

REFERENCE DATA

GROUP "A" – COPPER BASE ALLOYS –										
CLASS	RWMA NO.	GENERAL USE	DESCRIPTION	AVAILABILITY						
				1	2	3	4	5	6	
RWMA CLASS 1										
<i>ZIRCONIUM</i>	1.15000	Electrodes for welding aluminum alloys, magnesium alloys, coated materials, brass and bronzes. Can be used for both spot and seam welding.	A specially heat treated zirconium copper alloy that meets the minimum electrical conductivity and hardness specification of Class 1 Alloy.	X	X					
<i>CADMIUM</i>	1.16200		A high conductivity cadmium copper alloy , not heat treatable, but can be work hardened.	X	X					
<i>CHROMIUM</i>	1.18200		A specially heat treated chromium copper alloy that meets the minimum electrical conductivity and hardness specifications of Class 1.	X	X	X	X			
RWMA CLASS 2										
<i>CHROMIUM-ZIRCONIUM</i>	2.18150	These materials are stronger than Class 1 materials but have slightly lower conductivity. They are used for the spot and seam welding of cold and hot rolled steel, stainless steel and low conductivity brass & bronze. They are also used as flash welding dies, and as electrodes for the welding of steel & other coated materials.	A specially heat treated chromium zirconium copper alloy that meets the minimum electrical and hardness specification of Class 2 Alloys.	X	X	X				
<i>CHROMIUM</i>	2.18200		A high conductivity chromium copper alloy , that obtains its optimum properties from a combination of both heat treatment and cold work.	X	X	X	X	X		
RWMA CLASS 3										
<i>COBALT-BERYLLIUM COPPER</i>	3.17500	Their high hardness makes them ideal for electrodes for the spot and seam welding of high resistance materials such as stainless steel, nichrome and monel metal. As a casting, they are used for flash, butt and projection welding electrodes & fixtures. They can also be used for seam welder bearing and other current carrying structural parts.	Heat treatable copper alloys with a combination of high tensile strength and good electrical and thermal conductivity.	X	X	X	X	X		
<i>NICKEL-BERYLLIUM COPPER</i>	3.17510			X	X	X	X	X		
<i>BERYLLIUM-FREE COPPER</i>	3.18000			X	X	X	X			
RWMA CLASS 4										
<i>BERYLLIUM</i>	4.17200	Electrode material for special flash, flash butt and projection welding applications where pressures are extremely high and wear is severe but where heat is not excessive. Used in the form of inserts & facings.	A heat treatable copper alloy having the unusual combination of very high strength and lower electrical conductivity than Class 3. Can be annealed, machined & reheat treated to regain its properties.	X	X	X	X	X		
RWMA CLASS 5										
<i>ALUMINIUM</i>	5.95300	Typical uses are flash welding electrodes, secondary circuit welder arms, knees, platens and other current carrying fixtures where high strength, wear resistance and non-magnetic properties are required.	Copper base alloy usually furnished in the form of castings. It is not heat treatable.	X						



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REFERENCE DATA

GROUP "B" – REFRACTORY METAL COMPOSITION –									
CLASS	RWMA NO.	GENERAL USE	DESCRIPTION	AVAILABILITY					
				1	2	3	4	5	6
RWMA CLASS 10 <i>COPPER-TUNGSTEN</i>	10.74450	Flash and butt welding electrodes where higher electrical and thermal conductivity is necessary and where a degree of malleability is desired. They can also be used for spot welding low conductivity steels -- stainless.	A powder metallurgical combination of 45% copper & 55% of the refractory metal tungsten. Not a true alloy. This combination produces dense, hard metals of superior wear resistance and strength at elevated temperatures.	X					X
RWMA CLASS 11 <i>COPPER-TUNGSTEN</i>	11.74400	Projection welding electrodes, flash & butt welding electrodes, light upsetting electroforming & seam welder bushings. Harder than Class 10 & used where moderate pressure required.	A powder metallurgical combination of 25% copper and 75% of the refractory metal tungsten. Not a true alloy. This combination produces dense, hard metals with good thermal & electrical conductivity.				X		X
RWMA CLASS 12 <i>COPPER-TUNGSTEN</i>	12.74350	Heavy duty projection welding electrodes, electro-forming & electroforming electrodes, electrode facing for upsetting of studs and rivets, cross wire welding of large diameter wire and rod.	A powder metallurgical combination of 20% copper and 80% of the refractory metal tungsten. Not a true alloy. This combination produces dense, hard metals of superior wear resistance and strength at elevated temperatures.			X			X
RWMA CLASS 13 <i>TUNGSTEN</i>	13.74300	Cross wire welding of copper & brass electro brazing and some electro upsetting. Welding of braided copper wire to other materials.	Tungsten is extremely hard and has low ductility. It cannot be machined but can be ground to required contours. It does not alloy with non-ferrous materials.	X	X				X
RWMA CLASS 14 <i>MOLYBDENUM</i>	14.42300	Cross wire welding of copper & brass electro brazing and some electro upsetting. Welding of braided copper wire to other materials.	Molybdenum is not as hard as Class 13 and can be drilled and machined to special contours.	X	X	X	X		X
GROUP "C" – SPECIALTY MATERIAL –									
RWMA CLASS 20 <i>DISPERSION STRENGTHENED COPPER</i>	20.15760	Welding of metallic coated metal such as galvanized steel, tern plate, etc.	A powder metallurgy material consisting of copper and aluminum oxide with high temperature hardness and physical properties different than the copper alloys.	X	X				
AVAILABILITY CODING EXPLANATION									
<ul style="list-style-type: none"> • 1 = CASTING • 2 = FORGING • 3 = ROD & BAR • 4 = PLATE • 5 = TUBE • 6 = INSERTS 									
<p>• GENERAL SUGGESTED APPLICATIONS, NOT TO BE INTERPRETED AS THE OPTIMUM FOR ANY SPECIFIC APPLICATION</p>									



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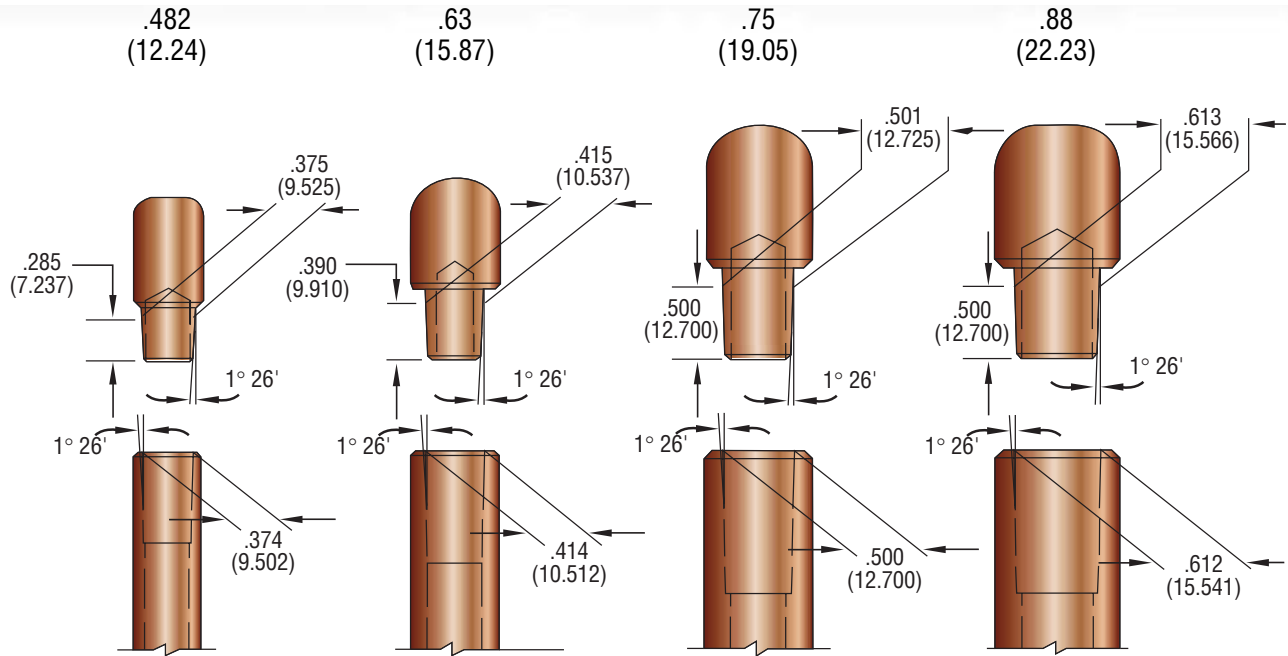
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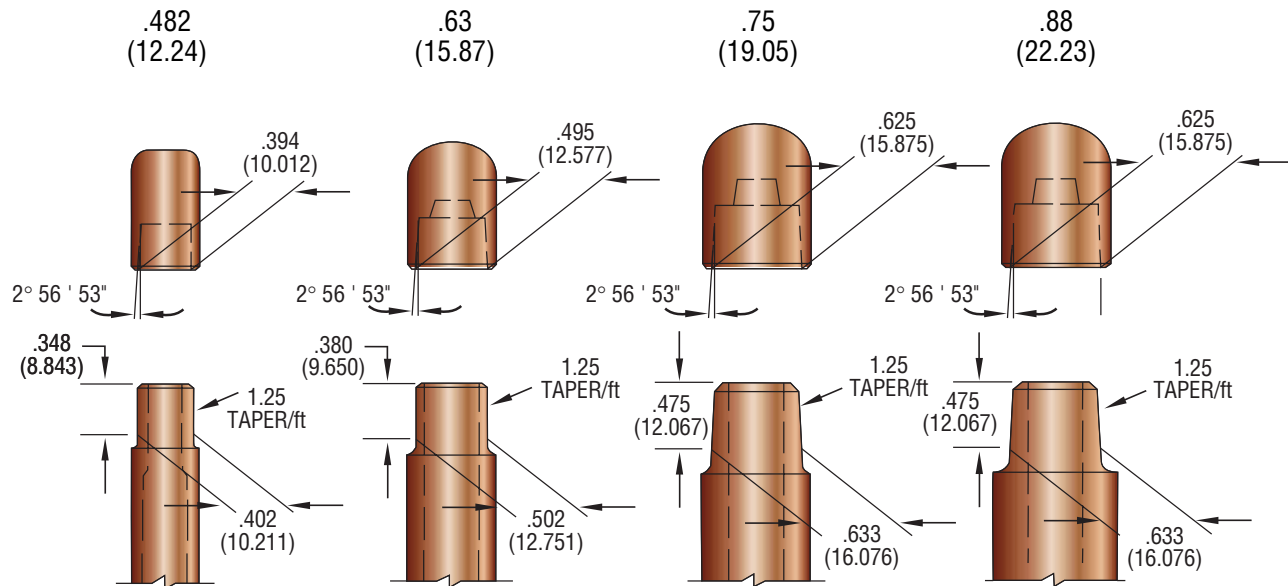
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REFERENCE DATA

MALE CAP DATA



FEMALE CAP DATA



Dimensions Shown Are: inches (mm)



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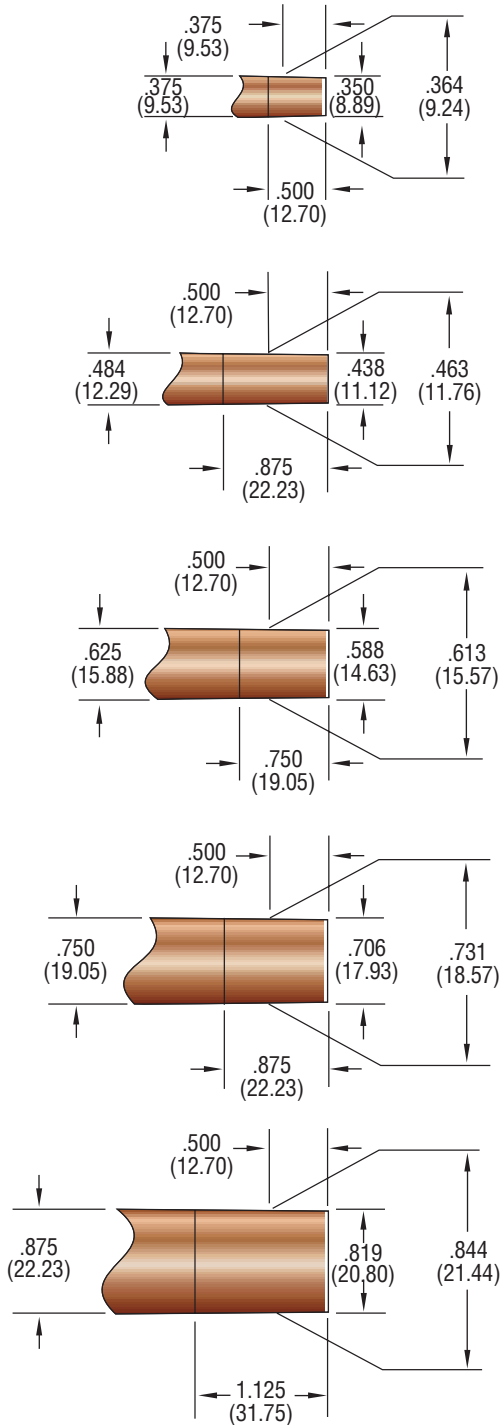
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REFERENCE DATA

ELECTRODE AND ADAPTER TAPERS

(Refer to pages 3-12 to 3-14)



#0 MT - #3 RW

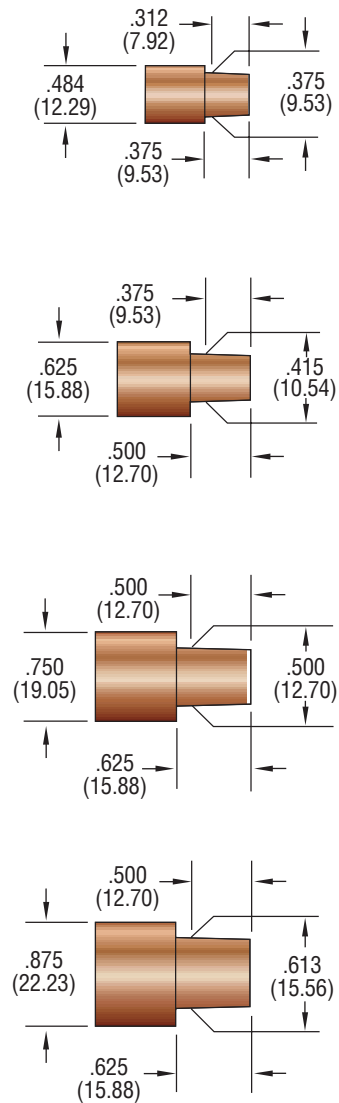
#1 MT - #4 RW

#2 MT - #5 RW

#6 RW

#3 MT - #7 RW

CAP TAPERS



Dimensions Shown Are: inches (mm)

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ELECTRODE MAINTENANCE

This Chart shows graphically the importance of Electrode maintenance. This is not only important from the quality of the weld, which is of first importance, also extra load added to the welding machine and equipment. Read the data on the chart, you can then draw your own conclusions.

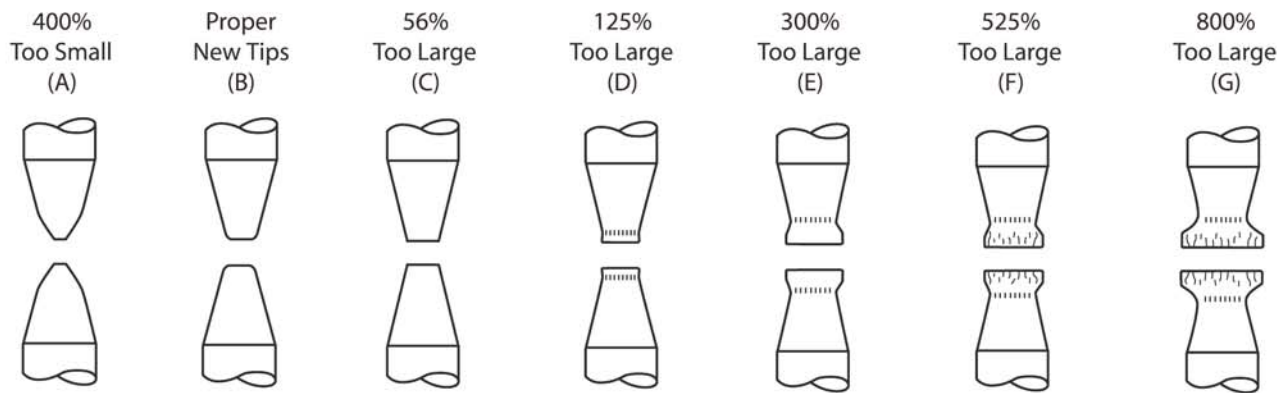
YOU CAN'T AFFORD TO NEGLECT YOUR ELECTRODES!

Keep your Electrodes dressed for maximum production and quality welds.

A TIP DRESSER WILL PAY DIVIDENDS!

We can supply you with hand operated Tip Dressers or Pneumatic Power Driven Dressers. Design or type will depend on your production requirements. Pages 66 & 67.

RESISTANCE WELDING



Approx. .012 sq. in. at 1/8" Dia.	Approx. .049 sq. in. at 1/4" Dia.	Approx. .077 sq. in. at 5/16" Dia.	Approx. .110 sq. in. at 3/8" Dia.	Approx. .197 sq. in. at 1/2" Dia.	Approx. .307 sq. in. at 5/8" Dia.	Approx. .442 sq. in. at 3/4" Dia.
2,460 amperes only would be required (†)	9,823 amperes would be required (†)	15,337 amperes would be required (†)	22,100 amperes would be required (†)	39,300 amperes would be required (†)	61,350 amperes would be required (†)	88,500 amperes would be required (†)
127,640 lbs. sq. in. pressure (*)	31,960 lbs. sq. in. pressure (*)	20,470 lbs. sq. in. pressure (*)	14,200 lbs. sq. in. pressure (*)	7,990 lbs. sq. in. pressure (*)	5,120 lbs. sq. in. pressure (*)	3,500 lbs. sq. in. pressure (*)
RESULT: Four times too much pressure, current, Very severe indentation and spitting from high current density.	RESULT: Correct pressure, current, tips. Excellent weld. This is the size tip (new) for which the pressure, time, and current are adjusted.	RESULT: Only 60% of proper pressure, current. Borderline weld. Lower strength. Last diameter size tolerated unless current and pressure were set between the 1/4 and 5/16 size tips.	RESULT: Only 45% of the required pressure and current. Welds would be unacceptable. If the current or time were increased with tips in this condition a large weak weld would result.	RESULT: Only 25% of required current and pressure. No weld would be made if tips were left in this condition.	RESULT: Only 16% of required current and pressure. This is a very serious condition and the only cure is to dress the tips back to (B) condition.	RESULT: Only 11% of needed current and pressure. This is an absurd (though often seen) condition that only heats a spot.
CORRECTION: Cut pressure to 1/4 Cut current to 1/4						

(†) Current density required for this gage to be 200,000 amps per sq. in. Setting is 9,900 amps for condition (B)

(*) Five inch diameter air cylinder A 80 lbs. air pressure—1570 lbs. on ram.

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SPOT WELDING DATA

SPOT WELDING DATA

OPTIMUM CONDITIONS

SCHEDULES FOR SPOT WELDING LOW CARBON STEEL—SAE 1010

Thick-ness of Thinnest Outside Piece (Inches)	Electrode Diameters and Shape*			Recommended Minimum Standard Electrode Size	Weld Force (Lbs.)	Weld Time (Cycles) (60 Cycles per Sec.)	Hold Time (Cycles) (Min.)	Welding Current (Amps.) (Approx.)	Weld Shear Strength (For Steels Having Ultimate Tensile Strength of 90,000 psi and below) Minimum Strength (Lbs/Weld)	Diameter of Fused Zone (Approx.)	Minimum Weld Spacing	Minimum Contacting Overlap
	Flat Face		Radius Face									
	Maximum d (Inches)	Min. D (Inches)	Radius R (Inches)									
0.010	0.125	1/2	2	4RW 1MT	160	4	5	4,000	130	0.113	1/4	3/8
0.021	0.187	1/2	2	4RW 1MT	244	6	8	6,500	300	0.139	3/8	7/16
0.031	0.187	1/2	2	4RW 1MT	326	8	10	8,000	530	0.161	1/2	7/16
0.040	0.250	5/8	3	5RW 2MT	412	10	12	8,800	812	0.181	3/4	1/2
0.050	0.250	5/8	3	5RW 2MT	554	14	16	9,600	1,195	0.210	7/8	9/16
0.062	0.250	5/8	3	5RW 2MT	670	18	20	10,600	1,717	0.231	1	5/8
0.078	0.312	5/8	3	5RW 2MT	903	25	30	11,800	2,365	0.268	1-1/8	11/16
0.094	0.312	5/8	4	7RW 3MT	1,160	34	35	13,000	3,054	0.304	1-1/4	3/4
0.109	0.375	7/8	4	7RW 3MT	1,440	45	40	14,200	3,672	0.338	1-5/16	13/16
0.125	0.375	7/8	4	7RW 3MT	1,760	60	45	15,600	4,300	0.375	1-1/2	7/8
0.156	0.500	7/8	6	Male or Female Threaded	2,500	93	50	18,000	6,500	0.446	1-3/4	1
0.187	0.625	1	6	Male or Female Threaded	3,340	130	55	20,500	9,000	0.516	2	1-1/2
0.250	0.750	1-1/4	6	Male or Female Threaded	5,560	230	60	26,000	18,000	0.660	4	1-1/2

PERMISSIBLE SCHEDULE VARIATIONS FOR SPOT WELDING LOW CARBON STEEL

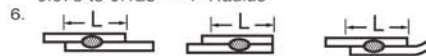
Low Carbon Steel Spot Welding Data Chart—Single Impulse Welding

DATA COMMON TO ALL CLASSES OF SPOT WELDS				WELDING SET-UP FOR BEST QUALITY—CLASS A WELDS					WELDING SET-UP FOR MEDIUM QUALITY—CLASS B WELDS					WELDING SET-UP FOR GOOD QUALITY—CLASS C WELDS					
Thick-ness of Each of the Two Work Pieces (Inches)	Electrode Diam. & Shape		Min. Weld Spacing (Note 4)	Min. Contacting Overlap (Note 6)	Weld Time (Cycles)	Electrode Force (Pounds)	Welding Current (Amps.)	Diam. of Fused Zone (Dw)	Average Tensile Shear Strength ±14% (Pounds)	Weld Time (Cycles)	Electrode Force (Pounds)	Welding Current (Amps.)	Diam. of Fused Zone (Dw)	Average Tensile Shear Strength ±17% (Pounds)	Weld Time (Cycles)	Electrode Force (Pounds)	Welding Current (Amps.)	Diam. of Fused Zone (Dw)	Average Tensile Shear Strength ±20% (Pounds)
	Min. D	Max. d																	
.010	1/2	1/8	1/4	3/8	4	200	4000	.13	235	5	130	3700	.12	200	15	65	3000	.11	160
.021	1/2	3/16	3/8	7/16	6	300	6100	.17	530	10	200	5100	.16	460	22	100	3800	.14	390
.031	1/2	3/16	1/2	7/16	8	400	8000	.21	980	15	275	6300	.20	850	29	135	4700	.18	790
.040	5/8	1/4	3/4	1/2	10	500	9200	.23	1305	21	360	7500	.22	1230	38	180	5600	.21	1180
.050	5/8	1/4	7/8	9/16	12	650	10300	.25	1820	24	410	8000	.23	1700	42	205	6100	.22	1600
.062	5/8	1/4	1	5/8	14	800	11600	.27	2350	29	500	9000	.26	2150	48	250	6800	.25	2050
.078	5/8	5/16	1-1/8	11/16	21	1100	13300	.31	3225	36	650	10400	.30	3025	58	325	7900	.28	2900
.094	5/8	5/16	1-1/4	3/4	25	1300	14700	.34	4100	44	790	11400	.33	3900	66	390	8800	.31	3750
.109	7/8	3/8	1-5/16	13/16	29	1600	16100	.37	5300	50	960	12200	.36	5050	72	480	9500	.35	4850
.125	7/8	3/8	1-1/2	7/8	30	1800	17500	.40	6900	60	1140	12900	.39	6500	78	570	10000	.37	6150

NOTES:

- Low Carbon Steel as hot rolled, pickled, and slightly oiled with an ultimate strength of 42,000 to 45,000 PSI Similar to SAE 1005—SAE 1010.
- Electrode Material is CMW® 3.
- Surface of steel is lightly oiled but free from grease, scale or dirt.
- Minimum weld spacing is that distance for which no increase in welding current is necessary to compensate for the shunted current effect in adjacent welds.

- Radius Face electrodes may be used:
0.010 to 0.031 — 2" Radius
0.031 to 0.078 — 3" Radius
0.078 to 0.125 — 4" Radius



- Weld time is indicated in cycles of 60 cycle frequency.

- Tensile shear strength values are based on recommended test sample sizes:

Direction of Force	Thickness	Width	Length
	.000" to .029"	5/8"	3"
	.030" to .058"	1"	4"
	.059" to .115"	1-1/2"	5"
	.116" to .190"	2"	6"

- Tolerance for machining of electrode diameter "d" is ±.015" of specified dimension.
- Electrode force does not provide for force to press ill-fitting parts together.

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HELPFUL SUGGESTIONS

RESISTANCE WELDING

DO'S

- Use the RWMA recommended electrode material for the job you are running.
- Use RWMA standard electrodes whenever possible.
- Use the appropriate electrode diameter for the material being welded.
- Use open sight drains or have water flow gauges on out bound side to easily confirm water flow.
- Connect the water inlet hose to the proper holder inlet to insure water flows through the center cooling tube first.
- Recommended water flow for the electrodes is 1.5 gallons per minute of cold water.
- Insure that the water tube extends within 0.25" of the bottom of the electrode water hole.
- Adjust the water tube position when changing to another length electrode.
- Check water tube ends to insure they are not damaged and have an angled cut at the end to prevent water restriction.
- Use ejector type holders to simplify electrode removal.
- Keep the electrode and holder tapers clean to ensure good leak free conduction.
- Dress electrodes frequently to insure good quality welds.
- Use raw-hide or hard rubber hammers for alignment of electrodes.
- Provide cooling water on the exit side top and bottom of seam welding applications.
- Use properly designed knurling wheels to insure continuous dressing of the seam welding wheel.
- Lock out the machine when performing any type of maintenance.

DON'TS

- Never use unidentified electrodes or materials.
- Avoid special, offset, or irregular electrodes when the job can be done with standard electrodes.
- Do not use small electrodes on heavy gauge welding jobs or large electrodes on small gauge materials.
- Do not forget to turn the water on full force before starting to weld.
- Never use water hoses that do not fit the water fitting properly.
- Do not allow water connections to become leaky, clogged or broken.
- Avoid holders with leaking or deformed tapers.
- Never use holders that do not have adjustable water deflector tubes.
- Never use pipe tape or similar product to stop a leak.
- Do not let your electrode mushroom excessively.
- Do not dress electrodes with a file.
- Do not use a steel hammer to adjust any part of a welding machine.
- Do not permit seam welding wheels to run off the edge of the work piece.
- Do not enter a work cell or reach into a welder without using your lockout.



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RESISTANCE WELDING - PROBLEM SOLVING

EXPULSION AT WELD INTERFACE

- Short Squeeze Time
- Low Weld Force
- Dirty – Scaly Material
- Poor Fit Up
- Insufficient Edge Distance

SURFACE EXPULSION/ ELECTRODE STICKING

- Short Squeeze Time
- Long Weld Time
- Short Hold Time
- Low Weld Force
- High Weld Current
- Dirty – Scaly Material

ELECTRODE MUSHROOMING

- Insufficient Cooling
- Low weld Force
- High Weld Current
- Small Electrode Face Area
- Long Weld Time
- Welder Head Impacts Work

LOW WELD STRENGTH

- Short Weld Time
- Low Weld Force
- Low Weld Current
- Small Electrode Face Area
- Poor Heat Balance
- Welds Too Close Together

EXCESSIVE WELD INDENTATION

- Long Weld Time
- High Weld Force
- High Weld Current
- Poor Fit Up
- Welder Head Impacts Work

INTERNAL CRACKS IN WELD NUGGET

- Short Hold Time
- Low Weld Force
- Dirty – Scaly Material
- Metallurgy of Material Welded
- Poor Head Follow Up

DISPLACED WELD NUGGET

- Electrode Misalignment
- Poor Heat Balance
- Poor Fit Up

CRACKS IN PARENT MATERIAL

- High Weld Force
- Insufficient Cooling
- Metallurgy of Material Welded

HELPFUL HINTS

- Use standard RWMA design electrodes whenever possible. Use the RWMA recommended electrode material for the part being welded. Keep the electrodes aligned normal to the working face. Only use offset electrodes or weld at an angel when nothing else will work.
- Check the water deflector tubes each time you install electrodes. They should be within one quarter inch of the bottom of the water hole of the electrode.
- Confirm there is water flow from the electrodes, transformer, control and other cooled components before welding.
- Always use the proper size water hose, if removed check for obstructions that might impede flow.
- When a set up will not be used for a period of time remove the electrodes from the holders to avoid freezing into the holder due to corrosion.
- Use fine emery cloth to dress electrode faces. If wear is excessive remove from the machine and dress in lathe or other controlled machine. Dressing electrodes with files is not recommended because alignment and consistency are not possible with this manual method.
- If the use of a hammer is necessary on resistance welding machine or its components, use rubber, plastic, brass, raw-hide or other soft material. Never use a steel hammer.
- If a water leak is found repair as soon as possible, or report it to the appropriate maintenance personnel.
- Check all mechanical connections in the secondary connections. Check all shunts and cables for damage, replace as needed.
- Perform maintenance to Resistance Welding equipment as outlined in RWMA Bulletin 14.
- Keep in mind that sparks/expulsion are an indication that something is not right at the weld. It could be current, force, time, alignment and many other factors. Take time, check your set up for variance from the desired settings. Expulsion can be dangerous and could also result in questionable product.



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