance to corrosion and heat
- All-position welding reduces the need to dismantle equipment
- Easy slag removal saves time

Usage Procedure:

Use AC or DC reverse polarity with normal maintenance welding procedures. Surface area should be as clean as possible. However, Cronaweld™ Eagle 3881 is manufactured with special cleansing and fluxing agents to promote sound welds under most conditions. For vertical-down welding, hold a short arc and tilt the electrode 10° in the direction of travel, using a stringer bead technique.

3881 Electrode

Excellent Vertical-down and Overhead

Designed specifically to deposit sound ray quality welds in the vertical-down position.

Tensile Strength: 84,000 PSI

Elongation: 40%

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 75	**CW1805**
1/8	75 – 90	**CW1806***

Available in Assortment LP813. See page 56.

AUSTENITIC STAINLESS STEEL Alloys

Premium Austenitic Stainless Steel Electrodes

X-ray quality welds, smooth-running in all positions for joining the most common grades of stainless steels including 303, 304, 307, 308, 309, 316, 317 and the low carbon "L" version of these alloys.

Superior Advantages

- Minimal carbide precipitation
- Excellent resistance to corrosion and heat
- All-position welding reduces the need to dismantle equipment
- Easy slag removal saves time

Typical Applications

- Piping and tubing
- Food and medical processing equipment
- Housings and impellers
- Tanks and vats

3880 Electrode

Extra Low Carbon

Tensile Strength: 90,000 PSI

Elongation: Up to 42%

Polarity: AC or DC Reverse

Usage Procedure

Use AC or DC reverse polarity with normal maintenance welding procedures. Surface area should be as clean as possible. However, Cronaweld™ 3880 is manufactured with special cleansing and fluxing agents to promote sound welds under most conditions. Hold a medium to short arc and tilt electrode 10° in direction of travel. Remove slag between passes.

Dia. (Inches)	Amps	Part No.
1/16	30 – 55	**CW1885**
3/32	50 – 70	**CW1884**
1/8	85 – 115	**CW1883**
5/32	115 – 145	**CW1882**

3880T TIG Wire

Extra Low Carbon

Tensile Strength: 90,000 PSI

Elongation: Up to 42%

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1989**
1/16 x 36	**CW1023**
3/32 x 36	**CW1022**
1/8 x 36	**CW1800**
5/32 x 36	**CW3272**

3880M MIG Wire

Extra Low Carbon

Tensile Strength: 85,000 PSI

Elongation: Up to 42%

Gas: 98% Ar, 2% O_2 or 90% He, 7.5% Ar, 2.5% CO_2

Dia. (Inches)	Part No.
.024	**CW1795**
.030	**CW1813**
.030	**CW1778**
.035	**CW1814**
.035	**CW1775**
.035	**CW1938**
.045	**CW1776**
.045	**CW1939**
1/16	**CW1777**

3880M-FC MIG Wire

Extra Low Carbon

Tensile Strength: 90,000 PSI

Elongation: Up to 42%

Gas: 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.035	**CW3089**
.045	**CW3088**

Specialty Alloys

3880T-C TIG Wire

Flux-cored for stainless steel root passes with no shielding gas backup.

Tensile Strength: Up to 90,000 PSI

Elongation: Up to 42%

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
3/32 x 39	**CW3508A**

382 Electrode

All-position stainless steel for buildup and joining.

Tensile Strength: 80,000 PSI

Elongation: 35%

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 75	**CW1518**
1/8	70 – 90	**CW1519**

Maximum Versatility Austenitic Stainless Steel Wires

Ideally suited for welding AISI 309 stainless steel to itself and for welding 300 Series stainless steels to carbon steels.

Superior Advantages

- Crack-resistant due to a high Ferrite Number (FN)
- High heat resistance – in-service temperatures up to 1,000°F (538°C)

Typical Applications

- Pipelines
- Storage tanks and valves
- Hydroelectric components
- Stainless steel to carbon steel

329M MIG Wire

Tensile Strength: 95,000 PSI

Yield Strength: 76,500 PSI

Elongation: 33%

Gas: 90% He, 7.5% Ar, 2.5% CO_2 or 98% Ar, 2% O_2

Dia. (Inches)	Part No.
.035	**CW3503**
.035	**CW3504**
.062	**CW3506**

329M-FC MIG Wire

Tensile Strength: 95,000 PSI

Yield Strength: 76,500 PSI

Elongation: 33%

Gas: 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.035	**CW3501**
.035	**CW5133**
.045	**CW5134**

AUSTENITIC STAINLESS STEEL Alloys

Austenitic Stainless Steel Electrodes

High resistance to heat and corrosion with high-impact and high-strength characteristics.

Superior Advantages

- Extremely resistant to highly-corrosive acids
- High temperature applications up to1,600°F (871°C)
- Excellent operating characteristics

Typical Applications

- Severe service conditions where chemicals and acids are present
- Paper manufacturing equipment
- Food and chemical processing equipment

Usage Procedure

Use AC or DC reverse polarity. Maintain short arc and deposit stringer beads, peen to relieve stress in crack-sensitive areas. Remove slag between multiple passes. Avoid flat or concave deposits.

377 Electrode

High-temperature: up to 2,100°F (1,149°C). Repairs furnace parts, refinery and chemical processing equipment.

Tensile Strength: 95,000 PSI

Hardness: 190 BHN

Elongation: 50%

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	40 – 70	**CW1071**
1/8	50 – 100	**CW1070**

Nickel Alloy Electrodes and Wires

Compatible with Inconel, other nickel-based alloys, Monel® and dissimilar alloys.

Superior Advantages

- Extremely corrosion-resistant
- High temperature usage – up to 2,000°F (1,093°C)
- Low temperature usage – down to –320°F (–196°C)
- Maximum versatility
- Dissimilar metals joining

Typical Applications

- Furnaces and boilers
- Heat treat baskets
- Power plants
- Chemical processing

Usage Procedure

Use DC reverse polarity with normal maintenance welding procedures. Surface should be as clean as possible. Hold a short arc and tilt electrode 10° in the direction of travel. Remove slag between passes. Preheating the weld metal is not necessary unless the base metal and/or thickness require it. Do not weave more than twice the diameter of the core wire.

Withstands operating temperatures from –320°F to +2,000°F (–196°C to +1,093°C).

3000 Electrode

Tensile Strength: 100,000 PSI
Elongation: 33%
Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 70	**CW1992**
1/8	80 – 120	**CW1991**
5/32	125 – 145	**CW1990**

3000T TIG Wire

Tensile Strength: 100,000 PSI
Elongation: 33%
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1995**
3/32 x 36	**CW1996**
1/8 x 36	**CW1997**

3010T TIG Wire

Tensile Strength: 110,000 PSI
Elongation: 30%
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1976**
3/32 x 36	**CW1977**
1/8 x 36	**CW1978**

Specialty Alloys

For Use on Carpenter 20 and Alloy 20 Stainless

3990 Electrode

3990 Electrode is the ultimate stainless electrode for maintenance and repair of equipment subjected to the extreme corrosion conditions typical of petrochemical, pulp and paper industries. The unique formula of precision-balanced elements, including extra molybdenum and columbium, react synergistically to resist the problem of intergranular corrosion, pitting and chloride stress corrosion cracking.

Tensile Strength: 84,000 PSI

Hardness: Rb 210

Elongation: 48%

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 70	**CW1845**
1/8	85 – 120	**CW1844**
5/32	115 – 140	**CW1843**

Duplex Stainless Steel Wires

Duplex stainless steel combines the best of austenitic and ferritic stainless steels, providing increased yield strength and resistance to stress-corrosion cracking (SCC).

Superior Advantages

- Excellent corrosion resistance
- Resistance to stress-corrosion cracking
- High strength
- Superior operability

Typical Applications

- Chemical processing equipment
- Pulp and paper manufacturing machinery

3220T TIG Wire

Tensile Strength: 109,000 PSI

Yield Strength: 87,000 PSI

Elongation: 25%

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
3/32 x 36	**CW3608**
1/8 x 36	**CW3609**

Martensitic Stainless Steel Electrodes and Wires

Specially formulated for welding the 400 Series martensitic stainless steels such as 410, 416 and 420. Primary alloying elements are chromium, nickel and molybdenum so it can also be used on chrome-moly tool steels.

Superior Advantages

- Produces smooth, dense, porosity- and crack-free weld deposits
- Resistant to moderate corrosion and heat scaling (up to 1,200°F)
- Hard with excellent machinability
- Ideally suited for high temperature applications (up to 800°F)

Typical Applications

- Tubular frames and roll bars
- Forging dies
- Fractured tools and blades
- Shaft buildup
- Bearing surfaces
- Metal-to-metal wear

340 Electrode

Tensile Strength: 140,000 PSI
Elongation: 25%
Hardness: Rc 40
Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW1028**
1/8	85 – 120	**CW1029**
5/32	95 – 140	**CW1030**

340M MIG Wire

Tensile Strength: 140,000 PSI
Elongation: 25%
Hardness: Rc 40
Gas: 98% Ar, 2% O_2

Dia. (Inches)	Part No.
.035	**CW3430**
.045	**CW3431**

340T TIG Wire

Tensile Strength: 140,000 PSI
Elongation: 25%
Hardness: Rc 40
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1972**
1/16 x 36	**CW1973**
3/32 x 36	**CW1988**

ALUMINUM and TITANIUM Alloys

Alloy Selector Guide and Welding Procedures

Aluminum, Titanium

Cronatron™ A LAWSON BRAND

Stick Electrodes

B	510	(35,000 PSI)	Non heat-treatable	50

MIG Wires

B	510M	(35,000 PSI)	Non heat-treatable	51
A	556M	(45,000 PSI)	Heat-treatable	51

TIG Wires

B	510T	(35,000 PSI)	Non heat-treatable	51, 66
A	556T	(45,000 PSI)	Heat-treatable	51, 66

Group	Description	Common Metal Grades
A	Aluminum (Heat-treatable)	5XXX, 7XXX
B	Aluminum (Non heat-treatable)	1XXX, 2XXX, 3XXX, 4XXX, 6009, 6010, 6070
C	Titanium	Pure Ti – For Titanium Alloys, see notes below

Helpful Hints – Titanium: Cronatron's 59T can be used to weld pure Titanium and the following alloy grades as long as lower weld strength and increased ductility is acceptable. Alloy grades – 0.15Pd, 5Al-2.5Sn, 8Al-1Mo-1V, 8Mn, 6Al-4V, 6Al-1V, 13V-11Cr-3Al, 6Al-2Cb-1Ta-1Mo, 15V-3Al-3Sn-3Cr, 11Mo-6Zr-4.5Sn, 15Mo-2.7Nb-3Al-0.2Si, 6Al-2Sn-4Zr-2Mo, 6Al-2.75Sn-4Zr-0.4Mo-0.45Si

Bead Profiles and Techniques

Desired Bead Profile	Fillet welds should be slightly concave with smooth transitions. Undercutting and even weld spatter can greatly affect the fatigue life of a weld.
Technique	Multiple torch angles and weave techniques are acceptable.
Helpful Hints	Cleanliness of base metal and filler metal is critical to success. All metals listed react strongly to the atmosphere and inert shielding is required.
Base Metal ID	Vinegar will not affect aluminum. Titanium is usually a dull gray color and when ground emits pure white sparks.

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
A – Aluminum (Heat-Treatable 5XXX, 7XXX)	<1"	70°	Depends	N/A	N/A	These alloys in general are more susceptible to cracking, particularly crater cracks. Preheating, while sometimes necessary, can greatly reduce the weld strength. If preheat is necessary on large fabrications, preheat should be under 200°F. A full PWHT can restore base metal and weld metal properties. Use 75% Argon and 25% Helium for thick sections.
	1" – 2"	100°	Depends	N/A	N/A	
	>2"	150°	Depends	N/A	N/A	
B – Aluminum (Non Heat-Treatable 1XXX, 2XXX, 3XXX, 4XXX, 6XXX)	<1"	100°	N/A	N/A	N/A	A modest preheat is sometimes used to overcome the high thermal conductivity of aluminum. Use 75% Argon and 25% Helium for thick sections.
	1" – 2"	150°	N/A	N/A	N/A	
	>2"	200°	N/A	N/A	N/A	
C – Titanium	<1"	None	Depends	N/A	250°	Cleanliness is vital to sound welds. Must be TIG welded with an inert shielding gas. Keep gas coverage on weld until it cools to 300°F.
	1" – 2"	None	Depends	N/A	250°	
	>2"	None	Depends	N/A	250°	

For optimal operating parameters, refer to tech sheets.

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

Popular Aluminum Welding Alloys and Part Numbers

Welding Alloys:			Certanium® General Purpose		Cronatron Maximum Performance		
Process	AWS Class	Dia. (Inches)	Part No.	Pkg. Qty. (Lbs.)	Cronatron Product	Part No.	Pkg. Qty. (Lbs.)
MIG	ER4043	.030			510M	CW1794	1
		.035	41736	1	510M	CW1940	1
		.035	41737	15	510M	CW3530	5
		.035			510M	CW1941	16
		.045	41738	1	510M	CW3531	5
		.045	41739	15			
		3/64			510M	CW1943	16
		1/16	41740	15	510M	CW1944	16
	ER5356	.030			556M	CW5157	1
		.035	41744	1	556M	CW5160	1
		.035	41745	15	556M	CW5161	5
		.035			556M	CW5162	15
		.045	41746	1			
		.045	41747	15			
		3/64			556M	CW5163	1
		1/16	41748	15			
TIG	ER4043	1/16	41741	5	510T	CW1016	2
		3/32	41742	5	510T	CW1015	2
		1//8	41743	5	510T	CW1014	2
	ER5356	1/16	41749	5	556T	CW3269	2
		3/32	41750	5	556T	CW3270	2
		1//8	41751	5	556T	CW3271	2
Stick	E4043	3/32			510	CW1826	2
		1/8			510	CW1039	2
		5/32			510	CW1038	2

ALUMINUM Alloys

PROBLEM SOLVER

Cronatron 510

Non Heat-Treatable Aluminum Electrodes and Wires

PROBLEM:

Needing special equipment for aluminum repairs

- Repairing aluminum usually requires special MIG or TIG equipment and the use of inert shielding gases that may not be readily available

Poor weldability

- If you have ever tried using a typical aluminum stick electrode, it can be frustrating at best with the spatter and inconsistency of deposit

SOLUTION:

No Special Equipment

- Cronatron 510 will allow you to use your existing D/C stick welding machine to make aluminum repairs easily without time consuming changing of equipment or gases
- Cronatron 510 stick electrode can also be used as a gas welding or brazing rod if all you have is oxy-fuel equipment

Great Welds

- Hold a tight arc and you will be amazed at the ability of Cronatron 510 to lay a nice consistent weld bead

APPLICATIONS

- Boat repairs
- Aluminum castings
- Piping
- Appliances
- Trailers
- Farm equipment

510 Electrode

Tensile Strength: 35,000 PSI

Polarity: DC Reverse

Usage Procedure

Maintain the shortest arc possible, using DC reverse polarity only. On large heavy sections, preheating to 400°F (204°C) will produce faster, flatter deposit with no splatter. Electrode should be held almost perpendicular and use a rapid stringer or weaving technique with a backwhip at the crater. Bevel pieces 75° on sections 1/8" (3.2mm) or thicker.

Dia. (Inches)	Amps	Part No.
3/32	55 – 80	**CW1826**
1/8	90 – 140	**CW1039***
5/32	105 – 160	**CW1038**

**Available in Assortment LP813. See page 56.*

Non Heat-Treatable Aluminum Electrodes and Wires

Highly versatile alloys for all weldable types of aluminum including sheet, forgings, extrusions and castings.

Superior Advantages

- Stable, quiet arc with no undercutting
- Good corrosion resistance

Usage Procedure

Maintain the shortest arc possible, using DC reverse polarity only. On large heavy sections, preheating to 400°F (204°C) will produce faster, flatter deposit with no splatter. Electrode should be held almost perpendicular and use a rapid stringer or weaving technique with a backwhip at the crater. Bevel pieces 75° on sections 1/8" (3.2mm) or thicker.

510M MIG Wire

Tensile Strength: 35,000 PSI
Yield Strength: 12,000 PSI
Elongation: 12%
Gas: 100% Ar

Dia. (Inches)	Part No.
.030	**CW1794**
.035	**CW1940**
.035	**CW3530**
.035	**CW1941**
.045	**CW3531**
3/64	**CW1942**
3/64	**CW1943**
1/16	**CW1944**

510T TIG Wire

Tensile Strength: 35,000 PSI
Polarity: AC/High Frequency
Gas: Argon/Helium

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1016**
3/32 x 36	**CW1015**
1/8 x 36	**CW1014**

Heat-Treatable Aluminum Wires

High-strength alloy for joining alloyed grades of aluminum.

Superior Advantages

- Extremely versatile – use in a wide variety of applications
- Good combination of corrosion resistance, strength, toughness and workability
- Great for anodizing

Typical Applications

- Fill casting defects
- Reinforce weak joints
- Build up missing or broken aluminum sections

556T TIG Wire

Tensile Strength: 45,000 PSI
Yield Strength: 23,000 PSI
Elongation: 14%
Polarity: AC/High Frequency
Gas: Argon/Helium

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW3269**
3/32 x 36	**CW3270**
1/8 x 36	**CW3271**

556M MIG Wire

Tensile Strength: 45,000 PSI
Yield Strength: 23,000 PSI
Elongation: 14%
Gas: 100% Ar

Dia. (Inches)	Part No.
.030	**CW5157**
.035	**CW5160**
.035	**CW5161**
.035	**CW5162**
3/64	**CW5163**

COPPER and BRASS Alloys

Alloy Selector Guide and Welding Procedures

Copper and Brass

Cronatron™
A LAWSON BRAND

Stick Electrodes

C/D	625	(110,000 PSI)	55
A	667	(35,000 PSI)	54

MIG Wires

C/D	625M	(110,000 PSI)	55
B	665M	(58,000 PSI)	54

TIG Wires

C/D	625T	(110,000 PSI)	55
B	665T	(58,000 PSI)	54

T = TIG
M = MIG

Bead Profiles and Techniques

Desired Bead Profile	Fillet welds should be slightly concave with smooth transitions.
Technique	Multiple torch angles and weave techniques are acceptable.
Helpful Hints	Cleanliness of base metal and filler metal is critical to success. All metals listed react strongly to the atmosphere and inert shielding is used.
Base Metal I.D.	Aluminum bronzes tend to be gold in color while pure copper can be darker with a slight reddish tint.

Group	Description	Common Metal Grades
A	Pure Coppers	Pure Copper
B	Most Bronzes	Silicon Bronze, Phosphor Bronze
C	Aluminum Bronzes	Aluminum Bronze, Silicon Bronze, Copper-Nickel Alloys, Copper-Zinc Alloys, Manganese Bronze, Most Dissimilar Bronzes, Metal to Metal Wear
D	Dissimilars	Phosphor Bronze, Copper or Bronze Castings (For thick sections preheat to 400°F)

Helpful Hints: Welding copper-based alloys requires significantly higher current than welding steels due to high thermal conductivity. Preheat can be used when weld bead appears cold or on mostly pure copper because of high thermal conductivity. Welding-related distortion of metal is significantly higher in copper and bronze alloys.

Group	Thickness	Preheat °F	Postheat °F	Minimum Interpass °F	Maximum Interpass °F	Description
A – Pure Copper	<1"	600°	N/A	600°	N/A	These alloys have very high thermal conductivity, which creates the need for high preheat. Using Argon with some Helium will improve penetration and is very helpful, particularly on thicker or larger sections.
	1" – 2"	700°	N/A	700°	N/A	
	>2"	800°	N/A	800°	N/A	
B – Most Bronzes (Silicon, Phosphor, Beryllium)	<1"	200°	N/A	200°	N/A	A modest preheat is sometimes used to overcome the high thermal conductivity of these copper alloys. Using Argon with some Helium will improve penetration and is very helpful, particularly on thicker or larger sections.
	1" – 2"	300°	N/A	300°	N/A	
	>2"	400°	N/A	400°	N/A	
C – Aluminum Bronze	<1"	70°	Depends	N/A	300°	On thin sections, little or no preheat is typically used in this classification. Using Argon with some Helium will improve penetration and is very helpful, particularly on thicker or larger sections.
	1" – 2"	150°	Depends	N/A	300°	
	>2"	200°	Depends	N/A	300°	
D – Dissimilar	<1"	200°	N/A	200°	N/A	Minimize dilution when welding to iron (Fe) based materials. The preheat on the copper or brass material needs to be about 200°F to 600°F (93°C to 316°C) higher. Sometimes buttering the steel is necessary.
	1" – 2"	300°	N/A	300°	N/A	
	>2"	400°	N/A	400°	N/A	

Fumes generated by welding are HAZARDOUS. Take the necessary PRECAUTIONS and READ the product MSDS.

For optimal operating parameters, refer to tech sheets.

Pure Copper, Bronze and Dissimilar Electrodes and Wires

An assortment of alloys for various copper, brass and bronze repairs.

Superior Advantages

- Corrosion-resistant
- Excellent color matches
- Highly versatile

Typical Applications

- Steel to copper repairs
- Galvanized steel
- Bronze valves and fittings

Usage Procedure

Use DC reverse polarity. A close arc should be maintained using a weave or stringer bead technique. Hold electrode perpendicular to workpiece. Preheating is unnecessary on light gauge material. Heavy sections should be preheated to 850°F to 1,000°F (454°C to 538°C). Slag can be removed easily with light chipping or brushing after cooling.

667 Electrode

Pure copper for high electrical conductivity

Tensile Strength: 35,000 PSI

Elongation: 50%

Hardness: Rb 50-70

Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
1/8	100 – 130	**CW1868**

665T TIG Wire

Bronze/Dissimilar

Tensile Strength: 58,000 PSI

Hardness: Rb 60

Polarity: AC or DC Straight

Gas: 100% Ar

Technical Tip

Use argon gas for both 665T and 665M. When welding copper or copper alloys to steel, direct heat to copper and allow alloy to wash onto steel.

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1841**
3/32 x 36	**CW1840**
1/8 x 36	**CW1839**

665M MIG Wire

Bronze/Dissimilar

Tensile Strength: 58,000 PSI

Hardness: Rb 60

Gas: 100% Ar

Dia. (Inches)	Part No.
.035	**CW5123**

COPPER and BRASS Alloys

Aluminum Bronze Electrodes and Wires

Welds most ferrous and non-ferrous metals and joins most combinations of dissimilar metals (except white metals).

Superior Advantages
- Tough, crack-free, machinable welds
- Easy arc control with little preheat
- High frictional wear resistance
- High strength

Usage Procedure

Use DC reverse polarity. Clean surfaces of grease, rust or scale. Use short arc with weave or stringer bead. No preheating required, except on heavy sections: 500°F (260°C) steel; 900°F (482°C) copper. For TIG use direct current straight polarity (electrode–). Clean surfaces of grease, rust, scale, etc. Use pure argon gas or a mixture of argon/helium for heavy sections. Set the flow rate at 15 to 20 CFH. For best results, use a gas lens collet body. Amperage will depend on base metal type/thickness and wire diameter.

Typical Applications
- Brass, bronze or cast iron to steel
- Gear teeth, valves and castings
- Impellers, cams and shafts

Bronze Ring Attached to Cast Iron Cap

625 Electrode

Tensile Strength: 110,000 PSI
Hardness: Rc 21-23
Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 75	**CW1859**
1/8	100 – 120	**CW1045**
5/32	120 – 140	**CW1044**
3/16	140 – 180	**CW1043**

625T TIG Wire

Tensile Strength: 110,000 PSI
Hardness: Rc 21-23
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW3266**
3/32 x 36	**CW3267**
1/8 x 36	**CW3268**

625M MIG Wire

Tensile Strength: 110,000 PSI
Hardness: Rc 21-23
Gas: 100% Ar

Dia. (Inches)	Part No.
.035	**CW5166**
.045	**CW5167**

Alloy Selector Guide and Welding Procedures

Dissimilar Steels

Cronatron™ A LAWSON BRAND

Stick Electrodes

A	333	(125,000 PSI)	57, 58
A	3330	(127,000 PSI)	60
A	3333	(125,000 PSI)	60

MIG Wires

A	333M	(125,000 PSI)	58

TIG Wires

A	333T	(125,000 PSI)	58

Certanium®

Stick Electrodes

A	707	(120,000 PSI)	59

MIG Wires

A	707M	(120,000 PSI)	59

TIG Wires

A	707T	(120,000 PSI)	59

T = TIG
M = MIG

Group	Description	Common Metal Grades
A	Most 300 Stainless Steels and Dissimilar	201, 202, 205, 301, 302, 304, Carbon Steels, Cast Steels

DISSIMILAR STEEL Alloys

PROBLEM SOLVER

Cronatron 333

Dissimilar Steel Electrodes and Wires

PROBLEM:

Repairs to unknown, dissimilar or crack-sensitive steels

- Steels of unknown composition
- Unknown steels to join together
- Previous experience with weld-induced cracking

Broken studs and bolts

- Removing the bolt without damaging the threads
- Broken or stuck easy-outs, taps and drills
- Out-of-position or difficult to reach work areas

SOLUTION:

Cronatron 333 Dissimilar Steel Electrodes and Wires

- Can be used on any steel, even when the composition is unknown
- Use in any position
- Resists cracking
  - Resists carbon-induced cracking on high alloy and carbon steels
  - Has high tensile strength and excellent elongation
- Easily extract broken bolts, regardless of position
  - Works on surface or below surface breaks
  - Works on oxidized (rusted) bolts
- No need to drill and tap or use easy-outs
- Specially designed flux protects threads

APPLICATIONS

- Automotive and trucking
  - Leaf springs
  - Worm drives
  - Broken stud removal
- Manufacturing facilities
  - Equipment parts
  - Dissimilar steels

Dissimilar Steel Electrodes and Wires

All-position alloys for joining dissimilar steels – provides high-strength, crack-free welds on all combinations of weldable steel.

Superior Advantages

- Takes the guesswork out of alloy selection – can be used on ANY weldable steel
- High strength and elongation provide strong, crack-free welds
- Smooth, quiet arc, easy slag release

Usage Procedure

Use AC or DC reverse polarity. Maintain a medium to short arc. A stringer or weave bead is recommended for flat and horizontal welds.

333 Electrode

Tensile Strength: 125,000 PSI
Yield Strength: 100,000 PSI
Elongation: Up to 35%
Hardness: 235 BHN
Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/16	30 – 45	**CW1877**
3/32	60 – 90	**CW1049***
1/8	80 – 120	**CW1048***
5/32	110 – 160	**CW1047**
3/16	160 – 240	**CW1046**

*Available in Assortments LP812 and LP813. See page 56.

333 Steel Try-Pak

333M MIG Wire

Tensile Strength: 125,000 PSI
Yield Strength: 100,000 PSI
Elongation: Up to 35%
Hardness: 235 BHN
Gas: 90% He, 7.5% Ar, 2.5% CO_2 or 98% Ar, 2% O_2

Dia. (Inches)	Part No.
.035	**CW1787**
.035	**CW1936**
.045	**CW1786**
.045	**CW1937**

333T TIG Wire

Tensile Strength: 125,000 PSI
Yield Strength: 100,000 PSI
Elongation: Up to 35%
Hardness: 235 BHN
Polarity: DC Straight
Gas: 100% Ar

Dia. x Length (Inches)	Part No.
.035 x 36	**CW1993**
1/16 x 36	**CW1898**
3/32 x 36	**CW1899**
1/8 x 36	**CW1900**

DISSIMILAR STEEL Alloys

Dissimilar Steel Electrodes and Wires

All-position alloys for joining dissimilar steels – provides high-strength, crack-free welds on all combinations of weldable steel.

Superior Advantages

- Takes the guesswork out of alloy selection – can be used on ANY weldable steel
- High strength and elongation provide strong, crack-free welds
- Smooth, quiet arc, easy slag release

Typical Applications

- Automotive and trucking
- Rotors, blades and augers
- Pump and cast steel housings
- Broken stud removal
- Tool steels

Certanium® 707 Electrode

Tensile Strength: 120,000 PSI

Yield Strength: Up to 96,000 PSI

Elongation: 20%

Hardness: Rc 20-23

Polarity: AC or DC

Dia. (Inches)	Amps	Part No.
1/16	25 – 50	**P12655A**
1/16	25 – 50	**P12655**
5/64	40 – 75	**P12720A**
5/64	40 – 75	**P12720**
3/32	60 – 90	**P12565A**
3/32	60 – 90	**P12565**
1/8	90 – 130	**P12610A**
1/8	90 – 130	**P12610***
5/32	110 – 160	**P12705A**
5/32	110 – 160	**P12705**
3/16	140 – 190	**P12710A**
3/16	140 – 190	**P12710**

Available in Assortment LP849. See page 25.

Specialty Alloys

3330 Electrode

Exceptional out-of-position welding

High-strength, dissimilar steel joining. Excels in out-of-position applications. Vertical-up and overhead.

Tensile Strength: 127,000 PSI

Elongation: 37%

Hardness: 235 BHN

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 75	**CW1874**
1/8	75 – 100	**CW1873**
5/32	100 – 145	**CW1872**
3/16	140 – 185	**CW1871**

Stud Stretcher Kit

Broken Bolt Removal

An assortment of electrodes – enough to remove up to 150 broken bolts – complete with instructions in a handy storage drawer.

Description	Part No.
Repair Kit with AC34 Drawer	**CW3030**

Kit contains 333 in four sizes: 5/32" (1 lb.), 1/8" (2 lbs.), 3/32" (1.5 lbs.), 1/16" (0.5 lbs.); 3330 in 3/32" size (1 lb.)

3333 Electrode

Fast-freeze flux for vertical-down

Tensile Strength: 125,000 PSI

Elongation: Up to 35%

Hardness: 235 BHN

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW5696**
1/8	80 – 120	**CW5697**

BRAZING Alloys

Alloy Selector Guide

Silver Brazing Alloys for all Steels and Critical Applications

Cronatron™ A LAWSON BRAND

Premium

41F	(80,000 PSI)	1,135°F	Multi-purpose	63
42	(88,000 PSI)			64
43F	(88,000 PSI)	1,100°F	High-strength and low melt	64
45	–	1,220°F	Copper applications	62
46SP	–	1,190°F	Copper	62
47SP	–	1,300°F	Copper and brass	62

Environmentally and Chemistry Sensitive

40B/40F	(85,000 PSI)	1,140°F	Cadmium-free	64

Certanium®

Environmentally and Chemistry Sensitive

51F	(73,000 PSI)	1,300°F	Cadmium-free	64
52/52F	(70,000 PSI)	1,330°F	Cadmium-free – Good conductivity	63, 66
57F-CF	(70,000 PSI)	1,170°F	Cadmium-free – General purpose	64

Dissimilar Brazing Alloy

53	(17,500 PSI)	360°F		67

Cast Iron Brazing Alloys

Cronatron™ A LAWSON BRAND

Premium

22	(53,000 PSI)	1,800°F – 2,300°F	True match	65
23F	(68,000 PSI)	1,400°F – 1,600°F	Multipurpose flux-coated	65
30F	(100,000 PSI)	1,300°F – 1,600°F	Multipurpose with extra-high tensile	65

Aluminum Brazing Alloys

Cronatron™ A LAWSON BRAND

Aluminum

52	(40,000 PSI)	720°F	Low melt, self-fluxing	63, 66
54C	(34,500 PSI)	1,100°F	Internal flux	66
556T	(45,000 PSI)	1,200°F	Good capillary action (Use F56 flux)	66
510T	(35,000 PSI)	1,200°F	Low melt (Use F56 flux)	66

Copper and Brass Brazing Alloy

Cronatron™ A LAWSON BRAND

Premium

44	(42,000 PSI)	1,190°F – 1,300°F	Excellent conductivity	67
45	(92,000 PSI)	1,190°F – 1,260°F	Copper and copper alloys	62

Low Silver Brazing Alloys

These “sil-phos” alloys provide cost-effective solutions to joining copper and brass alloys.

Superior Advantages

- Thin flow provides excellent capillary action
- No flux required for copper-to-copper applications
- Fills gaps on poor fit-up joints

Typical Applications

- Electrical components
- Plumbing and HVAC
- Copper coils and tubing
- Rotors and armatures

Usage Procedure

Heat broad area using large torch tip; a neutral flame is suggested, and a distance of 2" to 3" from the base metal produces the best results. No flux is required on copper-to-copper welds. The joint area should be clean. When the copper turns dull red, the alloy should be applied and the flame should be kept in constant motion ahead of the rod. These alloys are especially effective on long lap joints, fillets and butts.

45 Brazing Alloy

Resists vibration, shock, impact

Brazing Range: 1,300°F to 1,450°F (704°C to 788°C)

Recommended Flux: F40 (for dissimilar)

Size (Inches)	Part No.
1/16 x .050 x 18	**CW1858**
1/8 x .050 x 18	**CW1013**

47SP Brazing Alloy

Excellent ductility and conductivity

Brazing Range: 1,300°F to 1,500°F (704°C to 815°C)

Recommended Flux: F40 (for dissimilar)

Size (Inches)	Part No.
1/16 x .050 x 20	**CW5766**
1/8 x .050 x 20	**CW5765**

46SP Brazing Alloy

Fill gaps without affecting joint strength

Brazing Range: 1,325°F to 1,500°F (718°C to 815°C)

Recommended Flux: F40 (for dissimilar)

Size (Inches)	Part No.
1/16 x .050 x 20	**CW5763**
1/8 x .050 x 20	**CW5764**

BRAZING Alloys

Medium Silver Brazing Alloys

With lower melting temperatures and better capillary action than low silver products, medium silver brazing alloys are excellent for joining copper, stainless steel, bronze alloys and nickel alloys.

Superior Advantages

- Thin-flowing for tight joints, yet fills and bridges gaps
- Strong and ductile
- Very good electrical conductivity

Typical Applications

- Electrical rotors, contacts and lugs
- Instrumentation and controls
- Plumbing
- Arts and crafts
- Stainless steel

Usage Procedure

Materials should be smooth and free of burrs or uneven edges. A carburizing oxyacetylene flame should be used, heating a broad surface along the joint line. Keep the flame cone one inch ahead of the alloy rod and a continuous fillet will form. Clean flux residue off with water.

Certanium® 52 Brazing Alloy

Cadmium-free

Tensile Strength: 70,000 PSI

Melting Temperature: 1,250°F to 1,410°F (677°C to 766°C)

Recommended Flux: 950

Dia. x Length (Inches)	Part No.
1/16 x 18	**P14035**

Certanium® 41F Brazing Alloy

Low-temperature application

Flux Coating Color: Red

Tensile Strength: 80,000 PSI

Brazing Range: 1,120°F to 1,150°F (604°C to 621°C)

Recommended Flux: F40 (if needed)

Dia. x Length (Inches)	Part No.
1/16 x 18	**CW1825**
3/32 x 18	**CW1824**

Certanium® 52F Brazing Alloy

Cadmium-free, flux-coated

Flux Coating Color: Yellow

Tensile Strength: 70,000 PSI

Melting Temperature: 1,250°F to 1,410°F (677°C to 766°C)

Recommended Flux: 950 (if needed)

Dia. x Length (Inches)	Part No.
1/16 x 18	**P14070**

High Silver Brazing Alloys

Providing maximum capillary action and the lowest melting temperatures, these high silver products waste less brazing alloy. They have the ability to join many different metals – tool steel, stainless steel, alloy steel, copper and brass alloys and many others.

Superior Advantages

- Thin flow provides excellent capillary action
- Excellent electrical conductivity
- Low melt temperatures

Typical Applications

- Electrical components
- Carbide tipping
- Copper coils and tubing
- Food, beverage and kitchen equipment (cadmium-free products)

Usage Procedure

Materials should be smooth and free of burrs or uneven edges. A carburizing oxyacetylene flame should be used, heating a broad surface along the joint line. Keep the flame cone one inch ahead of the alloy rod and a continuous fillet will form. Clean flux residue off with water.

Certanium® 51F Brazing Alloy

High-strength, cadmium-free

Flux Coating Color: White

Tensile Strength: Up to 73,000 PSI

Elongation: Up to 24%

Melting Temperature: 1,225°F to 1,370°F (663°C to 743°C)

Recommended Flux: 950 (if needed)

Dia. x Length (Inches)	Part No.
1/16 x 18	**P14075**

Certanium® 57F-CF Brazing Alloy

Cadmium-free, flux-coated

Flux Coating Color: Pink

Tensile Strength: 71,000 PSI

Bonding Temperature: 1,140°F to 1,200°F (616°C to 649°C)

Recommended Flux: 950 (if needed)

Dia. x Length (Inches)	Part No.
3/64 x 18	**P14446**
1/16 x 18	**P14447**

42 Brazing Alloy

Bare HI-Silver with low temperature feature

Tensile Strength: Up to 88,000 PSI

Melting Temperature: 1,100°F to 1,135°F (593°C to 613°C)

Recommended Flux: F40

Dia. x Length (Inches)	Part No.
3/64 x 18	**CW1823**
1/16 x 18	**CW1822**
3/32 x 18	**CW1821**

43F Brazing Alloy

General purpose for industrial applications

Flux Coating Color: Blue

Tensile Strength: 88,000 PSI

Bonding Temperature: 1,100°F (593°C)

Recommended Flux: F40 (if needed)

Dia. x Length (Inches)	Part No.
1/16 x 18	**CW1024**

Cadmium-free, use for food, beverage and kitchen equipment

40B Brazing Alloy

Tensile Strength: 85,000 PSI

Melting Temperature: 1,140°F (616°C)

Recommended Flux: F40

Dia. x Length (Inches)	Part No.
1/16 x 18	**CW1925**
3/32 x 18	**CW1926**

40B Ribbon Brazing Alloy

Tensile Strength: 85,000 PSI

Melting Temperature: 1,140°F (616°C)

Recommended Flux: F40

Size (Inches)	Part No.
1 x .005 x 36	**CW3526**

40F Brazing Alloy

Flux Coating Color: Orange

Tensile Strength: 85,000 PSI

Melting Temperature: 1,140°F (616°C)

Recommended Flux: F40 (if needed)

Dia. x Length (Inches)	Part No.
1/16 x 18	**CW1025**

BRAZING Alloys

Cast Iron and Steel Brazing Alloys

A selection of brazing alloys for joining cast iron and brazing sheet metal.

Superior Advantages

- Solid, dense deposits that can be machined
- Free-flowing for thin lapping and butted metal joining
- No base metal dilution making tough cast iron repairs possible

Typical Applications

- Sheet metal and auto body repairs
- Engine heads and blocks
- Piping, plumbing and pumps
- Gears, sprockets and pulleys

22 Brazing Alloy

"True Color Match" Cast Iron

Tensile Strength: 53,000 PSI

Hardness: Rc 18-20

Bonding Temperature: 2,300°F (1,260°C)

Recommended Flux: F22

For Cast Iron Only

Usage Procedure

Use neutral flame and preheat broad area along braze line. Concentrate flame on rod end and allow weld drops to flow on joint. Continue heating until it wets out and continue process. If a second layer is required, hold torch parallel to the work and apply drop-by-drop. When working with cast iron, avoid localized heating and cover finished braze to retard cooling process.

Dia. x Length (Inches)	Part No.
3/16 x 20	**CW3062**
5/16 x 24	**CW1829**

23F Brazing Alloy

Versatile, thin-flowing

Flux Coating Color: Blue

Tensile Strength: Up to 68,000 PSI

Bonding Temperature: 1,400°F to 1,600°F (760°C to 871°C)

Recommended Flux: F21 (if needed)

For Steel or Cast Iron

Dia. x Length (Inches)	Part No.
3/32 x 18	**CW1003**
1/8 x 18	**CW1002**

30F Brazing Alloy

Maximum strength for joining and buildup

Flux Coating Color: Pink

Tensile Strength: 100,000 PSI

Temperature: 1,300°F to 1,600°F (704°C to 871°C)

Recommended Flux: F21 (if needed)

For Steel or Cast Iron

Usage Procedure

Clean joint areas thoroughly. Heat metal with neutral flame until flux liquifies. Base metals should be dull red as Cronabraze™ 30F commences to penetrate the joint. Use rapid weaving motion with torch to deposit alloy drop-by-drop. Do not concentrate heat enough to melt base metal. Remove flux residue with water.

Dia. x Length (Inches)	Part No.
1/16 x 18	**CW1836**
3/32 x 18	**CW1006**
1/8 x 18	**CW1005**
3/16 x 18	**CW1004**

Aluminum Brazing Alloys

A selection of alloys for joining all types of aluminum.

Superior Advantages
- Products for joining and buildup
- Easy to apply

Typical Applications
- Aluminum frames
- Tubing and piping
- Ornamental aluminum
- Cast aluminum

52 Brazing Alloy

High-strength, self-fluxing

Tensile Strength: 40,000 PSI

Bond Strength: 28,000 PSI

Application Temperature: 720°F (382°C)

Usage Procedure

Heat base metal with 1-X acetylene feather flame. Melt off small amount of Cronabraze Eagle™ 52 and scrub (tin) area of repair using a clean stainless steel wire brush. Use circular motion of torch when applying buildup or repair alloy. Copper or carbon block is suggested as a chill bar when soldering thin sections. No flux is required.

Dia. x Length (Inches)	Part No.
1/8 x 18	**CW1735**

54C Brazing Alloy

Flux-cored for all types of aluminum

Tensile Strength: 34,500 PSI

Application Temperature: 1,110°F (599°C)

Recommended Flux: F56 (if needed)

Usage Procedure

Bevel heavy sections to allow 100% weld metal penetration. Broadly heat area to be brazed with a large, soft and slightly carburizing flame to about 1,050°F (566°C). Warm the end of the rod and rub on base metal until flux flows freely. 54C will then begin to wet the base metal. Deposit the 54C to fill the joint. Flux residue may be removed with warm water and brush.

Dia. x Length (Inches)	Part No.
1/8 x 32	**CW1857**

510T TIG Wire

High-strength, all purpose

Tensile Strength: 35,000 PSI

Recommended Flux: F56

Usage Procedure

Bevel heavy sections to allow 100% weld metal penetration. Broadly heat area to be brazed with a large, soft and slightly carburizing flame to about 1,050°F (566°C). Warm the end of the rod and rub on base metal until flux flows freely. Flux residue may be removed with warm water and brush. If additional flux is needed, use F56 flux.

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1016**
3/32 x 36	**CW1015**
1/8 x 36	**CW1014**

556T TIG Wire

High alloy

Tensile Strength: 45,000 PSI

Yield Strength: 23,000 PSI

Elongation: 14%

Recommended Flux: F56

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW3269**
3/32 x 36	**CW3270**
1/8 x 36	**CW3271**

BRAZING Alloys

Copper and Brass Brazing Alloy

For a variety of copper and brass applications.

Superior Advantages

- High strength
- Lower cost compared to silver alloys
- Good color match

Typical Applications

- Electrical contacts
- Copper wire splicing
- Brass and bronze fittings
- Copper pipes
- Copper to steel

Usage Procedure

Use a slightly carburizing flame to obtain a free-flowing bead. Cronabraze™ 44 does not require fusion of the base metal. For joining copper to copper, no flux is required, but with brass or bronze, F40 flux is needed for a strong, sure bond. It is recommended that 2" to 3" of distance be maintained between the flame cone and the base metal for best results.

44 Brazing Alloy

Silver Solder Substitute

Brazing Range: 1,350°F to 1,550°F (732°C to 843°C)

Recommended Flux: F40 (if needed)

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW1838**
3/32 x 36	**CW1012**
1/8 x 36	**CW1837**

Dissimilar Brazing Alloy

Easily joins white and pot metals.

Superior Advantages

- Lead- and cadmium-free
- Extremely low melting point
- Two times stronger than ordinary solder

Typical Applications

- Air conditioning and refrigeration units
- Brazing/soldering of copper to aluminum, brass to steel, stainless to zinc, etc.

Usage Procedure

Base metal must supply heat, as a direct flame is unworkable. A carburizing flame should be used. A flux is required for all applications where good bonding is desired.

53 Brazing Alloy

Low temperature, dissimilar pot metal

Tensile Strength: 17,500 PSI

Application Temperature: 360°F (182°C)

Recommended Flux: F53

Dia. x Length (Inches)	Part No.
1/16 spooled	**CW1842**
1/8 x 18	**CW1017**

FLUXES for Brazing and Soldering

Metallurgically formulated to improve the application of brazing and soldering alloys.

Product	Purpose	For Use With	Size	Part No.	Pkg. Qty.
F21	Steel, stainless steel, brass, bronze, copper, Inconel, Monel® and nickel	23F and 30F Brazing Alloys	1 Lb. Jar	**CW1081**	**1**
F22	Active cleansing action to clean the weld puddle, prevent formulation of hard carbides and promote solid, dense weld deposits on cast iron	22 Brazing Alloy	12 Oz. Jar	**CW1830**	**1**
F40	Effective on tool, stainless and carbon steels, brass, bronze and copper alloys when using a silver brazing alloy	40B/40F, 41F, 42, 43F, 44, 45, 46SP and 47SP Brazing Alloys	1 Lb. Jar	**CW1078**	**1**
F53	Low heat performance to provide cleansing, deoxidation and catalytic action on dissimilar and pot metal applications	53 Brazing Alloy	8 Oz. Jar	**CW1073**	**1**
F56	For all types of weldable aluminum and its alloys. Comes in powder form and melts to a clear liquid when brazing temperature has been reached. Mix with water or alcohol to form a paste	510T, 556T	6 Oz. Jar	**CW1642**	**1**
F930	Highly active paste flux that removes oxides for superior solder bonding. (Not for use on aluminum or magnesium)	92C Soldering Alloy	8 Oz. Jar	**CW1092**	**1**
932	Non-corrosive liquid soldering flux. Ideal for electrical applications	Soldering Alloy	16 Oz. Bottle	**P16565**	**1**
934	Removes dirt, scale, rust and other impurities in preparation for tinning and soft soldering	Soldering Alloy	12 Oz. Bottle 16 Oz. Net Wt. (gel)	**P16500**	**1**
934	Removes dirt, scale, rust and other impurities in preparation for tinning and soft soldering	Soldering Alloy	16 Oz. Bottle (liquid)	**P16570**	**1**
950	All-purpose silver brazing flux to dissolve surface oxides and ensure excellent wetting action	51F, 52/52F, 54/54F and 57F-CF Brazing Alloys	16 Oz. Jar	**P16540**	**1**

SOLDERING Alloys

Lead-Free Solder

For use on potable water systems (plumbing), food and beverage equipment and other high-purity applications.

Superior Advantages

- Completely non-toxic – free of lead, cadmium, arsenic and zinc
- Low heat application
- High strength
- Suitable for stainless steel, copper alloys, steel and nickel alloys

Solid Core

Shear Strength: 11,000 PSI

Recommended Flux: CW1092 paste, P16500 gel or 20552 paste

Alloy Content: Tin, Copper, Antimony, Silver

Description	Content	Dia. (Inches)	Melting Point	Cookson Part No.	Part No.
16 Oz. Spool	Sn/Cu/Sb/Ag	0.125 (1/8)	425°F (218°C)	13945	**20553**
0.75 Oz. Dispenser	Sn/Cu/Sb/Ag	0.062 (1/16)	425°F (218°C)	53945	**20554**

Acid Core

Description	Tin/Antimony Content	Dia. (Inches)	Melting Point	Cookson Part No.	Part No.
1 Oz. Dispenser	95/5	0.062 (1/16)	425°F (218°C)	51950	**20541**

Rosin Core

Description	Tin/Antimony Content	Dia. (Inches)	Melting Point	Cookson Part No.	Part No.
8 Oz. Spool	95/5	0.062 (1/16)	425°F (218°C)	21955	**20545**

Lead-Free Paste Solder and Flux

Description	Tin/Antimony Content	Cookson Part No.	Part No.
6 Oz. Paste Solder Jar	95/5	52955	**20546**
2 Oz. Paste Flux Jar	–	51053	**20552**
P98 16 Oz. Paste Solder Jar			**CW1080**

Lead-Free – Silver Bearing Solder

Acid Core

Description	Content	Dia. (Inches)	Melting Point	Cookson Part No.	Part No.
16 Oz. Spool	Sn/Cu/Sb/Ag	0.125 (1/8)	425°F (218°C)	12945	**20548**
0.9 Oz. Dispenser	Sn/Cu/Sb/Ag	0.062 (1/16)	425°F (218°C)	54945	**20549**

Lead-Free Dissimilar Solders

Silver-reinforced alloy is suitable for all dissimilar metals such as chrome-plated steels, stainless steel, copper, brass and bronze.

Tensile Strength: 22,000 PSI

Temperature: 425°F (218°C)

Recommended Flux: CW1092 paste, P16500 gel or 20552 paste

Superior Advantages

- Lead- and cadmium-free – complies with food and beverage industry restrictions
- Highly resistant to corrosion
- Many times stronger than standard solders – resists vibration
- Low application heat

Typical Applications

- Food, beverage and kitchen equipment
- Hospital equipment
- Instrument repairs
- Vats, tanks and vessels

92C Acid Core Solder Alloy

Not for use in electrical applications

Description	Dia. (Inches)	Part No.
1/16 x 9 Ft. Dispenser	0.062 (1/16)	**CW1020**
16 Oz. Spool	0.062 (1/16)	**CW1021**
16 Oz. Spool	0.125 (1/8)	**CW1816**

92C Solid Core Solder Alloy

Description	Dia. (Inches)	Part No.
16 Oz. Spool	0.062 (1/16)	**CW1819**
16 Oz. Spool	0.125 (1/8)	**CW1818**

92C Rosin Core Solder Alloy

Description	Dia. (Inches)	Part No.
1/16 x 9 Ft. Dispenser	0.062 (1/16)	**CW1815**

Conductaloy™ Super-Set™ Solder

Silver-bearing solder with super-active rosin flux

- Low melting temperature (355°F/179°C) means less chance of heat damage to surrounding parts and circuit boards
- Instant setting helps reduce cold solder joints
- Non-corrosive, non-charring rosin flux core cleans like an acid flux but does not damage delicate printed circuit board traces
- Silver content provides high conductivity

Description	Dia. (Inches)	Part No.
12' Pocket Tube	0.032 (1/32)	**P52064**
11' Pocket Tube	0.062 (1/16)	**P52067**

- Excellent tensile and shear strength, up to 25% stronger than 60/40 solders
- Applications: High-vibration electrical connections, sensitive electronic components and circuit chips, battery cables and terminals, large terminal lugs and hard-to-solder materials

Technical Information

Characteristics	Super-Set™	Ordinary Solder
Tensile Strength	Up to 8,700 PSI	7,500 PSI or Less
Shear Strength	Up to 6,930 PSI	5,500 PSI or Less
Plastic Range	0°	60°
Melt Temperature (°F)	355°	421°
Re-melt Temperature (°F)	355°	361°
Flux Type	Controlled Flux Cored	Liquid or Dry Powder
Wetting Ability	Excellent	Fair
Pre-cleaning of Oxidized Copper	Not Required	Required

SOLDERING Alloys

General-Purpose Soldering Alloys

Rosin Core

- Quick-wetting rosin core helps assure perfect solder connections
- Optimal combination of tensile strength and low melting point prevents damage of sensitive components used in electronics
- For all electrical applications of copper, silver plate, tin plate and gold plate
- Non-corrosive, non-acid core

Description	Tin/Lead Content	Dia. (Inches)	Melting Point	Alpha Fry Part No.	Part No.
16 Oz. Spool	60/40	0.062 (1/16)	376°F (191°C)	11604	**20543**
16 Oz. Spool	60/40	0.093 (3/32)	376°F (191°C)	11649	**20542**
4 Oz. Spool	60/40	0.032 (1/32)	376°F (191°C)	31605	**20556**
8 Oz. Spool	60/40	0.032 (1/32)	376°F (191°C)	21643	**20544**
8 Oz. Spool	60/40	0.062 (1/16)	376°F (191°C)	21604	**20555**

Acid Core

- For all non-electrical applications of copper, steel, nickel plate, brass and tin plate
- Excellent for auto radiators, copper tubing, tools and gutters

Description	Tin/Lead Content	Dia. (Inches)	Melting Point	Alpha Fry Part No.	Part No.
9 Oz. Spool	40/60	0.062 (1/16)	491°F (255°C)	52406	**20540**
16 Oz. Spool	40/60	0.093 (3/32)	460°F (238°C)	12406	**20539**

Solid Core

- Tin/lead content 50/50
- Use on sweat fittings, sheet metal and other big jobs
- Does not contain flux
- 0.125" dia.
- Melting point: 421°F (216°C)
- Recommended fluxes: F930 (Part No. CW1092), 934 Gel (Part No. P16500) and Acid Paste Flux (Part No. 20550)

Description	Tin/Lead Content	Dia. (Inches)	Melting Point	Alpha Fry Part No.	Part No.
16 Oz. Spool	50/50	0.125 (1/8)	421°F (216°C)	13505	**20538**

Solder Paste Flux

Pre-mixed flux in ready-to-use paste form. Apply to joint and heat with a torch or soldering iron.

- Acid flux for all non-electrical applications such as nickel alloys, copper, steel, brass, galvanized iron and tin flux
- Excellent for sweat fittings
- Highly effective acid flux for non-electrical soldering
- Helps keep copper clean during heating, and helps solder wet the copper surface
- Use with acid core, solid core and lead-free solders

Description	Size	Alpha Fry Part No.	Part No.
Acid Paste Flux	2 Oz. Can	51012	**20550**

Hardfacing Product Summary

Assessing the Application:

What size is the media creating the wear problem?

What is the media made of?

At what velocity is the media traveling?

What is the base metal?

What products have been used with moderate success?

What is the product failure risk and does the customer understand the risks?

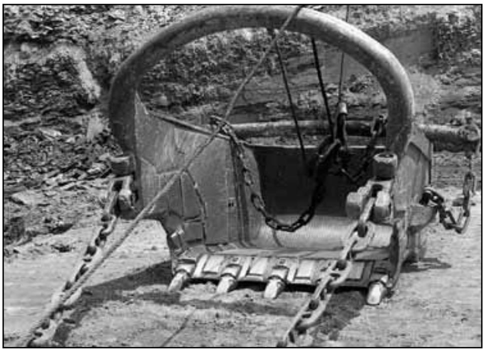
What is the customer's history and skill with hardfacing?

What welding processes can be used?

Other Factors: Are there other wear considerations like heat, friction, corrosion or extreme velocity?

Usage Procedure for Tubular Electrodes

Use 1/4" tubular electrodes at approximately 90A – 100A for edges and out-of-position welding. Use 3/8" and 1/2" tubular electrodes for high deposition. Use AC or DCRP.



Dragline bucket liners

CAUTIONS:

Fine particle impingement creates enormous wear problems. Example: Sand blasting – never use a carbide product in this kind of application. The fine particles of sand will wear out the soft matrix instead of the carbide.

We do not recommend mixing product classes. For example, putting a Martensitic product over an Austenitic buildup. In rare cases we will mix and match some, but you must be very careful when doing this, and the risk of failure increases. Please consult Lawson Engineering for assistance.

We do not recommend applying more than two layers of carbide-bearing material, because the likelihood of chunking or spalling increases rapidly. It is acceptable to put as many layers as needed of Martensitic and Austenitic products.

HARDFACING Alloys

When comparing products in the same group, use the following codes to help differentiate products.

^ = Higher alloyed product
! = Better corrosion resistance
( ) = Certanium® product

Impact ⟵ **Determine impact/abrasion balance to determine best product selection.** ⟶ **Abrasion**

				#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#10	
		Buildup		Austenitic Products	Low Rc Martensitic	High Rc Martensitic	Carbide-Bearing Products								Specialty Products
	Product Description and Contents	**General Purpose and Carbon Steels**	**Multipurpose for All Steels**	**High Manganese**	**High Carbon, Heat-Treated**		**Boron Carbide**	**Low Chrome Carbide**	**Titanium Carbide**	**Moderate Chrome Carbide**	**Stabilized Chrome Carbide**	**High Chrome Carbide**	**Complex Carbide**	**Tungsten Carbide**	**Cobalt, Nickel, Chrome, Boron**
Applications	General Description	Torch cuttable	Non-torch cuttable, work hardens in use	Good impact resistance, poor abrasion resistance	Moderate abrasion resistance and high impact	Good abrasion resistance and significant impact	Good abrasion resistance and moderate impact			Very good abrasion resistance, minimal impact	Good abrasion resistance with improved corrosion resistance	Very good abrasion resistance, little impact	Very good abrasion resistance in corrosive environment	Maximum abrasion resistance	High heat, metal to metal
Applications	Specific	Carbon Steels Hard but easily machinable	Manganese Steel Work hardens in use	Large rock crusher rolls	Large crushers	Medium rock crushers	Fine particle wear	Gravel crushers	Fine particle wear	Auger flights	Dredge pumps	Fork lift tines	Coal oven chutes	Earth core drill	–
				Crushing hammers	Hard but machinable applications	Blade edges and debarkers	Screw conveyors	Chutes – Volleyball size rocks	Buckets – Rock and coal	Chutes – Softball size rocks	Screw conveyor	Chutes – Sand, coal, gravel, etc.	Coke pushers	Coal augers	–
				2 foot boulder at 5 foot drop		Leading edge of buckets	Chromium-free hardfacing	Mining truck beds – Small and medium rock	–	Mining truck beds – Dirt and sand	–	–	Cement paddles	–	–
Hardfacing	Brazing Alloys	–	–	–	–	–	–	–	–	–	–	–	–	75	79
Hardfacing	Wire Alloys	VX-GP	7770M-FC (706FC) VX-MP	7109M-FC (282FC) VX-H1	7540M-FC	^7500M-FC (281FC) VX-H3	VX-H4	(284FC) VX-H5	VX-H6	VX-H7	–	7310M-FC	7000M-FC VX-H10	–	MAD-H 65 and 75
Hardfacing	Tubular Alloys	–	–	–	–	–	–	–	–	7350 (247)	7370 (248)	7330 7355 (246)	!7230	7220 7222A	–
Hardfacing	Stick Alloys	–	7770, 706	777 7108	–	–	–	711 284	–	–	–	–	7000	–	747
	Plate	–	–	–	–	Certa Plates (201)	–		–	Dim 1 (Single)	–	–	–	–	–

LAWSON Products

Hardfacing Alloy Selector Guide

High Abrasion/Low Impact (Carbide Bearing Products)

Cronatron™ A LAWSON BRAND

Stick Electrodes

711	High chrome carbide	Rc 58-63	75

Stick Tubulars

7000	Vanadium/Tungsten carbide	Rc 60	78
7220	Extreme condition with tool steel matrix and complex Tungsten/Chrome carbides	Rc 68	78
7222A	Tungsten carbide	Rc 65	78
7230	High temperature, high abrasion	Rc 65	78
7350	Chrome carbide in austenitic matrix	Rc 64	75
7355	High chrome carbide	Rc 62	76
7370	Martensitic matrix with complex carbides	Rc 64	77

MIG Wires

711FC	Medium chrome carbide	Rc 56-58	75
7000M-FC	Vanadium/Tungsten carbide	Rc 60	78
7310M-FC	Chrome carbide. Good for overlaying on Manganese steels	up to Rc 57	77
MAD-H	Premium, maximum abrasion-resistant product (see Specialty Wear Section)	Rc 63-77	78

Torch Brazing

75	Tungsten carbide	–	78

Moderate Abrasion/Moderate Impact (Martensitic)

Cronatron™ A LAWSON BRAND

Stick Electrodes

750	79

MIG Wires

7500M-FC	79
7540M-FC	79

Certanium®

MIG Wires

281M-FC	79

Buildup

Cronatron™ A LAWSON BRAND

Stick Electrodes

7770	81

MIG Wires

7770M-FC	81

Wearplate and Tiles

Dimension 1	84
Certawear 201 Tiles	84

Certanium®

Stick Electrodes

706	81

MIG Wires

706M-FC	81

Volume

Cronatron™ A LAWSON BRAND

MIG Wires

VX-H1	83
VX-H3	83
VX-H4	83
VX-H5	83
VX-H6	83
VX-H7	83
VX-H10	83
VX-GP	83
VX-MP	83

Low Abrasion/High Impact (Austenitic)

Cronatron™ A LAWSON BRAND

Stick Electrodes

777	80
7108	80

MIG Wires

7109M-FC	80

Specialty

Cronatron™ A LAWSON BRAND

Stick Electrodes

625	82
747	82

MIG Wires

625M	82
MAD-H 65	78
MAD-H 75	78

TIG Wires

625T	82
79	82

HARDFACING Alloys

Carbide Bearing Hardfacing Electrodes and Wires

Designed for high abrasion resistance in low to moderate impact situations.

High Abrasion, Moderate Impact Resistance

Superior Advantages

- Low spatter
- High operator appeal – smooth running, quiet and with minimal sparks

Typical Applications

- Bucket teeth and grader blades
- Asphalt mixer paddles
- Feeder screws
- Sizing screens

711 Flux-Coated Electrode

Moderate chrome carbide

Hardness: Rc 58-63

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	60 – 90	**CW1865**
1/8	80 – 130	**CW1066**
5/32	120 – 160	**CW1065**
3/16	150 – 200	**CW1064**

711FC MIG Wire

Moderate chrome carbide for use in moderate- to high-temperature environments

Hardness: Rc 56-58, up to two passes

Gas: None

Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
.045	120 – 230	**P12539**
.045	120 – 230	**P12540**
1/16	225 – 400	**P12550**

High Abrasion, Low Impact Resistance

Superior Advantages

- Minimal base metal dilution
- Maximum recovery (95% versus 65% typical)
- 1/4" dia. provides good out-of-position welding
- Good edge control

Typical Applications

- Augers
- Conveyor chutes
- Crusher liners and jaws
- Truck bed liners

7350 Tubular Electrode

(Former matching alloy: Certanium® 247)

For high-stress grinding and gouging abrasion resistance

Hardness: Rc 64 (2nd pass)

No. of Passes: Two

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/4	80 – 130	**CW2708**
3/8	75 – 200	**CW1916**
3/8	75 – 200	**CW1916B**
1/2	140 – 300	**CW1917**
1/2	140 – 300	**CW1917B**

PROBLEM SOLVER

Cronatron 7355

Carbide Bearing Hardfacing Electrodes and Wires

PROBLEM:

Time-consuming equipment dismantling required

- Lack of time or inability to disassemble parts or equipment for repair
- Need to make repairs in the overhead position

Multiple passes required to obtain maximum properties

- Multiple passes increase costs

Need to edge-apply hardfacing

- Base metal melting

SOLUTION:

Cronatron 7355 Carbide Bearing Hardfacing Electrodes and Wires

- Easy to use in all positions, including vertical and overhead
- Runs on low amperage to decrease dilution, decreasing the need for multiple passes and reducing distortion and warping
- High recovery rate (90%) saves money
- No burn-over on thin edges
- Excellent control on fine edges

APPLICATIONS

- Heavy construction and farm equipment
  - Plow and dozer blades
  - Shovel buckets
- Mixing and conveyor parts
  - Auger flights
  - Chutes
  - Mixer paddles

All-position, general-purpose overlay

7355 Tubular Electrode

(Former matching alloys: 7330, Certanium® 246)

High abrasion and heavy impact resistance for austenitic manganese steel

Hardness: Rc 62 (2nd pass)

No. of Passes: Up to three

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/4	75 – 150	**CW1918**
1/4	75 – 150	**CW1918A**
3/8	75 – 200	**CW1913**
3/8	75 – 200	**CW1913B**
1/2	140 – 300	**CW1914**
1/2	140 – 300	**CW1914B**

Can be used for out-of-position welding

HARDFACING Alloys

Carbide Bearing Hardfacing Electrodes and Wires

Designed for high abrasion resistance in low to moderate impact situations.

High Abrasion, Moderate Impact Resistance

Superior Advantages

- Minimal base metal dilution
- Maximum recovery (95% versus 65% typical)
- 1/4" dia. provides good out-of-position welding
- Good edge control

Typical Applications

- Dredge pumps
- Screw conveyors
- Chutes for transporting sand and gravel
- Bucket lips
- Skid pads

7370 Tubular Electrode

(Former matching alloy: Certanium® 248)

Corrosion-resistant stabilized chrome carbide

Hardness: Rc 64 (2nd pass)

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/4	80 – 130	**CW2707**
3/8	75 – 200	**CW1919**
3/8	75 – 200	**CW1919B**
1/2	140 – 300	**CW1920**
1/2	140 – 300	**CW1920B**

NOTE: Not recommended for manganese steel

7310M-FC MIG Wire

Chrome carbide alloy for severe abrasion and impact

Hardness: Up to Rc 57 (3rd pass)

No. of Passes: Up to three

Polarity: DC Reverse

Gas: None or 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.045	**CW1804**
.045	**CW1803**
1/16	**CW1785**
7/64	**CW1927**

Carbide Bearing Hardfacing Electrodes and Wires

Maximum Abrasion Resistance

Superior Advantages

- Maximum carbide content provides maximum abrasion resistance

Typical Applications

- Augers
- Conveyor chutes
- Crusher liners and jaws
- Truck bed liners

7230 Tubular Electrode

Corrosion and extreme abrasion resistance up to 1,500°F (816°C)

Hardness: Rc 65 (2nd pass)

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/8	75 – 200	**CW1910**
1/2	140 – 300	**CW1911**

7220 Tubular Electrode

Ultimate abrasion resistance on carbon and low-alloy steels

Hardness: Rc 68 (2nd pass)

No. of Passes: Two maximum

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/4	90 – 125	**CW1846**
3/8	130 – 180	**CW1847**
1/2	200 – 400	**CW1848**

7222A Tubular Electrode

Tungsten carbide alloy for extreme abrasion resistance

Hardness: Rc 65 (2nd pass)

Polarity: AC or DC Straight

Dia. (Inches)	Amps	Part No.
1/4	85 – 110	**CW1908**

7000 Tubular Electrode

Tungsten and vanadium alloy for severe abrasion applications on all types of steels

Hardness: Rc 60

Polarity: DC Straight

Dia. (Inches)	Amps	Part No.
5/32	80 – 130	**CW2054**
3/16	130 – 165	**CW2055**

7000M-FC MIG Wire

Tungsten and vanadium alloy for severe abrasion applications on all types of steels

Hardness: Rc 60

Polarity: DC Reverse

Gas: None or 75% Ar, 25% CO_2

Dia. (Inches)	Amps	Part No.
1/16	150 – 200	**CW2063**

Tungsten 75 Brazing Rod

Composite rod deposits tungsten carbides on a wide variety of metals

Hardness – Matrix: Rb 60-70

Hardness – Carbides: Knoop – 2400

Application Temperature: 1,300°F to 1,600°F (704°C to 871°C)

Dia. (Inches)	Carbide Size (Inches)	Part No.
3/8	3/8 x 1/4	**CW1740**
3/8	1/4 x 3/16	**CW1741**

30F Brazing Rod can be used as a base. F21 Flux is ...mmended.

Micro Alloyed Diamond-Hard wires use nanotechnology to create deposits as hard as carbides but with the impact of tool steels

MAD-H 65 MIG Wire

Hardness: Rc 63-70

Gas: None

Dia. (Inches)	Type	Part No.
1/16	Open-Arc	**CW6122**

MAD-H 75 MIG Wire

Hardness: Rc 70-77

Gas: 75% Ar, 25% CO_2

Dia. (Inches)	Type	Part No.
.045	Gas Flux Core	**CW6120**
1/16	Gas Flux Core	**CW6121**

HARDFACING Alloys

Martensitic Hardfacing Electrodes and Wires

Designed for moderate abrasion resistance and impact situations.

Superior Advantages

- Good for metal-to-metal wear
- Torch cuttable
- Heat-treatable
- Unlimited pass-over-pass applications
- Provides good impact resistance

Typical Applications

- Dredger and shovel teeth
- Hammers
- Conveyor screws
- Shredders
- Shear blades

7500M-FC MIG Wire

High alloy martensitic flux-cored hardfacing wire for moderate abrasion and impact

- Torch cuttable alloy for buildup
- Exceptional impact and abrasive wear resistance

Hardness: Rc 55-60

Polarity: DC Reverse

Gas: 75% Ar, 25% CO_2 or 100% CO_2

Dia. (Inches)	Part No.
.035	**CW3066**
.045	**CW5169**
.045	**CW1789**
1/16	**CW1798**

Certanium® 281M-FC MIG Wire

Flux-cored, self-shielded hardfacing wire for moderate abrasion and impact.

- Unlimited buildup, heat-treatable and torch cuttable
- Excellent for shear blades, hammers and metal-to-metal wear

Hardness: Rc 54-58

No. of Passes: Two maximum

Polarity: DC Reverse

Gas: None or 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.045	**P12510**
1/16	**P19573**
7/64	**P12039**

7540M-FC MIG Wire

Low carbon martensitic alloy for metal-to-metal wear – machinable

Hardness: Rc 36-42

No. of Passes: Unlimited

Polarity: DC Reverse

Gas: None

Dia. (Inches)	Part No.
.045	**CW5170**
1/16	**CW5171**

750 Electrode

All-position alloy for carbon and alloy steels

Hardness: Rc 55-60

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/8	80 – 120	**CW1514**
5/32	110 – 160	**CW1515**
3/16	140 – 180	**CW1516**
1/4	175 – 250	**CW1517**

Austenitic Hardfacing Electrodes and Wires

Designed for low abrasion resistance and high impact situations.

Superior Advantages

- Work hardens under heavy impact conditions
- Unlimited pass-over-pass applications
- High operator appeal – smooth running, quiet and minimal sparks

Typical Applications

- Bucket teeth
- Hammer mill and mill swing hammers
- Tampers and jackhammers
- Impactor crusher bars

777 Electrode

For severe impact and extreme shock (torch cuttable)

Tensile Strength: 115,000 PSI

Hardness: Rb 54

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
1/8	100 – 150	**CW1063**
5/32	130 – 170	**CW1062**
3/16	150 – 220	**CW1061**

7109M-FC MIG Wire

Buildup and joining of manganese steels and carbon steels

Hardness: Up to Rc 54 (3rd pass)

No. of Passes: Up to three

Polarity: DC Reverse

Gas: None or 75% Ar, 25% CO_2

Dia. (Inches)	Part No.
.045	**CW3587**
1/16	**CW3588**
7/64	**CW1929**

7108 Electrode

Chromium-enriched alloy for overlaying austenitic manganese steel (non-torch cuttable)

Tensile Strength: 120,000 PSI

Hardness: Up to Rc 55, work-hardened

No. of Passes: Unlimited

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
5/32	125 – 190	**CW2051**
3/16	150 – 260	**CW2052**

HARDFACING Alloys

Hardfacing Buildup Electrodes and Wires

Work hardening alloy for high impact and compressive loads

- Buildup and overlay for hardfacing
- Repairs on all types of steels including manganese and stainless
- Ideal for crusher rolls, jaws, frog and switch railroad repairs

Superior Advantages

- Versatile – easy to use on all steels
- Resists cracking
- Increased deposition rates save time and money
- Work hardens under impact

Typical Applications

- Shaft buildup
- Equipment part repairs – gears, booms, crusher rolls and hammers
- Welding alloy steel to manganese steel
- Frogs and switch points

7770 Electrode

All-position alloy for buildup on all types of steel

Elongation: 35%

Hardness: Rc 45, work-hardened

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	65 – 90	**CW1881**
1/8	115 – 145	**CW1880**
5/32	155 – 190	**CW1879**
3/16	220 – 270	**CW1878**
1/4	250 – 350	**CW1876**

7770M-FC MIG Wire

Elongation: 35%

Hardness: Rc 45, work-hardened

Polarity: DC Reverse

Gas: None

Dia. (Inches)	Part No.
.045	**CW1779**
.045	**CW1781**
1/16	**CW1780**
3/32	**CW1788**

Alloys for repairs and buildup prior to overlaying with more abrasion-resistant hardfacing.

Superior Advantages

- Versatile – easy to use on all steels
- Resists cracking
- Increased deposition rates save time and money
- Work hardens under impact

Typical Applications

- Shaft buildup
- Equipment part repairs – gears, booms, crusher rolls and hammers
- Welding alloy steel to manganese steel
- Frogs and switch points

Certanium® 706 Electrode

Buildup for hardfacing, joining manganese, carbon steels and stainless steels

Tensile Strength: 101,000 PSI

Elongation: 34%

Hardness: Rc 45, work-hardened

Polarity: AC or DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	65 – 100	**P12785**
1/8	110 – 150	**P12775**
5/32	160 – 200	**P12675**
3/16	225 – 270	**P12665**
1/4	250 – 350	**P12961**

Certanium® 706FC MIG Wire

Tensile Strength: 95,000 PSI

Elongation: 38%

Hardness: Rc 45, work-hardened

Polarity: DC Reverse

Gas: None

Dia. (Inches)	Part No.
.045	**P19557**
1/16	**P19543**

Specialty Wear and Hardfacing Electrodes and Wires

A selection of alloys to meet specialty wear or hardfacing needs.

High frictional wear resistance for most ferrous and non-ferrous metals.

625 Electrode

Cronatron 625 Bronze Alloy can be used to repair most types of copper, bronze and dissimilar metals. High tensile strength and elongation produce tough, crack-free, machinable welds. It has a high resistance to friction which makes it excellent for shaft buildup and metal-to-metal wear.

Tensile Strength: 110,000 PSI

Hardness: Rc 21-23

Polarity: DC Reverse

Dia. (Inches)	Amps	Part No.
3/32	50 – 75	**CW1859**
1/8	100 – 120	**CW1045**
5/32	120 – 140	**CW1044**
3/16	140 – 180	**CW1043**

79 Brazing Alloy

Nickel-chrome-silicon-boron alloy that is resistant to corrosion and withstands temperatures up to 2,000°F (1,093°C)

Application Temperature: 1,300°F to 1,600°F (704°C to 871°C)

Hardness: Rc 58-62

Dia. x Length (Inches)	Part No.
1/8 x 18	**CW1027**
3/16 x 18	**CW1026**

747 Electrode

Cobalt alloy formulated for hardness, corrosion resistance and stability at temperatures up to 2,000°F (1,093°C)

Compressive Strength: To 230,000 PSI

Hardness: Up to Rc 42, work-hardened

Polarity: AC or DC Straight or Reverse

Dia. (Inches)	Part No.
1/8	**CW1832**
5/32	**CW1833**

625M MIG Wire

Tensile Strength: 110,000 PSI

Hardness: Rc 21-23

Gas: 100% Ar

Dia. (Inches)	Part No.
.035	**CW5166**
.045	**CW5167**

625T TIG Wire

Tensile Strength: 110,000 PSI

Hardness: Rc 21-23

Polarity: DC Straight

Gas: 100% Ar

Dia. x Length (Inches)	Part No.
1/16 x 36	**CW3266**
3/32 x 36	**CW3267**
1/8 x 36	**CW3268**

HARDFACING Alloys

Volume Hardfacing Wires

A selection of alloys to meet a broad spectrum of hardfacing needs in volume quantities.

Superior Advantages

- All VX wires are self-shielding, saving money on gas
- Our technical team will work closely with you to determine the best product for your specific application

Typical Applications

- Buckets and dozer blades
- Dump beds and truck liners
- Chutes and augers
- Crushers and hammers

VX-H5 MIG Wire

Most Universal

Withstands moderate impact with good abrasion resistance

Specifications: Low chrome carbide CrC

Hardness: Rc 49

No. of Passes: Three to four

Dia. (Inches)	Part No.
.045	**CW6061**

VX-MP MIG Wire

Buildup on all types of steel

Hardness: Rc 40-47

No. of Passes: Unlimited

Dia. (Inches)	Part No.
.045	**CW6011**
1/16	**CW6016**

VX-H1 MIG Wire

Extreme impact with little or no abrasion

Specifications: CrMnC

Hardness: Work-hardens to Rc 47-50

No. of Passes: Unlimited

Dia. (Inches)	Part No.
.045	**CW6021**

VX-H7 MIG Wire

Significant abrasion resistance with low impact characteristics

Specifications: Moderate chrome carbide CrC

Hardness: Rc 60

No. of Passes: Up to three

Dia. (Inches)	Part No.
.045	**CW6081**
1/16	**CW6086**
1/16	**CW6087**

VX-H3 MIG Wire

Versatile – for significant impact and abrasion

Specifications: Martensitic

Hardness: Rc 60-65

No. of Passes: Unlimited

Dia. (Inches)	Part No.
.045	**CW6041**

VX-H4 MIG Wire

Chromium-free for good abrasion and significant impact resistance

Specifications: BMnC

Hardness: Rc 65

No. of Passes: Up to four

Dia. (Inches)	Part No.
.045	**CW6051**

VX-GP MIG Wire

Buildup and joining on typical carbon steels

Hardness: Rc 18-21

No. of Passes: Unlimited

Dia. (Inches)	Part No.
.045	**CW6001**

VX-H6 MIG Wire

For fine particle abrasion applications and significant impact

Specifications: Low carbide CrTiC

Hardness: Rc 57

No. of Passes: Three to four

Dia. (Inches)	Part No.
.045	**CW6071**

VX-H10 MIG Wire

Pure abrasion applications

Specifications: Complex carbide

Hardness: Rc 65

No. of Passes: Up to two

Dia. (Inches)	Part No.
1/16	**CW6116**

Dimension 1 Plate

Excellent Abrasion Resistance

Dimension 1 plate has an average 35% alloy composition in a tough austenitic matrix, clad to a mild steel backing. Its carbide content, composition and wear life exceed typical chrome carbide plates and works great in situations where there is significant abrasion and some impact. It can easily be fabricated to fit most applications.

Dimension I pipe and elbows are available and offer excellent abrasion resistance for pipe conveyor lines. Pipe diameters available as small as 2" (I.D.). High chrome carbide deposits are uniform and flat for minimal resistance to media flow. Elbows offer exceptional wear resistance at transition points. See your Lawson agent for ordering details.

Superior Advantages

- Bulk hardness: Rc 58-62
- High carbide content (an average of 35%+) provides excellent abrasion and some impact wear resistance – reduces labor and replacement costs
- Extremely flat for applications where close tolerances are necessary
- Uniform bead deposits with no high spots
- Austenitic matrix for impact and corrosion resistance

Typical Applications

- Chutes and conveyors for transporting mid-sized rocks
- Mining and aggregate truck beds
- Auger flights
- Dump beds and bucket liners
- Skid pads
- Augers
- Chain guides
- Pipe conveyor lines

Description	Carbide (%)	Total Thickness (Inches)	Overlay Thickness (Inches)	Mild Steel Thickness (Inches)	Plate Width (Inches)	Plate Length (Inches)	Plate Weight per Sq. Ft. (Lbs.)	Plate Weight (Lbs.)	Plate Part No.	Per Lb. Part No.
Single Pass Overlay	30	3/8	.13	.25	48	96	16	512	**VP2605B**	**VP2605**
	30	3/8	.19	.19	48	96	16	512	**VP2610B**	**VP2610**
	30	1/2	.25	.25	48	96	21.5	688	**VP2615B**	**VP2615**
	30	5/8	.25	.38	48	96	26.6	851	**VP2616B**	**VP2616**
	30	3/4	.25	.50	48	96	31.7	1,014	**VP2617B**	**VP2617**
Double Pass Overlay	39	1/2	.25	.25	48	96	21.5	688	**VP2620B**	**VP2620**
	39	3/4	.38	.38	48	96	43	1,031	**VP2625B**	**VP2625**
	39	1	.5	.5	48	96	43	1,376	**VP2630B**	**VP2630**

Certawear 201 Wear-Resistant Tiles

Tiles provide effective abrasion and impact wear protection and are easy to install. They can be applied with minimal equipment downtime and with minimal labor.

- Through-hardened to Rc 55-57
- Available in 3" x 6" tiles
- Certawear Kit includes tiles and 5 lbs. of Certanium® 706 1/8" electrodes (Part No. P12775)
- For severe impact

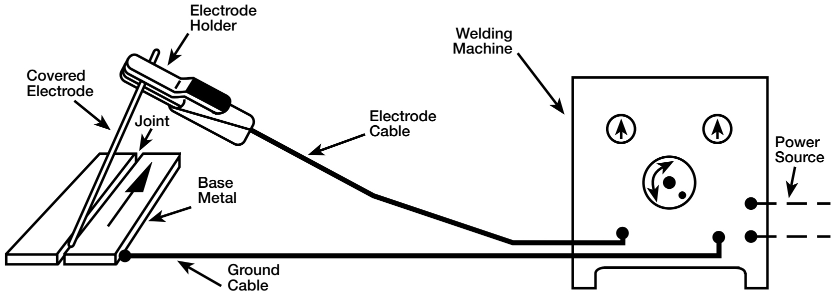
Description	Total Thickness (Inches)	Size	Coverage	Pieces Per Pkg.	Part No.
Certawear 201 Tiles	5/32	3"W x 6"L	–	20	**P12981**
Certawear 201 Tile Kit (includes 32 tiles and 5 lbs. 1/8" 706)	–	–	4 Sq. Ft.	32	**P7579**

TECHNICAL DATA

For Cronatron and Certanium® Alloys

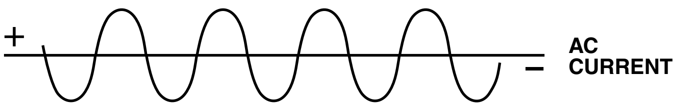
ARC WELDING (SMAW)

The arc welding process (Shielded Metal Arc Welding) is most often used for maintenance and small production welding. This process uses an electric arc generated between a flux covered electrode and the metal being welded (base metal). Heat from the arc melts the end of the electrode and the base metal. A typical arc welding station is illustrated below.



The equipment used in arc welding provides an electric current which may be either AC (alternating current) or DC (direct current). The amount of current (amperage) is adjustable. The diameter of the electrode and thickness of the base metal will determine the kind and amount of welding current required.

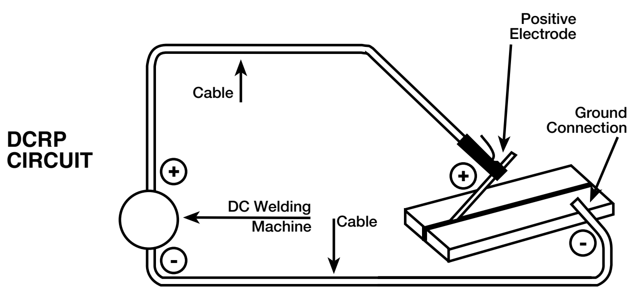
ALTERNATING CURRENT (AC) is an electrical circuit which periodically reverses its direction. In a typical AC circuit, the current goes in one direction and then reverses 60 times a second, so that the current changes its direction 120 times per second.



DIRECT CURRENT (DC) is an electrical circuit where the electricity flows constantly and in one direction. In DC circuits electrical flow is always from the negative pole to the positive pole. In arc welding, control of the direction of electrical flow by arrangement of the poles can affect the running characteristics of an electrode and the depth of penetration.

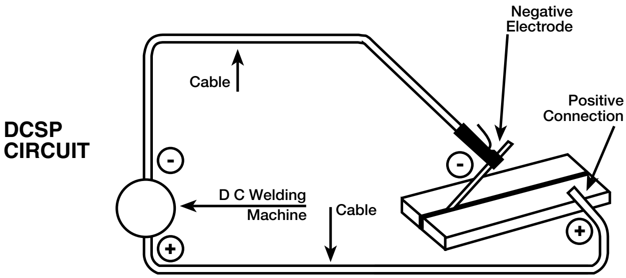
In a DC arc welding circuit two terms are used to define electrical flow:

DCRP – DC Reverse polarity – Electrode positive
DCSP – DC Straight polarity – Electrode negative



REVERSE POLARITY (DCRP): The arc welding leads are arranged so that the electrode is the positive pole and the base metal is the negative pole in the arc circuit. The decision to use DCRP depends on a number of variables including the material to be welded, the position of the weld, and the electrode being used. In general, DCRP will provide deeper penetration than AC or DC straight polarity. DCRP yields the smoothest running characteristics.

STRAIGHT POLARITY (DCSP): The arc welding leads are arranged so that the electrode is the negative pole and the base metal is the positive pole. In general, DCSP will provide shallow penetration in comparison to DCRP.



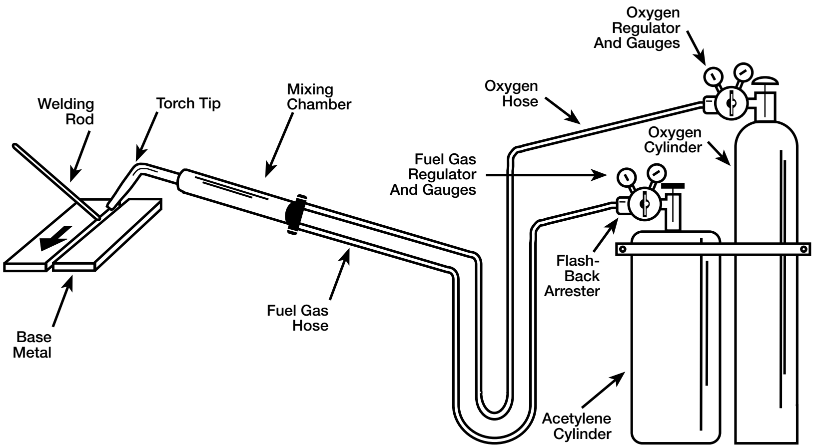
WELDING SAFETY

1. Keep equipment in clean and safe operating condition, free from grease, oil, liquid and metallic particles (in electrical parts) that can cause short circuits.
2. Avoid breathing fumes that may arise from your work. Use equipment in a well ventilated area.
3. Use equipment a safe distance from flammable and explosive materials including gas cylinders. Use fire-resistant covers or screens to prevent sparks from contacting combustibles where a safe distance cannot be maintained.
4. Wear recommended personal protective equipment and clothing, especially when welding in vertical and overhead positions.
5. Protect your eyes from accidental flashes struck when helmet is raised by wearing flash goggles in addition to a helmet.
6. Screen off work area to protect nearby persons from arc flashes. If not screened, keep nearby persons away from welding area or provide them with eye protection.
7. Do not weld where chlorinated hydrocarbon vapors from cleaning, spraying or degreasing can be drawn into the atmosphere surrounding the welding operation. Vapors can be decomposed into a highly toxic gas, and other irritating decomposition products by the heat of the arc.
8. Do not weld where ultraviolet light from the arc can penetrate atmospheres containing vapors from solvents such as perchloroethylene or trichloroethylene to cause decomposition to phosgene and other irritating products.
9. Tighten loose hardware including all electrical connections.
10. Never weld in a damp area without suitable insulation against shock. Keep hands, clothing and feet dry.
11. Never touch two electrode holders from individual power sources at the same time.
12. Replace all worn or damaged power cables and connectors immediately. Check for frayed and cracked insulation particularly in areas where conductors enter equipment.

OXYACETYLENE WELDING/BRAZING

The oxyacetylene welding/brazing process uses an oxygen–acetylene mixture to provide a high temperature flame for welding and brazing. This flame provides enough heat for welding most metals and for all types of brazing.

In this process the acetylene and oxygen are supplied from separate cylinders. Both cylinders must be equipped with a pressure reducing regulator. Each regulator has two gauges. One high pressure gauge indicates the pressure in the cylinder. The other is a low pressure gauge which indicates the pressure of the gas being fed to the torch. Pressure settings for the low pressure gauges should be between ten and 15 pounds for the oxygen and approximately five pounds for the acetylene gas. The acetylene line pressure should never exceed 15 PSI.

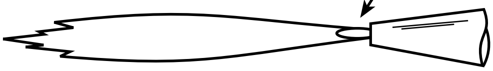


Separate hoses carry the gases to the torch. The torch has two needle valves. One valve controls the flow rate of oxygen; the other the flow rate of acetylene to the torch mixing chamber. The mixed gases, ignited by external means, burn at the torch tip. The type and intensity of the flame is adjustable based on the oxygen and acetylene mixture.

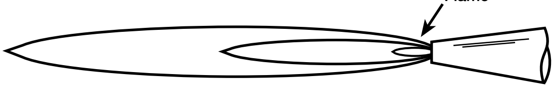
Recommended steps for lighting an oxyacetylene torch are as follows:

1. Set the gauges as stated above.
2. Open acetylene torch valve slightly and light the acetylene with a spark lighter.
3. Increase or decrease the acetylene flow until a wisp of smoke appears at the end of the yellow flame.
4. Begin adding oxygen slowly by opening the oxygen torch valve.
5. Continue to add oxygen until the inner blue cone of the flame is short and rounded (neutral flame).
6. Adjust the oxygen and/or the acetylene valves to achieve the desired type of flame and flame volume.

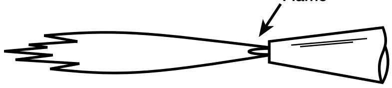
There are three types of flames used when gas welding or brazing. They are: neutral, carburizing and oxidizing.



A **neutral flame** has an equal mixture of oxygen and acetylene and is normally used when you need to build up an area or when you do not want the filler metal to free flow. This is the flame used in most welding processes. A neutral flame burns at approximately 6,000°F (3,316°C) which provides enough heat for fusion welding of steel and cast iron. A neutral flame can be identified by its singular inner cone which is rounded at the tip and has a bluish white color.



A **carburizing flame** has a slight excess of acetylene and is normally used when you want the filler metal to be very free flowing and wet rapidly as when hardfacing and welding light metal. A carburizing flame can be identified by the size of the inner cone. The length of the inner cone is controlled by the amount of acetylene. As the acetylene is increased the cone gets longer. The size of this cone is sometimes referred to as 2x, 3x, 4x, etc. This refers to the length of the cone compared to a neutral flame.



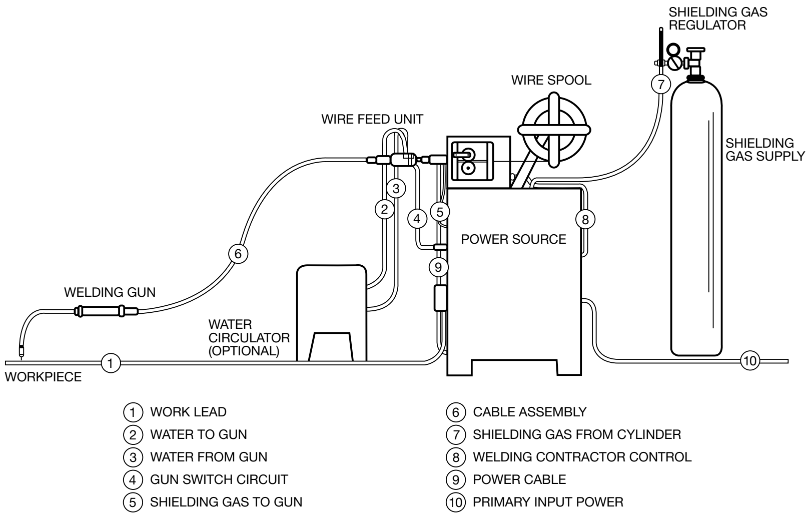
An **oxidizing flame** has a slight excess of oxygen and will tend to burn the metal being welded. It is almost never used when brazing. An oxidizing flame results in a short, noisy, hissing sound. The inner cone has a sharp point and is outlined in an iridescent blue color.

OXYACETYLENE SAFETY

1. Before attaching the oxygen and acetylene regulators, crack each cylinder valve slightly to blow out any dirt that may plug the regulators. Close valves.
2. Attach regulators, check valves, hoses and the torch to cylinders. Release adjusting screws on regulators by turning them counterclockwise.
3. Stand to one side of the regulator and open each cylinder valve slowly. The acetylene valve should be opened 1/4 turn. The oxygen valve should be completely opened.
4. Set regulator adjusting screws to the proper pressure. The acetylene regulator pressure should never exceed 15 PSI.
5. With the hoses and torch assembly attached, individually purge both the oxygen and acetylene lines before lighting the torch.
6. Always open the acetylene valve and light the torch before opening the oxygen valve.
7. Open the oxygen valve to adjust the torch.
8. Never use oil or grease on torches, fittings, regulators or other equipment in contact with oxygen.
9. Do not use oxygen as a substitute for air.
10. Always keep the work area clean of flammable materials.
11. When finished, turn off the acetylene torch valve followed by the oxygen torch valve.

MIG WELDING

MIG (Metal Inert Gas) Welding is also known as Gas Metal Arc Welding (GMAW). MIG is a welding process that uses an arc between a continuous filler metal electrode and the base metal. Equipment required for MIG Welding is shown below:



The basic equipment components are the welding gun and cable assembly, wire feed unit, power supply and source of shielding gas. The gun guides the wire and conducts the electrical current and shielding gas. The shielding gas enhances weld quality and keeps impurities out of the puddle.

Choosing a MIG Welding Process

When MIG Welding you may choose from two types of arc processes: Short Circuiting and Spray Arc.

1. **Short Circuiting Transfer Process** is generally used on sheet metals up to 1/4" and uses small diameter wires of 0.023" to 0.045" at low currents and voltage. In this process the arc physically goes on and off with the wire short circuiting to the workpiece approximately 90 times per second. Metal is transferred with each short circuit. The low heat input and low deposit rates control distortion on thin materials as well as permitting easy out-of-position welds on heavier materials.
2. **Spray Arc Transfer Process** is generally used for flat and horizontal welding positions with wires of 1/16" to 7/64" dia. With spray arc, there is a continuous arc which results in high deposition rates. This makes spray arc transfer ideal for heavy weldments and multi-pass welding.

Both the Short Circuit and Spray Arc processes use direct current (DC). When welding thin materials use DC straight polarity (DCSP) to obtain shallow penetration. When welding on materials over 1/8" use DC reverse polarity (DCRP) to achieve greater penetration.

Setting Arc Current

Amp settings will depend on the thickness of material to be welded and the type of joint. A good rule of thumb is one amp for each .001 thousand of thickness (example: when welding 1/8" steel [.125] use an arc current of 125 amps.) Less amperage will be used on gap type joints than on tight butt type joints or horizontal welds.

Gas Selection

Various shielding gases are available. Each individual welding wire may require a specific gas or combination of gases depending on the arc process chosen to achieve optimum performance. Therefore the specifications for each welding wire should be closely reviewed to assure the most appropriate shielding gas is selected.

Typical ranges are listed in the chart below.

	SHIELDING GAS		GAS
METAL	Preferred	Alternative	Flow Rate CFH
Aluminum Magnesium	100% Argon	75% Argon 25% CO_2	35-40
Carbon Steel Low Alloy Steel	98% Argon 2% O_2	75% Argon 25% CO_2	35-40
Stainless Steel	98% Argon 2% O_2	100% Argon	35-40
Nickel Nickel Copper Alloy Nickel Chromium-Iron Alloy	75% Argon 25% He	100% Argon	35-40
Copper Copper-Nickel Alloy	75% Argon 25% He	100% Argon	35-40
Silicon Bronze Aluminum Bronze Phosphor Bronze	75% Argon 25% He	100% Argon	35-40

Determining Wire Speed

The rate at which the wire is fed to the weld can be adjusted to vary the outcome of the weld. It is important to note that when volts and amps are increased it is necessary to increase the wire speed to avoid the wire fusing to the contact tips of the welding gun. In general, the wire speed setting has a direct correlation with the amperage setting. As amps are increased so does wire speed. Often it is necessary to adjust the wire speed until the optimum weld is achieved.

Arc Voltage

Arc voltage is the electrical potential between the electrode and the workpiece. Arc voltage is dependent upon many factors including metal thickness, type of joint, the welding position, wire size, type of shielding gas and the type of weld. A decrease in arc voltage will shorten the arc and produce a higher, narrow bead with shallow penetration. An increase in arc voltage will lengthen the arc, increase penetration and produce a wider, flatter bead. As voltage increases, amperage will increase accordingly, and wire feed must be increased to compensate for the increased voltage.

DIAMETER	VOLT RANGE	WIRE FEED	AMPERAGE RANGE
.023" (.58 mm)	15 – 20	120 – 648	40 – 130
030" (.76 mm)	16 – 22	176 – 324	60 – 180
035" (.89 mm)	16 – 23	132 – 228	80 – 200
.045" (1.1 mm)	18 – 24	149 – 208	160 – 230
1/16" (1.6 mm)	25 – 34	220 – 280	300 – 450

TIG WELDING (Tungsten Inert Gas)

TIG welding is also known as GTAW (Gas Tungsten Arc Welding) or Heli-Arc. This welding process uses a non-consumable tungsten electrode to initiate an arc. The arc melts the base metal as well as the filler metal which is added to the molten weld pool. The inert gas shield protects the molten weld puddle from contamination.

TIG welding has a number of advantages and disadvantages:

Advantages:

1. Excellent heat control allows joining of thin sections without burn through.
2. The heat source and the addition of filler metal are separately controlled.
3. TIG can be used on almost all metals including aluminum, magnesium and titanium.
4. It is a very precise method and produces the best appearance of any process.
5. The weld is finished as welded with no slag. Typically no cleanup is needed.

Disadvantages:

1. It is the slowest of welding processes.
2. Exposure of the hot filler rod to the atmosphere can cause contamination.
3. Inert gas and tungsten electrode add to the cost.
4. Equipment costs are higher than other welding equipment.

Gases

The flow rate of the gas is an important aspect of producing good TIG results. Flow rate measured in CFH (cubic feet per hour) is a function of tungsten size and amperage.

SHIELDING GASES: Argon, Helium, or a mix of the two are generally used (the term Heli-Arc is derived from the use of Helium as the shielding gas). Argon is generally preferred for the following reasons:

1. Easier arc starting.
2. Better arc stability (smoother arc).
3. Better cleaning of metals when used in AC mode.
4. Heavier than helium and therefore provides better coverages in drafty areas.
5. Less expensive than helium.

Exact gas selection depends on the type of work being done. Argon is the usual choice of maintenance welding shops. Argon is the best choice for aluminum, especially the 1100 grades. A mixture of 75% argon and 25% helium is best when welding austenitic stainless (308, 316, 304, etc.).

Tungsten Types

Pure Tungsten is generally identified with a green tip. Used for non-ferrous metals such as aluminum, brass, and copper. Normally run on ACHF (High Frequency) with a shiny ball 1.5 times the diameter of the electrode. The ball is formed by putting the machine on DCRP and striking an arc on a piece of copper.

1% Thoriated Tungsten is generally identified with a yellow tip. Used on all steels and cast iron. To grind, use a clean wheel and make certain all grinding marks go in the same direction as the shielding gas will flow. Use a rounded point for cast iron and a sharp point for steels.

2% Thoriated Tungsten is generally identified with a red tip. Applications are the same as the 1% Thoriated Tungsten.

Zirconium Tungsten is generally identified with a brown tip. This specialized electrode is primarily used where X-ray quality welds are needed on stainless steel, titanium, and root passes on pipe systems.

Rare Earth is used exactly as Thoriated Tungsten. Rare earth electrodes generally last longer and perform equal to or better than Thoriated Tungsten. Rare earth tungstens are superior to thoriated types, as rare earths emit no radioactive isotopes.

Polarities:

DCSP: This setting is used for all metals except light metals. This polarity setting places about 70% of the heat on the workpiece.

ACHF: This setting is used for light metals such as aluminum and magnesium. It has two benefits; the frequency oscillation of the welding current breaks up surface oxidation and only places 50% of the heat on the workpiece.

ELECTRODE SIZE	CUP/NOZZLE	FILLER METAL DIAMETER	AMPERAGE		GAS CFH
			ACHF	DCSP	
.020" (.51mm)	8 – 10	1/16"	30 – 60	40 – 80	10 – 15
.040" (1.0mm)	8 – 10	1/16"	30 – 70	40 – 90	10 – 15
1/16" (1.6mm)	8 – 10	1/16"	50 – 100	70 – 150	10 – 15
3/32" (2.4mm)	8 – 12	3/32"	100 – 160	140 – 235	10 – 18
1/8" (3.2mm)	12 – 16	1/8"	150 – 210	225 – 325	15 – 25
5/32" (4.0mm)	12 – 16	1/8"	200 – 275	300 – 425	15 – 25

MATERIAL IDENTIFICATION AND PREHEAT FOR WELDING CHART

MATERIAL	SPARK TEST	MAGNETIC	RECOMMENDED PREHEAT
Carbon Steels:			
C < 0.20	Long, white, few forks	Yes	Up to 200°F
C = 0.20 – 0.40	Medium, white, medium forks	Yes	200°F to 500°F
C > 0.40	Medium, white, many forks	Yes	500°F to 800°F
HSLA Steels	Varies with alloy	Yes	Up to 800°F (1)
Cast Iron	Small, red to straw, fine repeating forks	Yes	500°F to 1,200°F (1)
Nickel Steels	Few, orange	(2)	Not usually required
Tool Steels:			
Hardened	(Carbon) long, white, many fine, reapeating forks	Yes	Below lower tempering temperature
Annealed	(Alloy) long, red to straw, not many forks	Yes	Upper limit of tempering temperature
Stainless Steels:			
300 Series	Few, yellow/orange	No	Not recommended (3)
400 Ferritic	Medium, straw/yellow, forks	Yes	300°F to 450°F
400 Martensitic	Medium, straw/yellow, forks	Yes	400°F to 600°F
Austenitic Manganese Steel: (Hadfields)	Medium large, white, fine reapeating forks	No	Up to 200°F (4)
Aluminum Alloys	No sparks	No	For thick sections only, under 300°F
Magnesium Alloys	No sparks	No	For thin sections, highly restrained, 350°F to 750°F
Copper Alloys	No sparks	No	100°F to 800°F (5)
Hardsurfacing	Varies with alloy	(1)	As recommended for base metal

NOTES:

(1) Varies according to base metal or hardsurfacing alloy

(2) May have none to weak magnetic attraction, depending on alloy

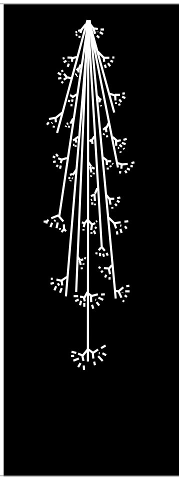
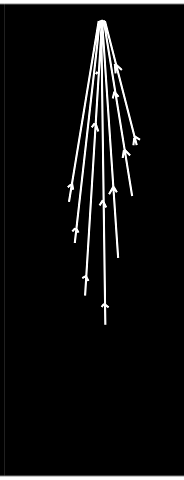
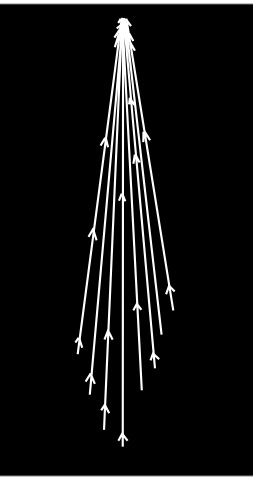
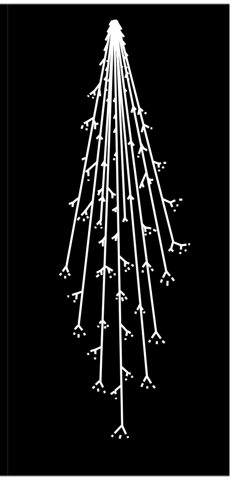
(3) Prolonged exposure of 800°F to 1,600°F (427°C to 871°C) may cause serious carbide precipitation (sensitization)

(4) Preheat to remove chill and to dry only – temperatures over 500°F (260°C) can cause serious embrittlement of the base metal

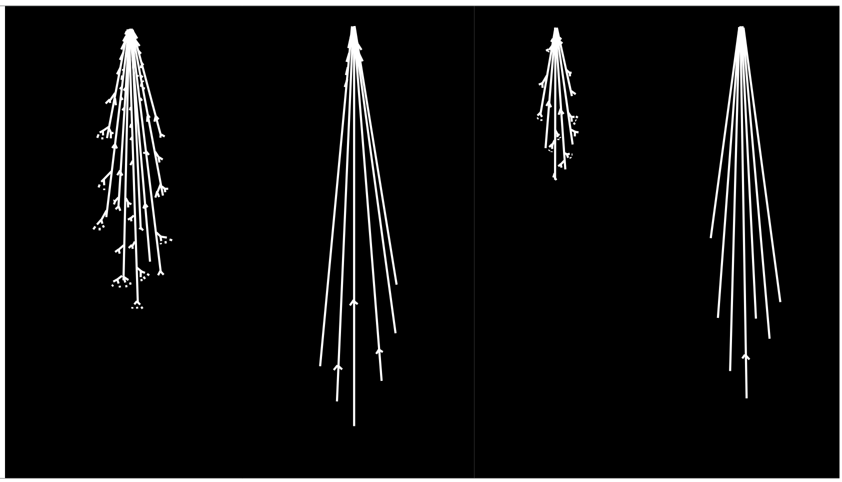
(5) Preheat for copper alloys varies with alloy and thickness

For additional information on Welding Preheat and Ferrous Metallurgy, see Cronatron Technical Sheet No. WE 54.

METAL IDENTIFICATION CHART

TEST	Manganese Steel	Stainless Steel	Low Carbon Steel mild steel .30% carbon and below	Medium Carbon Steel .30 to .45% carbon
Appearance	Dull cast finish	Bright, smooth surface lines	Gray fine	Gray finish
Fracture	Rough grained	Bright appearance	Gray bright crystalline	Light gray
Magnetic	Non-magnetic	Depends on exact composition	Highly magnetic	Highly magnetic
Torch	Turns bright red and melts quickly	Turns bright red and melts quickly	Gives off sparks when melted and pool solidifies rapidly	Melts quickly and gives off some sparks
Chip	Hard to chip	Smooth chip, smooth bright color	Chips easily smooth, long chip	Chips easily smooth, long chip
Spark	Bright white bursts heavy pattern	Very few short full red sparks with few forks	Long white sparks some forks near end of stream	Long white sparks with secondary bursts along stream
Volume of Stream	Moderately large	Moderate	Moderately large	Moderately large
Spark Configuration				

METAL IDENTIFICATION CHART

TEST	High Carbon Steel .45% carbon and above	Wrought Iron	Cast Iron	High Sulfur Steel
Appearance	Dark gray smooth finish	Gray, fine surface lines	Rough, very dull gray	Dark gray
Fracture	Light grayish white and finer grained than low carbon steel	Fibrous structure, split in the direction which the fibers run	Brittle gray	Gray, very fine grain
Magnetic	Highly magnetic	Highly magnetic	Highly magnetic	Highly magnetic
Torch	Melts quickly and molten metal is brighter than low carbon steel	Melts quickly and has a slight tendency to spark	Turns dull red first, puddle is very fluid, no sparks	Melts quickly and turns bright red before melting
Chip	Difficult to chip because of brittleness	Chips easily, continuous chip	Very small brittle chips	Chips easily, smooth, long chip
Spark	Large volume of brilliant white sparks	Straw colored sparks near wheel, few white forks near the end of the stream	Dull red sparks formed close to the wheel	Bright carrier lines with cigar shaped swells
Volume of Stream	Moderate	Large	Small	Large
Spark Configuration				

WELDING PROCEDURE

Carbon and Alloy Steel

All good welding procedures call for identification of the base metal as a prerequisite. However, in maintenance welding, base metal identification is limited generally to segregating metals into their families; cast iron, bronze/brass or steel for example.

Each metal family is comprised of many alloy variations which increase strength, hardness, ductility, and elasticity.

Of all the metals families, steel has the most alloy variations. So many alloys are available that even the professional standards associations such as SAE, ASTM and ASME have not been able to successfully categorize them all. In many cases, steels, designed by a mill to do specific jobs are given trademarked names like Jalloy, Cor-Ten, HY-80 and AR plate to name a few.

However, as important as alloy constituents may be to engineers, carbon is the critical element to welders. Carbon is the primary element that determines hardenability and weldability.

In steel there must be at least .30% carbon present to be hardenable through heat treatment. Heat treating a steel is accomplished by heating the steel to red heat (over 1,333°F or 723°C) and cooling it rapidly to room temperature (quenching). Welding is a form of local heat treatment. Welding on steels with .30% carbon and above can cause them to become hard and brittle in the heat-affected zone (HAZ).

Certanium® developed a testing procedure to determine the weldability of the steel. These tests lead to practical welding procedures for virtually all steels.

ALLOY TEST

The first step in the procedure is to determine the alloy content if any. This can be done with a simple spark test. Determining the alloy content helps to select the proper welding alloy.

Next test for carbon content. There are two tests.

Carbon Test 1

Heat the corner of the steel to be welded to bright cherry red and quench with water or a rag soaked in water. When the steel is cool try to cut the area heated with a hacksaw or a file.
If it cuts easily the carbon content is below .30%. If the steel is difficult to cut or does not cut, carbon is above .30%. Preheat and stress relieving must be used when welding these steels.

Carbon Test 2

The tab test is a simple field test to determine which preheat will be best for the steel. A tab is a piece of cold rolled steel 3/4" x 2" x 4". To conduct the tab test do the following:

1. With a torch heat the steel to be welded to approximately 300°F (149°C). (Use Tempil crayons or other heat measuring devices.)
2. Place the tab on the steel with the 4" length against the steel forming a "T" joint.
3. Run a fillet weld the length of one side of the tab with Cronaweld™ 315 or 375 (Certanium® 704, 5/32").
4. After all the red goes out of the weld, using at least a two lb. hammer, hit the tab from the unwelded side.
5. If the weld breaks out of the steel more preheat is required. Raise the preheat in 100°F (38°C) increments and retest until the tab either bends over or the weld breaks through center. When either of these happens you have achieved the proper preheat for the steel.

(Continued on next page)

WELDING PROCEDURE

1. Prepare the joint using a V or double V by sawing, grinding, arc-air, oxyacetylene torch or with Cronacut™ 1100. Be sure to open the root at least 3/16" to ensure complete penetration.
2. On sections over 2" in thickness cut stress relieving grooves in the walls of the V. The first groove should be at least 3/4" from the root and should be 3/8" wide and 1/4" deep.
3. For steels requiring a preheat, heat with natural gas torches ideally. (Oxyacetylene is okay.) Preheat one hour for each inch of thickness and an additional hour to achieve a good soak.
4. Using the appropriate welding alloy and the largest diameter possible for the job, fill the stress relieving grooves using short stringer beads (max 3" in length). Chip slag and lightly peen each deposit.
5. Use a **backstep skip weld procedure**. (See Cast Iron Welding Procedure). Maintain an interpass temperature of no more than 100°F (38°C) above or below the preheat temperature.
6. After filling the grooves butter the sides of the V's two passes deep using the backstep skip weld procedure.
7. With the sides buttered begin to join at the root.* Use a 1/8" or in some cases a 3/32" dia. electrode. Weld using the same procedure.
   *In some cases it is best to weld the root pass with Cronaweld™ 315 or 375 (Certanium® 747 or 704). These products provide the extra ductility necessary in this critical area.
8. If using a double V configuration, grind the root pass from the opposite side after filling 1/3 of the first side. Grinding removes inclusions or unwelded areas.
9. Run a root pass from the back side using the same procedure.
10. Complete the fill on the backside with the largest diameter alloy possible using the same short stringer bead, backstep and skip weld technique. Always peen each pass and maintain the appropriate interpass temperature.
11. After completing the back side finish the first side.
12. After welding, allow the steel to slow cool to room temperature.
13. Stress relieve the welded area by heating the steel to 800°F to 1100°F (427°C to 593°C) for one hour. Slow cool to room temperature.

Manganese Steel

Manganese steel is sometimes referred to as the "upside down" steel. Manganese steel heated to a cherry red and quenched will become soft and ductile.

To successfully weld 11% – 14% manganese steel follow all the steps listed above. Use no preheat. Maximum interpass temperature is 500°F (260°C).

STEEL PREHEATING CHART

Preheating will help eliminate crack formation, reduce distortion and reduce shrinkage stresses.

Metal Group	Metal Designation	Carbon %	Recommended Preheat
Plain Carbon Steels	Plain carbon steel	Below .20	Up to 200°F
		.20 – .30	200°F – 300°F
		.30 – .45	300°F – 500°F
		.45 – .80	500°F – 800°F
Carbon Moly Steels	Carbon moly steel	.10 – .20	300°F – 500°F
		.20 – .30	400°F – 600°F
		.30 – .35	500°F – 800°F
Manganese Steels	Silicon structural steel	.35	300°F – 500°F
	Medium manganese steel	.20 – .25	300°F – 500°F
	SAE T 1330 steel	.30	400°F – 600°F
	SAE T 1340 steel	.40	500°F – 800°F
	SAE T 1350 steel	.50	600°F – 900°F
	12% manganese steel	1.25	Usually not Required
High Tensile Steels (See also steels below)	Manganese moly steel	.20	300°F – 500°F
	Manten steel	.30 Maximum	400°F – 600°F
	Armco high tensile steel	.12 Maximum	Up to 200°F
	Mayari R steel	.12 Maximum	Up to 300°F
	Nax high tensile steel	.15 – .25	Up to 300°F
	Cromansil steel	.14 Maximum	300°F – 400°F
	Cor-ten steel	.12 Maximum	200°F – 400°F
	Yoloy steel	.05 – .35	200°F – 600°F
Nickel Steels	SAE 2015 steel	.10 – .20	Up to 300°F
	SAE 2115 steel	.10 – .20	200°F – 300°F
	2-1/2% nickel steel	.10 – .20	200°F – 400°F
	SAE 2315, 2320 steel	.15 – .20	200°F – 500°F
	SAE 2330, 2340 steel	.30 – .40	400°F – 600°F
Medium Nickel Chromium Steels	SAE 3115, 3125 steel	.15 – .25	300°F – 400°F
	SAE 3130, 3140 steel	.30 – .40	500°F – 700°F
	SAE 3150 steel	.50	600°F – 900°F
	SAE 3215, 3230 steel	.15 – .30	400°F – 600°F
	SAE 3240, 3250 steel	.40 – .50	800°F – 1,000°F
	SAE 3315 steel	.15	500°F – 700°F
	SAE 3325, 3435 and 3450	.25 – .50	900°F – 1,100°F
Moly Bearing Chromium and Chromium Nickel Steels	SAE 4140 steel	.40	600°F – 800°F
	SAE 4340 steel	.40	700°F – 900°F
	SAE 4615 steel	.15	400°F – 600°F
	SAE 4630 steel	.30	500°F – 700°F
	SAE 4640, 4820 steel	.40 – .20	600°F – 800°F
Low Chrome Moly Steels	2% Cr. – 1/2% Mo. steel	Up to .15	400°F – 600°F
	2% Cr. – 1/2% Mo. steel	.15 – .25	500°F – 800°F
	2% Cr. – 1% Mo. steel	Up to .15	500°F – 700°F
	2% Cr. – 1% Mo. steel	.15 – .25	600°F – 800°F
Medium Chrome Moly Steels	5% Cr. – 1/2% Mo. steel	Up to .15	500°F – 800°F
	5% Cr. – 1/2% Mo. steel	.15 – .25	600°F – 900°F
	8% Cr. – 1% Mo. steel	.15 Maximum	600°F – 900°F
Plain High Chromium Steels	12% – 14% Cr. Type 410	.10	300°F – 500°F
	16% – 18% Cr. Type 430	.10	300°F – 500°F
	23% – 30% Cr. Type 446	.10	300°F – 500°F

The need for preheating increases as the following factors are changed.

1. The larger the mass being welded.
2. The lower the temperature of the parts.
3. The lower the atmospheric temperature.
4. The smaller the weld rod in diameter.
5. The greater the speed of welding.
6. The higher the carbon content of the steel.
7. The greater the alloy content.
8. The more complicated the shape.

INTRODUCTION TO TOOL STEELS

General Description

Tool steels are a group of iron based (ferrous) alloys, mostly with high carbon contents (up to 2.5%), that are used for a variety of cutting and forming tools. These steels may also be alloyed with various elements, including chromium, molybdenum, vanadium, tungsten, manganese and cobalt. The purpose of these alloy additions is to achieve desired properties such as high tensile and compressive strengths, increased wear resistance, higher hardnesses and greater resistance to both thermal and mechanical shock.

Types of Tool Steels

In general, tool steels have been classified by the method in which they are hardened, the three main methods being water-, oil- and air-hardened. Additionally, tool steels are classified by the way in which they are applied. Primary classifications of tool steels are given in the following.

Water-Hardening Tool Steels (W group)

Water-hardening tool steels are basically carbon steels with carbon contents of 0.50% to 1.40%. Small additions of chromium and vanadium have been added to some of the W group tool steels to improve wear resistance and toughness.

The W group tool steels are used for applications such as cold header dies, coining and restrike dies, shear blades, trimming dies, blanking dies, pressbrake tools, etc. The water-hardening tool steels are considered to have good weldability with a proper welding procedure.

Air-Hardening Tool Steels (A group)

These A group tool steels have carbon contents of around 1% and are additionally alloyed with up to 5% chromium, 1% molybdenum and may also have additions of manganese, nickel, vanadium and tungsten.

The air-hardening tool steels are most commonly used for gauges, blanking, forming and trimming dies, and for dies used for roll-forming of threads. Because of the high hardenability of these A group tool steels, special care must be taken during welding.

High Carbon-High Chromium (D group)

The high carbon-high chromium tool steels contain from 1.00% to 2.25% carbon and 12% chromium. In addition, they may also contain molybdenum, vanadium and cobalt.

These tool steels have good abrasion resistance and low dimensional changes upon heating and are commonly used for master gauges, drawing dies, blanking and piercing dies and thread rolling dies. Although these tool steels may exhibit carbide precipitation as seen in stainless steels, they are considered weldable with proper procedures.

High Speed Steels (M and T groups)

The high speed steels are highly alloyed. In general, carbon contents range from 0.75% up to 1.50%. Both M and T groups are alloyed with up to 4% Chromium and may have 1% to 5% vanadium. The M group steels have 3.5% to 9.5% molybdenum (M), whereas the T group steels have 12% to 18% tungsten (T).

These two types of tool steels are characterized by having high hardness at elevated temperatures and are widely used in metal cutting tools such as drills, taps, reamers, milling cutters, etc., and are also used for extrusion dies, burnishing tools and blanking punches and dies. As with the other tool steels, the high speed steels are considered weldable with proper procedures.

(Continued on next page)

Types of Tool Steels *(Continued)*

Hot Work Die Steels (H group)

The hot work die steels all have very high red hardness and therefore are widely used for hot work tooling applications. Subgroups of the H group include: chromium type – 3% to 5% chromium plus vanadium, tungsten, molybdenum or cobalt; tungsten type – 9% to 18% tungsten plus chromium and vanadium; and molybdenum type – 5% to 8% molybdenum with tungsten and vanadium.

Typical applications for these H group steels include extrusion dies, die casting dies, forging dies, mandrels, hot shears, etc., and are considered weldable using special procedures.

Shock Resisting Tool Steels (S group)

The S group tool steels are used in applications where impact strength is required such as impact hammers, chisels, rock tools, punches, forming dies and shear blades. The S group tool steels' properties of hardness and impact strength are obtained by fairly low carbon contents (0.50% to 0.60%) with alloying of low levels of vanadium, chromium, tungsten and molybdenum.

Low Alloy Tool Steels (L group)

This group of tool steels have carbon levels of 0.50% to 1.20% and usually not more than 2% additional alloy content. These tool steels are normally oil-hardened and find use as bearings, rollers, clutch plates, wrenches, etc.

Mold Steels

Mold steels are low carbon steels with alloying of chromium and nickel in addition to molybdenum and vanadium and are used primarily for casting and injection dies for molding of plastics.

Tool Steel Welding Procedures

With proper welding procedures, all tool steels are considered weldable. Because of their high carbon contents and in most cases the presence of a variety of alloying elements that provide the tool steels their desired properties, care must be taken when it comes to welding applications. Problems most frequently encountered when welding tool steels include weld cracking, underbead cracking, decarburization and contamination of the base metal with impurities.

The following is a list of procedural considerations for the welding of tool steels. By observing these items, the ability to make successful tool steel welds will be greatly enhanced.

Electrode Selection

Cronatron has developed the Equagrain® Series of tool steel alloys for SMAW or TIG welding of a variety of tool steels (see Selection Chart in this Section). In general, filler metal may be selected for the following conditions:

1. Base metal in the hardened condition – select Cronatron filler metal with as-welded hardness that matches requirement for the base metal application as post weld hardening will not be accomplished.
2. Base metal in the annealed condition (to be hardened after welding) – select Cronatron Equagrain® alloy to match most nearly the base metal being welded (see Selection Chart in this section). By doing this, weld and base metal will respond in a similar manner during heat treatment.
3. Base metal buildup – select Cronaweld™ 315, Cronaweld™ 375, or TIG equivalent (see Selection Chart in this section) to build up area to near final dimensions. Then choose a Cronatron Equagrain® alloy as in 1 or 2 above according to base metal and subsequent heat treatment requirements.
4. Broken tool repair – select Cronaweld™ 340, Cronaweld™ 333, or TIG equivalent for repair. Cronaweld™ 333 should be selected where tool is subjected to high shock.

Tool Steel Welding Procedures *(Continued)*

Preheat/Interpass/Post Weld Tempering

When possible, it is recommended to repair weld tool steels in the hardened and tempered condition to avoid subsequent heat treatments that can cause dimensional changes. Tool steels that have been hardened, but not tempered, should be annealed prior to welding.

Preheat should always be used when welding tool steels. Preheat temperature should be selected according to base metal requirements (see Selection Chart in this section). When preheating hardened and tempered tool steels, it is important not to exceed the lower temperature limit for tempering as softening of the base metal would result. Preheat should be accomplished in a slow and uniform manner to avoid thermal shock to the part and should be maintained continuously during welding.

Interpass temperatures should be observed and maintained and, after welding, the entire weldment should be slow cooled, uniformly, to near 150°F (65.5°C).

Postweld stress relieving should be done immediately after cooling and can be done at the preheat temperature. After tempering, cool slowly to room temperature and allow weldment to sit for a while to stabilize prior to machining, grinding or other processing.

Joint Preparation

All surfaces of the tool steel to be welded must be thoroughly cleaned and dry. Areas to be welded should be beveled (U groove), and care should be taken to make the groove as uniform as possible. Assure that all cracks or damaged material have been removed from the surface.

Annealed tool steel weld preparation can be made by torch or grinding, whereas hardened tool steels require grinding or arc gouging. Care should be taken not to damage the surrounding base metal during joint preparation.

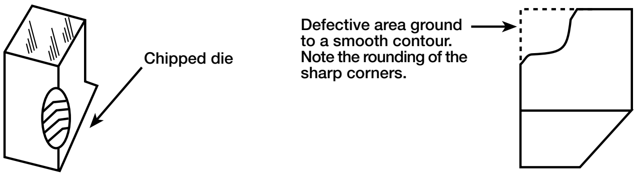
Welding Hints

The following hints for the welding operation will help insure successful welds and repairs on tool steels:

1. Use the smallest electrode that will do the job.
2. Keep heat input from welding to a minimum.
3. Do not strike arcs on base metal away from the weld joint.
4. Peening the weld bead while still very hot is beneficial to relieve high stresses.
5. Weld in the flat to slightly uphill position if possible.
6. Use stringer bead technique; weaving is not recommended.
7. Break the arc properly to fill crater and avoid arc strikes on the base metal.
8. Do not overweld, i.e., deposit the minimum amount of weld metal required, thus minimizing post weld grinding.
9. For thick buildup, use a high strength, ductile weld metal for the buildup (Cronaweld™ 315 or Cronaweld™ 375) then the appropriate Equagrain® tool steel alloy for the final surface.

EASY GUIDE TO TOOL STEEL REPAIRS

THIS TYPICAL PROCEDURE WILL ENABLE SUCCESSFUL REPAIRS ON A WIDE VARIETY OF TOOL AND DIE STEELS

1. Prepare surface by removing fatigued, chipped, and cracked metal. Remove all sharp corners by grinding.
2. 

   Preheat 1 hour per inch of thickness (see Tool Steel Selector Chart).
3. For heavy buildups butter the entire repair area with one pass of Cronaweld™ 349. Use 1" stringer beads with a backstep skip weld technique. After each 1" deposit, peen the bead while still red, using a ball peen hammer.
4. Keep the base metal at preheat temperature. This is known as the interpass temperature. Overlay with proper Certanium® tool and die alloy. Use 1" stringer beads with a backstep and skip technique. After each 1" deposit, peen while still red. Continue to build up, allowing sufficient weld metal for final grinding to size.

5A. Unless precision machining or full heat treatment is contemplated, allow base metal to slow cool to room temperature, finally temper and grind to size.

5B. If precision machining or full heat treatment is desired, allow base metal to slow cool to room temperature, anneal, machine, harden, quench and temper.

NOTE: Tempering to the upper end of recommended temperature range for best toughness, or to the lower end of range for highest hardness.

Refer to Cronatron Tool Steel Selector Chart

Austenitic Stainless Steel Welding Procedure

There are three broad categories of stainless steel: Austenitic, Ferritic and Martensitic. The most commonly used stainless is the Austenitic grade (300 series) because of its corrosion resistance properties and ease of welding.

The 300 series is easily welded, but care must be taken to control the heat input during welding to ensure that corrosion resistance characteristics are maintained.

When austenitic stainless is heated to temperatures between 800°F and 1,500°F (427°C and 816°C) (the sensitizing temperature) chromium (a strong carbide former) develops a strong affinity for carbon and forms chromium carbides. Allowed to cool slowly from these temperatures, the carbides move (precipitate) to the grain boundary depleting the center of the grain of chrome. The reduction in chrome leaves the steel vulnerable to corrosive attack. Stainless steel not properly welded will fail alongside the weld in the heat-affected zone (HAZ).

Austenitic Stainless Steel Welding Procedure *(Continued)*

Successful stainless steel welding has three critical elements: 1) electrode selection; 2) proper preparation; 3) heat control.

1. Always select the best and most appropriate electrode or wire for the stainless being welded. When in doubt select a welding alloy with higher corrosion resistance, and/or an alloy with a low carbon content or one that is stabilized.
2. Ideal preparation procedures would include sawing, filing, chipping or grinding with a medium grit aluminum oxide grinding stone. These procedures keep heat input to a minimum. Never use a torch, arc air or fiber disc grinder.
3. The best welding procedure follows these steps:
   a. Use the smallest diameter reasonable to reduce volumetric heat input.
   b. Use short stringer beads.
   c. Backstep and skip weld to control heat input.
   d. To promote rapid cooling use a copper backup block and/or quench with a wet rag, or air jet.
   e. Never allow to slow cool.

Stainless Steels

Stainless Steels are iron base alloys containing 12% or more chromium. The chromium gives stainless the corrosion resistant properties they are noted for.

Types of Stainless Steels

Austenitic Stainless Steels contain chromium and nickel in addition to iron as the principal alloying elements, and are identified as AISI 300 Series grades. Those containing chromium, nickel and manganese are identified as AISI 200 Series grades.

Austenitic Grades can be hardened by cold working but not by heat treatment. In the annealed condition they are non-magnetic. Some grades can become slightly magnetic by cold working. They are noted for their corrosion resistance and excellent strength at high and low temperatures. They are considered to be the most weldable of the stainless groups requiring neither preheat nor postheat.

Martensitic Stainless Steels contain chromium as the principal alloying element. They are hardenable by heat treatment and are magnetic. This group is identified by AISI 400 Series numbers. The most common grades are 410, 420, 431 and 440. These grades are weldable, but must be preheated from 400°F to 600°F (204°C to 316°C), and postheated above 1,500°F (816°C) and slow cooled.

Ferritic Stainless Steels contain chromium as the principal alloying element and are identified by the AISI 400 Series numbers. These types are magnetic in all conditions, but are not hardenable by heat treatment. The most common grades are 409, 430, 434, 436, 442 and 446. These grades are weldable but require a preheat of 300°F to 450°F (149°C to 232°C), postweld annealing at 1,450°F (788°C) and slow cooling to 1,100°F (593°C), followed by rapid cooling (water quench).

Aluminum Arc Welding Procedure

The problem with welding aluminum is its high heat conductivity. If there isn't enough heat, poor penetration results. Too much heat may cause the part to collapse, or change the temper and reduce strength of heat treatable grades. Too wide a temperature gradient between the weld area and the balance of the part can cause thermal strains which may lead to cracking during or after welding.

The best and most efficient way to weld aluminum is to arc weld. This allows the weld to be completed with the least amount of preheat and localizes heat input. Less wide spread heating of the aluminum means less chance for thermal strains and subsequent cracking.

Aluminum Arc Welding Procedure *(Continued)*

To arc weld aluminum:

1. Aluminum 1/4" thick and up must be beveled. Use a V or double V design.
2. To prepare the area for welding, saw or machine the parts when possible. Use of arc-air and other electric arc metal working tools create a serious heat-affected zone. (HAZ). The HAZ must be removed prior to welding.
3. Preheat 1/4" thick and above to a minimum of 400°F (204°C).
4. Select the largest diameter electrode possible for the job.
5. Hold the electrode perpendicular to the workpiece.
6. Hold a very tight arc and use a weave or circular technique. Watch the bead closely and increase travel speed as the aluminum heats up.
7. When multiple passes are required, thoroughly remove slag with a chipping hammer and wire brush.

INTRODUCTION TO CAST IRON

General Description

Cast irons are a group of iron based (ferrous) alloys that contain from 2% to 4% carbon and from 1% to 3% silicon.

In addition, alloying elements including chromium, copper, molybdenum, nickel and others are sometimes added to obtain cast iron alloys with special properties such as higher strength, increased hardness or wear resistance or increased corrosion resistance.

The constituents of weldable cast irons include a steel matrix with free graphite in the form of flakes or nodules.

Types of Cast Iron

Cast irons have been generally classified by the appearance of the fractured surface as well as by the form of the graphite or "free carbon" in the structure and include the following:

White Cast Iron

White cast iron is very hard and brittle and is not readily machined. There is virtually no "free carbon" in white cast iron. All carbon remains combined with iron in the form of iron carbides. White cast iron is often used where properties of abrasion and wear resistance are required. The fracture surface has a very light color, and white cast irons are not normally welded.

Gray Cast Iron

Gray cast iron normally has a matrix of ferrite and/or pearlite phases with free carbon present in the form of graphitic flakes which give the fracture surface its gray coloring. Gray cast iron is one of the most common forms of cast iron due to its ease of casting and its high level of machinability. Typical uses of gray cast iron include brake drums, clutch parts, cam shafts, furnace parts, glass molds, melting pots and various pipes, valves, flanges and fittings. Gray cast irons have low ductility but are generally considered weldable with proper procedures.

Malleable Cast Iron

Malleable cast iron is generally a white cast iron that has been heat treated to allow the carbon previously in the form of iron carbides to precipitate as free carbon in a nodular form. Malleable irons have better ductility than either white or gray cast irons due to the nodular graphite form. Uses of malleable cast iron include flanges, pipe fittings, valve parts and numerous automotive applications including steering components, transmission and differential parts, connecting rods and universal joints.

Types of Cast Iron *(Continued)*

Ductile Cast Iron

Ductile cast iron or nodular cast iron is similar to gray cast iron, except that during the melt cycle additions of cerium or magnesium cause the free carbon to form into nodules or spheres in a steel matrix. Ductile cast iron has higher strength and ductility than gray cast iron, is easily machined and readily welded with proper procedures. Ductile cast irons are used frequently in culvert, sewer and pressure piping as well as in fittings, valves and pumps.

Alloy Cast Irons

Many variations of cast irons are obtained by alloying with different elements such as chromium, nickel, molybdenum, copper, etc., to obtain specific properties. Improvements in corrosion resistance, heat resistance, abrasion and wear resistance, and higher tensile and fatigue strengths can all be obtained through proper alloying. These alloy cast irons are generally considered weldable with proper procedures.

Cast Iron Welding Procedures

All types of cast iron, with the exception of white cast iron, are considered weldable. The success of a cast iron repair may depend greatly upon the selection of the proper welding electrode, the decision to preheat or not, proper preparation of the base metal and treatment of the finished weld; e.g., peening, slow cooling, etc.

The following is a list of procedural considerations for welding cast iron. By observing these, the ability to make successful cast iron repairs will be greatly enhanced.

Electrode Selection

The Cronatron brazing and welding products listed in this section on cast iron welding have been specially designed to help ensure the success of the cast iron repair. For cast iron welding it is generally recommended to use adequate sized electrodes for the application but to use welding currents as low as possible, consistent with producing a sound weld bead with good contour. This technique minimizes dilution of the weld metal with cast iron (very high carbon levels) and can be important in avoiding weld metal and heat affected zone cracking.

Preheat

In general, preheating of the cast iron prior to welding or brazing should be used whenever possible. Preheat of 400°F to 1,200°F is recommended for thick sections or for complex shapes. Preheating, when used, should be applied uniformly to the entire part and maintained throughout welding. After welding, the entire structure should be cooled slowly back to room temperature.

If preheating is not possible due to configuration or proximity of gears, bearings, etc., then the entire component should be kept as cool as possible (near room temperature).

Joint Preparation

As with any welding operation, the cast iron base metal should be cleaned, if possible, to remove oils, greases, dirt, corrosion products, etc. The casting “skin” should be removed and the joint gouged out as required using Cronacut Eagle™ 1100 or by grinding with carbide tipped tool, chipping, etc.

Bead Size/Sequence/Peening

Stringer bead technique should normally be utilized with weaving kept to a minimum (upper limit 3 times electrode diameter). Short bead lengths (maximum of 3") and staggered sequence welding will both aid in reducing stresses that might cause cracking. In addition, a light peening of the weld bead, while hot, with a round blunt nosed tool helps stretch the weld bead and compensate for shrinkage during cooling. In applications where cold welding is performed (no preheat) allow each bead to cool until it can be touched with the bare hand before another bead is made in the same area.

Cast Iron Welding Procedures *(Continued)*

Studding

Where high strength joints are required, the joint should be gouged out and the casting drilled and tapped along the length of the joint side walls for insertion of studs. The placement of the studs along the length of the joint should be staggered so that studs are not directly across the joint from each other.

The size and number of studs used should be selected to provide approximately 30% of the cross-sectional area of the joint. The holes should be drilled and tapped to a depth that will allow the stud to be screwed into the casting to a depth equal to the stud diameter. The studs should project about 3/16" to 1/4" above the surface into which they are mounted.

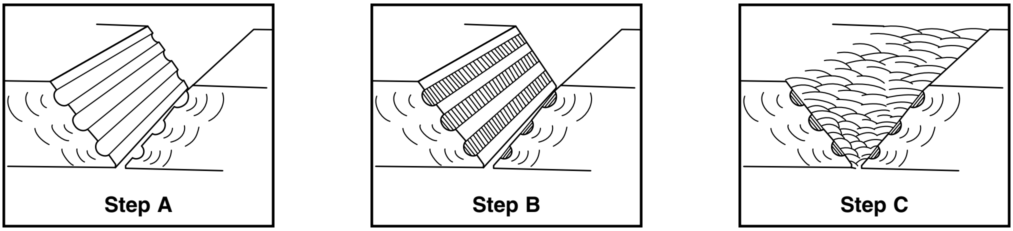
Initial beads are deposited around the studs to fuse them with the cast iron. The complete joint is filled following recommended procedures for the electrode used. This technique is limited to joints with thickness of approximately 2" and greater.

Cast Iron Repair

- To repair existing crack, drill 1/8" to 1/4" hole at both ends to prevent crack propagation
- Where possible, preheat should be employed (600°F to 800°F [315°C to 427°C])
- Excavate area by arc gouging and/or grinding "U" groove geometry is preferable, avoid "V" groove geometry
- Use largest electrode diameter at lowest end of rated amperage setting
- Deposit short beads (1" to 2") with a skip technique
- Peen weld deposits while hot
- Complete repair at the same preheat temperature and promote slow cool to room temperature via torches, furnace, etc.

To prevent crack propagation on heavy sections, use Cronacut™ 1100 and gouge grooves into the sidewalls of the joint (as shown below). Fill the grooves with the appropriate nickel base alloy. Chip and wire brush and continue to fill the groove using the techniques previously shown.

NOTE: These drawings are for illustration only, as stated a "U" groove is preferable, ideally a double bevel "U" groove.



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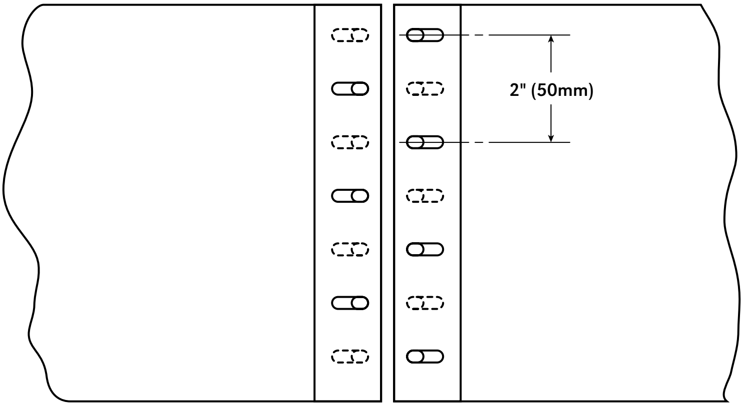
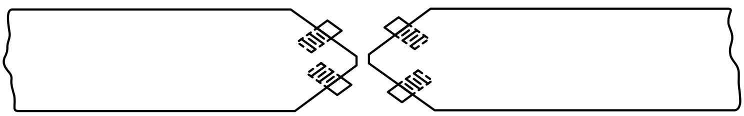
Cast Iron Repair *(Continued)*

To increase strength in heavy sections, drill and tap holes approximately 1/4" dia. and approximately 3/4" long (see below). Screw in threaded bar stock about 1/2" deep. Weld the studs with the appropriate nickel base alloy. Then proceed to fill in the groove using the techniques set forth in this procedure.

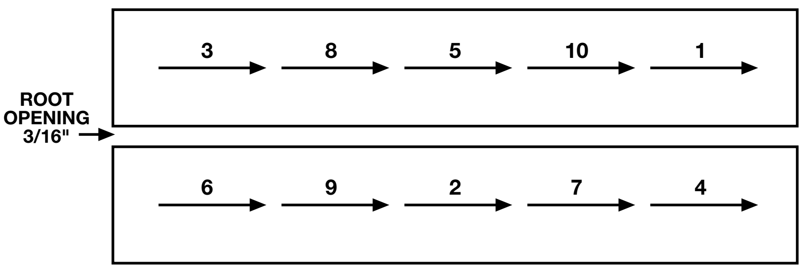


Stagger studs as shown



Skip Welding – Backstep Welding

Backstep skip welding – filling and overlaying side of bevel.

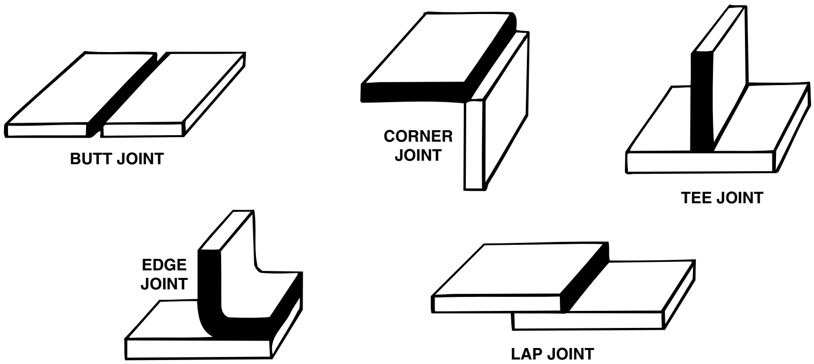


SKIP WELDING

SKIP WELDING

Backstep – be sure to slightly overlap each pass.

THE FIVE FUNDAMENTAL TYPES OF JOINTS



APPROXIMATE HARDNESS CONVERSION

BRINNEL (BHN)	VICKERS (VPN)	ROCKWELL C	ROCKWELL B	SHORE SCLER-OSCOPE	BRINNEL (BHN)	VICKERS (VPN)	ROCKWELL C	ROCKWELL B	SHORE SCLER-OSCOPE
–	–	–	–	–	255	256	25	–	37
–	–	–	–	–	248	248	24	–	36
–	–	–	–	–	241	241	23	100	35
–	1150	70	–	160	235	235	22	99	34
–	1050	68	–	100	229	229	21	98	33
–	960	66	–	95	223	223	20	97	32
–	885	64	–	91	217	217	–	96	31
–	820	62	–	87	212	212	–	96	31
627	765	60	–	84	207	207	–	95	30
601	717	58	–	81	202	202	–	94	30
578	675	57	–	78	197	197	–	93	29
555	633	55	–	75	192	192	–	92	28
534	598	53	–	72	187	187	–	91	28
514	567	52	–	70	183	183	–	90	27
495	540	50	–	67	179	179	–	89	27
477	515	49	–	65	174	174	–	88	26
461	494	47	–	63	170	170	–	87	26
444	472	46	–	61	166	166	–	86	25
429	454	45	–	59	163	163	–	85	25
415	437	44	–	57	159	159	–	84	24
401	420	42	–	55	156	156	–	83	24
388	404	41	–	54	153	153	–	82	23
375	389	40	–	52	149	149	–	81	23
363	375	38	–	51	146	146	–	80	22
352	363	37	–	49	143	143	–	79	22
341	350	36	–	48	140	140	–	78	21
331	339	35	–	46	137	137	–	77	21
321	327	34	–	45	134	134	–	76	21
311	316	33	–	44	131	131	–	74	20
302	305	32	–	43	128	128	–	73	20
293	296	31	–	42					
285	287	30	–	40					
277	279	29	–	39					
269	270	28	–	38					
262	263	26	–	37					

The values above represent approximate equivalents and are provided as a general guide.

COLORS AND APPROXIMATE TEMPERATURES (For Carbon Steel*)

TEMPERATURE (°F)	COLOR	TEMPERATURE (°F)	COLOR
400	Faint Straw	1,050	Dark Blood Red
440	Straw	1,175	Dark Cherry Red
475	Deep Straw	1,250	Medium Cherry Red
520	Bronze	1,375	Full Cherry Red
540	Peacock	1,550	Light Cherry (Scaling)
590	Full Blue	1,650	Salmon (Free Scaling)
640	Light Blue	1,725	Light Salmon
700	Gray	1,825	Yellow
800	Black	1,975	Light Yellow
900	Faint Red	2,220	White
990	Black Red		

**These colors may be observed on the machined, ground or filed surface of carbon steel. Addition of alloying elements may alter or eliminate coloring due to heating. The colors and temperatures are approximates and are given for general reference.*

CONVERSION CONSTANTS

TO CHANGE	TO	MULTIPLY BY
Inches	Feet	0.0833
Inches	Millimeters	25.4
Feet	Inches	12
Feet	Yards	0.3333
Yards	Feet	3
Square inches	Square feet	0.00694
Square feet	Square inches	144
Square feet	Square yards	0.11111
Square yards	Square feet	9
Cubic inches	Cubic feet	0.00058
Cubic feet	Cubic inches	1728
Cubic feet	Cubic yards	0.03703
Cubic yards	Cubic feet	27
Cubic inches	Gallons	0.00433
Cubic feet	Gallons	7.48
Gallons	Cubic inches	231
Gallons	Cubic feet	0.1337
Gallons	Pounds of water	8.33
Pounds of water	Gallons	0.12004
Ounces	Pounds	0.0625
Pounds	Ounces	16
Inches of water	Pounds per square inch	0.0361
Inches of water	Inches of mercury	0.0735
Inches of water	Ounces per square inch	0.578
Inches of water	Pounds per square foot	5.2
Inches of mercury	Inches of water	13.6
Inches of mercury	Feet of water	1.1333
Inches of mercury	Pounds per square inch	0.4914
Ounces per square inch	Inches of mercury	0.127
Ounces per square inch	Inches of water	1.733
Pounds per square inch	Inches of water	27.72
Pounds per square inch	Feet of water	2.310
Pounds per square inch	Inches of mercury	2.04
Pounds per square inch	Atmospheres	0.0681
Feet of water	Pounds per square inch	0.434
Feet of water	Pounds per square foot	62.5
Feet of water	Inches of mercury	0.8824
Atmospheres	Pounds per square inch	14.696
Atmospheres	Inches of mercury	29.92
Atmospheres	Feet of water	34
Long tons	Pounds	2240
Short tons	Pounds	2000
Short ton	Long tons	0.892285

DECIMAL EQUIVALENTS OF FRACTIONS

Inches	Decimals of an Inch	Inches	Decimals of an Inch
1/64	.015625	7/16	.4375
1/32	.03125	29/64	.453125
3/64	.046875	15/32	.46875
1/20	.05	31/64	.484375
1/16	.0625	1/2	.5
1/13	.0769	33/64	.515625
5/64	.078125	17/32	.53125
1/12	.0833	35/64	.546875
1/11	.0909	9/16	.5625
3/32	.09375	37/64	.578125
1/10	.10	19/32	.59375
7/64	.109375	39/64	.609375
1/9	.111	5/8	.625
1/8	.125	41/64	.640625
9/64	.140625	21/32	.65625
1/7	.1429	43/64	.671875
5/32	.15625	11/16	.6875
1/6	.1667	45/64	.703125
11/64	.171875	23/32	.71875
3/16	.1875	47/64	.734375
1/5	.2	3/4	.75
13/64	.203125	49/64	.765625
7/32	.21875	25/32	.78125
15/64	.234275	51/64	.796875
1/4	.25	13/16	.8125
17/64	.265625	53/64	.828125
9/32	.28125	27/32	.84375
19/64	.296875	55/64	.859375
5/16	.3125	7/8	.875
21/64	.328125	57/64	.890625
1/3	.333	29/32	.90625
11/32	.34375	59/64	.921875
23/64	.359375	15/16	.9375
3/8	.375	61/64	.953125
25/64	.390625	31/32	.96875
13/32	.40625	63/64	.984375
27/64	.421875	1	1

RELEVENT METRIC CONVERSIONS

Lengths
Inches to Millimeters

in.		mm
.024	=	0.6
.030	=	0.7
.035	=	0.9
.045	=	1.2
.050	=	1.3
3/63	=	1.2
1/16	=	1.6
3/32	=	2.4
7/64	=	2.7
1/8	=	3.1
5/32	=	4.0
3/16	=	4.7
1/4	=	6.3
5/16	=	7.9
3/8	=	10
7/16	=	11
1/2	=	13
7/8	=	22
1-1/8	=	29
3	=	76
14	=	356
17	=	432
18	=	457
24	=	610
36	=	914

Lengths
Feet to Centimeters

ft.		cm
9	=	274
12-1/2	=	381
14	=	427
15	=	457

Weights
Pounds to Kilograms

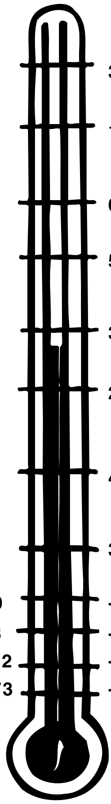
lbs.		kg
1	=	.45
2	=	0.9
5	=	2.3
10	=	4.5
13	=	5.9
25	=	11.3
30	=	14
33	=	15
44	=	20
50	=	23
60	=	27

Volume
Ounces to Mililiters

oz.		ml
12	=	355
16	=	473
18	=	532
24	=	710

Note: To convert pounds per square inch (PSI) to megapascals (MPa), divide by 145. For example 100,000 PSI/145 = 690 MPa.

MELTING POINT OF SOME METALS AND TEMPERATURES RELATED TO WELDING



°C	°F	
16,000	30,000	Tungsten Arc (Argon)
6,020	10,800	Iron Welding Arc
3,500	6,300	Oxyacetylene Flame
2,800	5,040	Oxyhydrogen Flame
1,870	3,360	Laboratory Burner Flame
1,535	2,800	Iron Melts
232	449	Tin Melts
0	32	Ice Melts
-39	-38	Mercury Melts
-78	-110	Dry Ice Vaporizes
-192	-315	Boiling Point of Liquid Air
-273	-459.4	Asbolute Zero

MELTING POINT OF COMMON METALS

METAL	APPROXIMATE MELTING POINT	METAL	APPROXIMATE MELTING POINT
Aluminum	1,220°F	Tungsten	6,170°F
Berylium	2,340°F	Yellow Brass	1,650°F
Boron	4,200°F	Alloy Steel	2,700°F
Cadmium	610°F	Manganese Bronze	1,630°F
Cast Iron	2,300°F	Stainless Steel	2,550°F
Magnesium	1,100°F	Monel®	2,600°F
Nickel	2,651°F	60-40 Lead Tin Solder	361°F
Silver	1,761°F	Manganese Steel	2,450°F
Copper	1,981°F	*Mild Steel	2,800°F

**Such as boiler plate, sheet steel, angle bars, etc.*

TERMS AND DEFINITIONS

Amp: The rate or quantity of flow in an electrical circuit.

Arc Blow: The deflection of an electric arc from its normal path because of magnetic forces.

Arc Voltage: The voltage across the welding arc.

Arc Welding: The group of welding processes wherein coalescence is produced by heating with an arc or arcs, with or without the application of pressure and with or without the use of filler metal.

As-Welded: The condition of weld metal, welded joints and weldments after welding prior to any subsequent aging, thermal, mechanical or chemical treatments.

Back Gouging: The forming of a bevel or groove on the other side of a partially welded joint to assure complete penetration upon subsequent welding from that side.

Backhand Welding: A welding technique wherein the welding torch or gun is directed opposite to the progress of welding.

Backing: Material (metal, weld metal, copper, carbon, granular flux, gas, etc.) backing up the joint during welding.

Backstep Sequence: A longitudinal sequence wherein the weld bead increments are deposited in the direction opposite to the progress of welding the joint.

Base Metal: The metal to be welded, soldered or cut.

Bevel: An angular type of edge preparation.

Bevel Angle: The angle formed between the prepared edge of a member and a plane perpendicular to the surface of the member.

Bond Line: The junction of the weld metal and the base metal or the junction of the base metal parts when weld metal is not present.

Butt Joint: A joint between two members lying approximately in the same plane.

Coalescence: The growing together, or growth into one body, of the base metal parts.

Complete Fusion: Fusion which has occurred over the entire base metal surfaces exposed for welding, and between all layers and passes.

Corrosive Flux: A flux with a residue that chemically attacks the base metal. It may be composed of inorganic salts and acids, organic salts and acids or activated rosins or resins.

Crater: In arc welding, a depression at the termination of a weld bead or in the weld pool beneath the electrode.

Deposited Metal: Filler metal that has been added during a welding operation.

Deposition Rate: The weight of metal deposited in a unit of time.

Depth of Fusion: The distance that fusion extends into the base metal or previous pass from the surface melted during welding.

Drop-Thru: An undesirable sagging or surface irregularity, usually encountered when brazing or welding near the solidus of the base metal caused by over-heating with rapid diffusion or alloying between the filler metal and the base metal.

Duty: A statement of operation conditions to which the machine or apparatus is subjected, their representative durations and their sequence in time.

Edge Preparation: The contour prepared on the edge of a member for welding.

Electrodes:

- **Arc Electrode** – A component of welding circuit through which current is conducted between the electrode holder and the arc.
- **Bare Electrode** – A filler-metal electrode, used in arc welding, consisting of a metal wire with no coating other than that incidental to its manufacture or preservation.
- **Carbon Electrode** – A non-filler-metal electrode, used in welding or cutting consisting of a carbon or graphite rod. The electrode may or may not be coated with copper.
- **Composite Electrode** – a filler-metal electrode, used in arc welding, consisting of more than one metal component combined mechanically. It may or may not include materials which protect the molten metal from the atmosphere, improve the properties of the weld metal or stabilize the arc.
- **Covered Electrode** – a filler-metal electrode, used in arc welding, consisting of a metal core wire with a relatively thick covering which provides protection for the molten metal from the atmosphere, improves the properties of the weld metal and stabilizes the arc.
- **Emissive Electrode** – a filler metal electrode used in Gas Metal-Arc Welding consisting of a metal wire with a very light coating applied during manufacture.
- **Flux Cored Electrode** – A continuous filler-metal electrode consisting of a metal wire with a powder core and a light coating applied subsequent to the drawing operation, primarily for stabilizing the arc.
- **Metal Electrode** – a filer or non-filler-metal electrode, used in arc welding, consisting of a metal wire, with or without a covering or coating.
- **Tungsten Electrode** – a non-filler-metal electrode, used in TIG welding, and principally of tungsten.

Face of Weld: The exposed surface of a weld on the side from which welding was done.

Fillet Weld: A weld of approximately triangular cross-section joining two surfaces approximately at right angles to each other on a lap joint, tee joint, or corner joint.

Fillet Weld Size: See preferred term Size of Weld.

Fixture: A device designed to hold parts to be joined in proper relation to each other.

Flat Position: The position of welding wherein welding is performed from the upper side of the joint and the face of the weld is approximately horizontal.

Flowability: The ability of molten filler metal to flow or spread over a metal surface.

Flux: Material used to prevent, dissolve or facilitate removal of oxides and other undesirable substances.

Full Fillet Weld: A fillet weld whose size is equal to the thickness of the thinner member joined.

Fusion: The melting together of filler metal and base metal, or of base metal only, which results in coalescence.

Fusion Welding: A group of processes in which metals are welded together by bringing them to the molten state at the surfaces to be joined, with or without the addition of filler metal, without the application of mechanical pressure or blows.

Gas Metal-Arc Welding (GMAW): An arc welding process wherein coalescence is produced by heating with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is obtained entirely from an externally supplied gas, or gas mixture. Some methods of this process are called MIG or CO_2 welding.

Gas Pocket: A cavity caused by entrapped gas.

Gas-Shielded Arc Welding: A general term used to describe Gas Metal-Arc Welding and Gas Tungsten-Arc Welding.

Gas Tungsten Arc Welding (GTAW): An arc-welding process wherein coalescence is produced by heating with an arc between a single tungsten (non-consumable) electrode and the work. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This process is frequently called TIG welding.)

Gouging: The forming of a bevel or groove by material removal.

Groove Weld: A weld made in the groove between two members to be joined.

Heat-Affected Zone: That portion of the base metal which has not been melted, but whose mechanical properties or microstructure have been altered by the heat of welding, brazing, soldering or cutting.

Horizontal Position:

Fillet Weld – The position of welding wherein welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface.

Grove Weld – The position of welding wherein the axis of the weld lies in an approximately vertical plane.

Inert Gas: A gas which does not normally combine chemically with the base metal or filler metal.

Interpass Temperature: In a multiple-pass weld, the temperature (minimum or maximum as specified) of the deposited weld before the next pass is started.

Joint Clearance: The distance between the facing surfaces of a joint. (In brazing this distance is usually referred to as that which is present before brazing, at the brazing temperature, or after brazing is completed.)

Lap Joint: A joint between two overlapping members.

Lead Angle: The angle that the electrode makes in advance of a line perpendicular to the weld axis at the joint of welding, taken in a longitude plane.

Leg of a Fillet Weld: The distance from the root of the joint to the toe of the fillet weld.

Liquidus: The lowest temperature at which a metal or an alloy is completely liquid.

Local Preheating: Preheating a specific portion of a structure.

Melting Range: The temperature range between solidus and liquidus.

Open-Circuit Voltage: The voltage between the output terminals of the welding machine when no current is in the welding circuit.

Overhead Position: The position of welding wherein welding is performed from the underside of the joint.

Overlap: Protrusion of weld metal beyond the toe or root of the weld.

Pass: A single longitudinal progression of a welding operation along a joint or weld deposit. The result of a pass is a weld bead.

Peening: The mechanical working of metals by means of impact blows.

Plug Weld: A circular weld made through a hole in one member of a lap or tee joint joining that member to the other. The walls of the hole may be partially or completely filed with weld metal. (A fillet-welded hole should not be construed as conforming to this definition.)

Porosity: Gas pockets or voids in metal.

Position of Welding: See Flat, Horizontal, Vertical and Overhead Positions.

Postheating: The application of heat to an assembly after a welding, brazing, soldering or cutting operation.

Preheating: The application of heat to the base metal immediately before welding, brazing, soldering or cutting.

Reducing Atmosphere: A chemically active protective atmosphere which at elevated temperature will reduce metal oxides to their metallic state. (Reduction Atmosphere is a relative term and such an atmosphere may be reducing to one oxide by oxidizing to another oxide.)

Residual Stress: Stress remaining in a structure or member as a result of thermal or mechanical treatment or both.

Reverse Polarity: The arrangement of direct current arc-welding leads wherein the work is the negative pole and the electrode is the positive pole of the welding arc.

Root Crack: A crack in the weld occurring at the root of a weld.

Root of Joint: That portion of a joint to be welded where the members approach closest to each other. In cross section the root of the joint may be either a point, a line or an area.

Root Opening: The separation between the members to be joined, at the root of the joint.

Shielded Metal-Arc Welding (SMAW): An arc-welding process wherein coalescence is produced by heating with an arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

Single-Welded Joint: In arc and gas welding, any joint welded from the one side only.

Size of Weld:

Groove Weld – The joint penetration (depth of chamfering plus, the root penetration when specified.)

Fillet Weld – For equal leg fillet welds, the leg length of the largest isosceles right-triangle which can be inscribed within the fillet-weld cross section. For unequal leg fillet welds, the leg length of the largest right-triangle which can be inscribed within the fillet-weld cross section.

Flange Weld – The weld metal thickness measured at the root of the weld.

Slag Inclusion: Non-metallic solid material entrapped in weld metal or between weld metal and base metal.

Solidus: The highest temperature at which a metal or alloy is completely solid.

Spatter: In arc and gas welding, the metal particles expelled during welding and which do not form a part of the weld.

Stitch Welding: The use of intermittent welds to join two or more parts.

Straight Polarity: The arrangement of direct current arc-welding leads wherein the work is the positive pole and the electrode is the negative pole of the welding arc.

Stress-Corrosion Cracking: Spontaneous failure of metals by cracking under combined action of corrosion and stress, residual or applied. In brazing, applied to cracking of stressed base metal by the presence of a liquid filler metal.

Stress-Relief Heat Treatment: Uniform heating of a structure or portion thereof to a sufficient temperature, below the critical range, to relieve the major portion of the residual stresses, followed by uniform cooling.

Stress Cracking: Cracking of a weld of base metal containing residual stresses.

Stringer Bead: A type of weld bead made without appreciable transverse oscillation.

Surfacing: The deposition of filler metal on a metal surface to obtain desired properties or dimensions.

Tack Weld: A weld made to hold parts of a weldment in proper alignment until the final welds are made.

Taps: A means for controlling welding voltage and current by varying the welding transformer turns ratio.

Tee Joint: A joint between two members located approximately at right angles to each other in the form of an L.

Thermal Stresses: Stresses set up within a metal or joint caused by differential heating or cooling.

Throat of a Fillet Weld:

Theoretical – The distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right-triangle that can be inscribed within the fillet-weld cross section.

Actual – The shortest distance from the root of a fillet weld to its face.

Toe of Weld: The junction between the face of a weld and the base metal.

Underbead Crack: A crack in the heat-affected zone generally not extending to the surface of the base metal.

Undercut: A groove melted into the base metal adjacent to the toe or root of a weld and left unfilled by weld metal.

Vertical Position: The position of welding wherein the axis of the weld is approximately vertical.

Volts: The intensity or pressure of an electric current. The pressure which forces the amps through the circuit.

Weave Bead: A type of weld bead made with transverse oscillation.

Weld: A localized coalescence of metal wherein coalescence is produced either by heating to suitable temperatures, with or without the application of pressure, or by the application of pressure, or by the application pressure alone, and with or without the use of filler metal. The filler metal either has a melting point approximately the same as the base metals or has a melting point below that of the base metals but above 800°F (427°C).

Weld Crack: A crack in weld metal.

Weld Metal: That portion of a weld which has been melted during welding.

Weldability: The capacity of a metal to be welded under the fabrication conditions imposed into a specific, suitably designed structure and to perform satisfactorily in the intended service.

Welding Current: The current in the welding circuit during the making of a weld.

Welding Procedure: The detailed methods and practices including all joint welding procedures involved in the production of a weldment.

Welding Rod: A form of filler metal used for welding or brazing wherein the filler metal does not conduct the electrical current.

Welding Technique: The details of a welding operation which, within the limitations of the prescribed joint welding procedure, are controlled by the welder or welding operator.

Weldment: An assembly whose component parts are joined by welding.

Wetting: The bonding or spreading of a liquid filler metal or flux on a solid base metal.

Work Angle: The angle that the electrode makes with a line perpendicular to the weld axis at the point of welding, taken in a transverse plane.

STANDARD STEEL SPECIFICATIONS

(Explanation of the SAE numbering system)

The numerical index system, commonly referred to as the SAE Standard System, was developed to provide a simple means of indicating the composition of the various steel grades in common usage. Knowing the analysis of a steel will often help determine the proper procedure and the appropriate Certanium® Alloy for welding.

The system is based on the use of numbers composed of four or five digits. The first digit indicates the type to which that particular steel belongs, as follows:

EXAMPLES

1.	Carbon Steel	1030
2.	Nickel Steel	2340
3.	Nickel Chromium Steel	3450
4.	Molybdenum Steel	4230
5.	Chromium Steel	5450
6.	Chromium Vanadium Steel	6235
7.	Tungsten Steel	7136
8.	Nickel Chromium Manganese Steel	8620
9.	Silicon Manganese Steel	9130

The second digit (in the case of alloy steels) indicates the approximate percentage of the principal alloy. The final two digits indicate the carbon content in one-hundredths of one percent. For example: In the case of SAE 2340, the number 2 indicates the principal alloying element is nickel, the number 3 indicates it has approximately 3% nickel and the number 40 indicates approximately .40% carbon. The analysis, as readily indicated by the SAE number gives important information as to the appropriate Certanium® Alloy to be used for welding.

Main elements alloyed with steel and their purpose:

Cr	=	Chromium	– for hardness
Mn	=	Manganese	– for resistance to wear and impact
Ni	=	Nickel	– for ductility
W	=	Tungsten	– for resistance to heat
V	=	Vanadium	– for elasticity
Mo	=	Molybdenum	– for strength
Si	=	Silicon	– for deoxidizing
Cu	=	Copper	– for resistance to atmosphere corrosion
B	=	Boron	– for hardenability
Co	=	Cobalt	– for resistance to heat, wear, impact

INTRODUCTION TO HARDFACING

WEAR DEFINITIONS

Wear of equipment component parts costs industry billions of dollars yearly in replacement parts, lost productivity and downtime.

Hardfacing can extend the service life of most equipment if the type of wear is properly identified. However, oftentimes the cause of wear is not appropriately diagnosed. Without proper diagnosis of the wear process, developing a procedure and materials list is an expensive guessing game.

There are two things to keep in mind when combating wear.

1. Wear cannot be stopped. Wear progression can only be retarded.
2. Closely examining the part that is worn will reveal the type of wear.

The following is a brief, uncomplicated definition of the various wear processes. As mentioned above, the first step in successfully controlling wear is to understand the wear process(es) at work. Therefore, you should first closely examine your application and then read this section selecting the wear process that most closely resembles your application. Then select the appropriate procedure and repair alloys using the selection chart (pages 73 and 74) found at the beginning of the Hardfacing section.

WEAR PROCESSES

Abrasion

Abrasion is wear by “hard” particles moving along a surface. “Hard” means that the abrading medium is harder than the surface. The medium usually has sharp edges that cut or file away the surface. The abrading media can be any size from large stones to particles a few microns in diameter.

Scratching abrasion is the movement of hard sharp particles across a surface. The particles are usually under a small amount of stress or force. A very small particle size will cause the surface to polish. Larger particles leave scratches or ridges similar to a coarse file.

High stress abrasion is a more severe form of scratching abrasion. In this situation the sharp hard particles are under extreme pressure. The pressure could be due just to the weight of the medium itself. High stress scratching abrasion is typified by small, deep, relatively uniform gouges.

Gouging abrasion is similar to high stress abrasion in that the wear media under pressure moving across a surface will remove chips of metal. Generally gouging abrasion can be distinguished from high stress abrasion by the size of the gouges and their irregularity. Gouging abrasion will show deeper and non-uniform gouges in the surface.

Solid particle impingement is the removal of material through repeated high velocity impact by solid particles. This process is used in sandblasting. Small particles traveling at high velocity remove a small amount of the surface material. Repeated blasting in a concentrated area can produce a crater and may ultimately culminate in a hole in the surface.

Abrasion at elevated temperatures amplifies the effect of any of the wear factors listed above. At elevated temperatures the base metal can be softened making it far more susceptible to wear.

(Continued on next page)

Erosion

Erosion is the progressive loss of material due to fluid flow. Fluid may be clear or may contain solids. In some cases the fluid may contain a chemical that reacts with the surface. This compounds the wear by adding the factor of corrosion. Fluid impingement erosion is the wearing away of a surface by the action of a fluid, liquid or gas striking a particular area. This type of erosion is very similar to solid particle impingement except that a fluid alone is traveling at a great enough velocity to remove chips from the metal surface. If the fluid contains a corrosive, the wear is hastened as the material is now subjected to both wear and corrosion.

Slurry erosion is the mixture of solid particles in a fluid. Slurry erosion incorporates both small particle impingement and fluid impingement erosion. A slurry may also contain a corrosive which will hasten the wear.

Cavitation is wear by the action of collapsing bubbles in a liquid. The liquid travels at a sufficient velocity to collapse the bubbles when coming into contact with the surface. The collapsing action is violent enough to remove small chips of metal. If the fluid is a corrosive the forces of corrosion will hasten wear.

Metal to Metal Wear

Adhesive wear occurs due to local bonding between two contacting surfaces. In this case the surfaces momentarily weld to each other and then rip apart causing material loss from one of the two surfaces. Once the surface tears, the wear mode changes to high stress or gouging abrasion.

Galling is a severe form of wear characterized by damage to one or both sides of two surfaces coming together. In this case a large chunk of material may be removed by the sliding action of two surfaces over one another. Continued galling usually produces seizure which is characterized as localized welding of the two surfaces through frictional forces. In this case, the weld area is large enough to seize or stop the surfaces' relative motion.

Surface fatigue is the loss of the material from small fractures caused by repeated rolling or sliding of one metal surface against another. In this case the metal structure is mechanically transformed and becomes more brittle, which causes it to crack and eventually results in breaking off surface particles to produce pitting.

Pitting is the removal of material by continued loading of one solid surface against another. Pitting causes metal fatigue, which ultimately results in subsurface cracks and a chip of metal being removed.

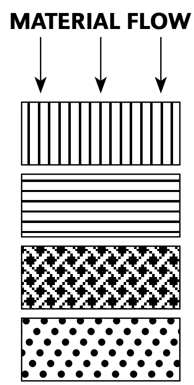
Impact

Impact fatigue is repeated high stress striking by the abrasive medium. In these cases, the abrasive media are usually large rocks or chunks of metal. Impact fatigue will cause the surface to fatigue, the grain structure to be transformed and chips to be removed.

PATTERNS FOR LONGER WEAR LIFE

When applying hardfacing specific patterns can be utilized on buckets, blades, and other equipment to trap material and increase the equipment's wear life.

1. When the primary medium being handled is rock use a pattern that is parallel to the material flow.
2. When the primary medium being handled is sand, use a pattern that is perpendicular to the material flow.
3. For a combination of small and large materials use a cross hatch, diamond or herringbone wear pattern.
4. To provide good abrasive and impact resistance to most media and to protect the equipment from distortion and impact use a dot pattern.



MIG PROCESS TROUBLESHOOTING

American Welding Society (AWS) Welding Handbook Committee, R.L. O'Brien, Editor, 1991, *Welding Processes*, Volume 2 of Welding Handbook, 8th Edition, Miami: American Welding Society. (Reprinted with Permission of AWS)

Table 4.16

Troubleshooting Electrical Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Difficult arc starting	Wrong polarity Poor workpiece lead connection	Check polarity; reverse the leads if necessary Secure the workpiece lead connection
Irregular wire feed and burn back	Power circuit fluctuations Polarity wrong	Check the line voltage Check the polarity; reverse the leads if necessary
Welding cables overheating	Cables are too small or too long Cable connections loose	Check the current-carrying requirements and replace or shorten if necessary Tighten
No wire feed speed control circuit	Broken or loose wires in control Defective PC board in governor	Check and repair if necessary Replace the PC board
Unstable arc	Cable connections are loose	Tighten the connections
Electrode won't feed	Control circuit fuse blown Fuse blown in power source Defective gun trigger switch or broken leads Drive motor burned out	Replace the fuse Replace the fuse Check the connections; replace the switch Check and replace
Wire feeds but no gas flows	Failure of gas valve solenoid Loose or broken wires to gas valve solenoid	Replace Check and repair if necessary
Electrode wire feeds but is not energized (no arc)	Poor workpiece connection Loose cable connections Primary contactor coil or points defective Contactor control leads broken	Tighten if loose; clean workpiece of paint, rust or other contaminant Tighten Repair or replace Repair or replace
Porosity in weld	Loose or broken wires to gas solenoid valve	Repair or replace

(Continued on next page)

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Table 4.17

Troubleshooting Mechanical Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Irregular wire feed and burn back	Insufficient drive roll pressure Contact tube plugged or worn Kinked electrode wire Coiled gun cable Conduit liner dirty or worn Conduit too long	Adjust Clean or replace Cut out; replace the spool Straighten the cables; hang the wire feeder Clean or replace Shorten, or use the push-pull drive system
Electrode wire wraps around drive roll ("birdnesting")	Excessive feed roll pressure Incorrect conduit liner or contact tip Misaligned drive rolls or wire guides Restriction in gun or gun cable	Adjust Match the liner and contact tip to the electrode size Check and align properly Remove the restriction
Heavily oxidized weld deposit	Air/water leaks in gun and cables Restricted shield gas flow; defective gas solenoid valve	Check for leaks and repair or replace as necessary Check and clean the nozzle and repair or replace
Electrode wire stops feeding while welding	Excess or insufficient drive roll pressure Wire drive rolls misaligned or worn Liner or contact tip plugged	Adjust Realign or replace, or both Clean or replace
Wire feeds but no gas flows	Gas cylinder is empty Gas cylinder valve closed Flow meter not adjusted Restriction in gas line or nozzle	Replace and purge the lines before welding Open cylinder valve Adjust to render the flow specified in the procedure Check and clean
Porosity in the weld bead	Failed gas valve solenoid Gas cylinder valve closed Insufficient shielding gas flow Leaks in gas supply lines (including the gun)	Repair or replace Turn valve on Check for restrictions in the gas line or nozzle and correct Check for leaks (especially at the connections) and correct
Wire feed motor operates but wire does not feed	Insufficient drive roll pressure Incorrect wire feed rolls Excessive pressure on wire spool brake Restriction in the conduit liner or gun Incorrect liner or contact tip	Adjust Match the feed rolls to the wire size and type Decrease the brake pressure Check the liner and contact tip; clean or replace, or both Check and replace with correct size
Welding gun overheats	Pinched or clogged coolant line Low coolant level in pump reservoir Water pump not fucntioning correctly	Check and correct Check and add coolant as necessary Check and repair or replace

MIG PROCESS TROUBLESHOOTING

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Table 4.18

Troubleshooting Process-Related Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Unstable arc	Weld joint area dirty	Clean to remove scale, rust, etc.
Heavily oxidized weld deposit	Improper gun angle Excessive nozzle-to-workpiece distance Air drafts Contact tube not centered in the gas nozzle distance	Use approximately 15° push angle or trail angle Reduce distance; distance should be approximately 12.7mm to 19.1mm (1/2" to 3/4") Protect the weld area from drafts Center the contact tip
Porosity in the weld bead	Dirty base material Excessive wire feed speed Moisture in the shielding gas Contaminated electrode Gas flow rate too high or too low	Clean to remove scale, rust. etc. Reduce Replace the gas cylinder Keep the wire protected while using. Clean the wire before it enters feeder Adjust
Electrode wire stubs into the workpiece	Excessive wire feed speed Arc voltage too low Excessive slope set on power source (for short-circuiting transfer)	Reduce the speed Increase the voltage Reset to reduce slope
Excessive spatter	Excessive arc voltage Insufficient slope set on power source (for short-circuiting transfer) Contact tip recessed too far in nozzle Excessive gas flow rate	Reduce the voltage Increase slope setting Adjust or replace with a longer contact tip Reduce flow
Welding gun overheats	Excessive amperage for gun	Reduce amperage or change to a higher-capacity gun

Successful 11% – 14% Manganese Repair

Repairing cracks in manganese is made easy with the use of Cronaweld™ 777 (Certanium® 706), Cronacut ™1100, and the following procedure:

1. Pierce a hole at each end of the crack using Cronacut™ 1100 to stop the crack from becoming larger.
2. Using Cronacut™ 1100 gouge the crack with a "U" groove 2/3 of the way through the material, making sure the groove is about twice as wide as it is deep. Keep the manganese below 500°F (260°C). Quench as necessary, as this helps the manganese stay ductile.
3. Remove contaminants and oxides using a coarse grit aluminum oxide grinding wheel or by machining.
4. Using the largest diameter Cronaweld™ 777 (Certanium® 706) possible to minimize heat input, weld the groove half full using short stringer beads (maximum 3") utilizing the skip, wander and backstep technique. Keep the manganese at a temperature where you can comfortably hold your hand near the weld; quench if necessary.
5. Using Cronacut™ 1100, remove the remaining 1/3 of the crack on the opposite side with a "U" groove. Use the same preparation and welding procedures outlined above to complete the repair.

TIG Welding

When TIG welding non-ferrous metals such as aluminum, brass and copper, it is best to use a rare earth lanthia tungsten or pure tungsten. To prepare the tungsten for welding put the machine on DCRP and strike an arc on a piece of copper. This will create the appropriate tip configuration for welding aluminum (a shiny ball about 1.5 times the size of the tungsten).

Aluminum is normally welded using ACHF, because the frequency oscillation of the welding current breaks up surface oxidation and only places 50% of the heat on the workpiece, which controls heat input.

The best choice of shielding gases when welding aluminum is 100% argon. Argon provides a smooth weld and the optimum penetration for aluminum. It is heavier than air and effectively blocks out air from the weld area. When deeper penetration is needed a mixture of 75% argon and 25% helium can be used.

Aluminum Preheat

Here is an easy way to determine the appropriate preheat when gas welding aluminum. Turn off the oxygen to your oxyacetylene torch and cover the area to be welded with acetylene soot. Then broadly heat the aluminum with a slightly carburizing flame. When the aluminum reaches about 950°F (510°C) the soot will dissipate and you can start welding.

How to Calculate Weld Material Required

To determine the weld material necessary, first calculate the area of the triangle. In any equal-sided right triangle (90°), the sides (base and height) are approximately equal to 1-1/2 times the throat. To determine the area, multiply the base by the height and divide by two.

Base x Height/2 = Area

Now that we know the area, we need to determine the volume of the proposed weld deposit. Volume is measured in cubic inches. To determine the volume, simply measure the length of the proposed weld.

Length x Area = Volume

All that remains is to determine the number of pounds of product needed. We have found, through our experience, that if the cubic inch figure is multiplied by .3 the result will be the number of pounds needed to do the job.

Volume x .3 = Number of pounds weld material required

Copper, Brass, Bronze Alloy Selection

When you cannot positively identify the base metal and are unsure of which welding alloy to choose, make your selection based on color! Color match the electrode to the base metal. Grind the grip end of a welding electrode or brazing rod and compare the color to a portion of the part needing repair that has been ground. This is a good rule of thumb for alloy selection.

Cronaweld™ 625, 665

Thin Metal Welding

To improve results when arc welding thin metals consider the following:

1. Use DCSP, when available, to achieve shallow penetration and minimize burn-through. If DCSP is not available, use AC.
2. Maintain as tight an arc as possible to limit overheating of the base metal.
3. In the event the amperage range on the welding machine is not suitable to use a 1/16" or 5/64" electrode, use a 3/32" or 1/8" electrode at the lowest possible amperage setting to minimize heat input and burn-through.

Brazing

If the brazing alloy “balls up” and does not wet to the surface, one of the following problems may exist:

1. Surface oxides were not removed.
2. The bonding surfaces have not been heated enough to allow the alloy to flow.
3. There is an insufficient application of flux.
4. Contaminants such as lubricants and machine oils were not properly removed.
5. Acids used for precleaning operations were not neutralized properly.

ALLOYS INDEX

WELDING

ALLOYS INDEX

WELDING *(Continued)*

BRAZING

HARDFACING

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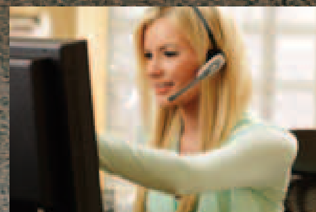

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