SPOT WELDING LOW CARBON STEEL

Thickness "T" of Thinnest Outside Piece (Inches)	Electrode Diameter (Inches)	Net Electrode Force (Lbs.)	Weld Time (Single Impulse) Cycles (60 Per Sec.)	Welding Current (Approx.) (Amps)	Minimum Contacting Overlap (Inches)	Minimum Weld Spacing (Inches)	Diameter of Fused Zone In. Approx.	Minimum Shear Strength Lbs. Tensile Strength Below 70000 PSI	Minimum Shear Strength Lbs. Tensile Strength 70000 PSI And Above	Thickness "T" of Thinnest Piece (Inches)
0.010	3/8	200	4	4000	3/8	1/4	0.10	130	180	0.010
0.021	3/8	300	6	6500	7/16	3/8	0.13	320	440	0.021
0.031	3/8	400	8	6600	7/16	1/2	0.16	570	800	0.031
0.040	1/2	500	10	9500	1/2	3/4	0.19	920	1200	0.040
0.050	1/2	650	12	10500	9/16	7/8	0.22	1350	–	0.050
0.062	1/2	800	14	12000	5/8	1	0.25	1850	–	0.062
0,078	5/8	1100	17	14000	11/16	1-1/4	0.29	2700	–	0.078
0.094	5/8	1300	20	15500	3/4	1-1/2	0.31	3450	–	0.094
0.109	5/8	1600	25	17500	15/16	1-5/8	0.32	4150	–	0.109
0.125	7/8	1800	26	18000	7/8	1-3/4	0.33	5000	–	0.125

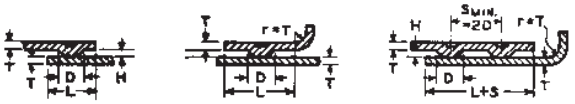
1. Type of steel: SAE 1010
2. Material should be free from scale, oxides, paint, grease and oil.
3. Welding conditions determined by Thickness "T" of thinnest outside piece.
4. Data for total thickness of pile-up not exceeding 4 "T". Recommended maximum ratio between two thicknesses: 3 to 1.
5. Electrode Material: Class 2 (Tuffaloy 77)
6. Minimum weld spacing is that spacing for two pieces for which no special precautions need be taken to compensate for shunted current effect of adjacent welds. For three pieces, increase spacing 30 per cent.

SPOT WELDING GALVANIZED STEEL

Thickness (of thinnest piece) Inches	Electrode Diameter Inches	Net Electrode Force Pounds	Weld Time Cycles	Welding Current (Approx.) Amps.	Minimum Overlap Inches
0.030	1/2	475	11	10,500	1/2
0.035	1/2	550	12	11,000	9/6
0.040	5/8	625	13	12,500	5/8
0.050	5/8	840	18	14,000	11/16
0.060	5/8	1050	23	15,500	3/4
0.075	3/4	1400	28	19,500	7/8
0.093	3/4	1800	34	24,000	1
0.109	3/4	2200	39	28,500	1-1/4

1. Type of galvanized: 1.25 oz/ft² nominal.
2. Material should be free from dirt, paint, grease and oil.
3. Welding conditions determined by thinnest of two pieces only. Schedule is good for thickness ratios up to 2:1.
4. Electrode material: Class 1 or 2 (Tuffaloy 88 or 77).
5. Electrode nose design: Dome or truncated cone.

(from International Lead, Zinc Research Organization, Inc.)



PROJECTION WELDING DATA FOR LOW CARBON AND STAINLESS STEEL

Thickness "T" of Thinnest Outside Piece (Nominal) Inches	Diameter of Projection "D" Inches	Height of Projection "H" Inches	Minimum Shear Strength (Single Projecting Only) Pounds Tensile Strength Below 70000 PSI	Minimum Shear Strength (Single Projecting Only) Pounds Tensile Strength 70000 Up To 150000 PSI	Minimum Shear Strength (Single Projecting Only) Pounds Tensile Strength 150000 PSI And Above	Diameter of Fused Zone Minimum (At Weld Interface Inches	Minimum Contacting Overlap "L" Inches
0.010	0.055	0.015	130	180	250	0.112	1/8
0.012	0.055	0.015	170	220	330	0.112	1/8
0.014	0.055	0.015	200	280	380	0.11 2	1/8
0.016	0.067	0,017	240	330	450	0.112	5/32
0.021	0.067	0.017	320	440	600	0.140	5/32
0.025	0.081	0.020	450	600	820	0.140	3/16
0.031	0.094	0.022	635	850	1100	0.169	7/32
0.034	0.094	0.022	790	1000	1300	0.169	7/32
0.044	0.119	0.028	920	1300	2000	0.169	9/32
0.050	0.119	0.028	1350	1700	2400	0.225	9/32
0.062	0.156	0.035	1950	2250	3400	0.225	3/8
0.070	0.156	0.035	2300	2800	4200	0.281	3/8
0.078	0.187	0.041	2700	3200	4800	0.281	7/16
0.094	0.218	0.048	3450	4000	6100	0.281	1/2
0.109	0.250	0,054	4150	5000	7000	0.338	5/8
0.125	0.281	0.060	4800	5700	8000	0.338	11/16
0.140	0.312	0.066	6000	–	–	7/16	3/4
0.156	0.343	0.072	7500	–	–	1/2	13/16
0.171	0.375	0,078	8500	–	–	9/16	7/8
0,187	0.406	0.085	10000	–	–	9/16	15/16
0.203	0.437	0,091	12000	–	–	5/8	1
0.250	0.531	0.110	15000	–	–	11/16	1-1/4

1. TYPES OF STEEL:
   Low-Carbon-SAE 1010
   Stainless-Types 309, 310, 316, 317, 321, 347 and 349.
   (Non-Hardenable: Max. Carbon content 0.15%)
2. Material should be free from scale, oxides, paint, grease and oil.
3. Size of projection normally determined by thickness of thinner piece, and projection should be on thicker piece where possible.
4. Data based on thickness of thinner sheet, and for two thicknesses only.
5. Contacting overlap does not include any radii from forming, etc.
6. Weld should be located in center of overlap.
7. Projection should be made on piece of higher conductivity when dissimilar metals are welded.
8. For diameter of projection "D" a tolerance of 0.003 in. in material up to and including 0.050 in. in thickness and 0.007 in. in material over 0.050 in. in thickness may be allowed.
9. For height of projection "H" a tolerance of 0.002 in. in material up to and including 0.050 in. in thickness and 0.005 in. in material over 0.050 in. in thickness may be allowed.

PROJECTION WELDING SCHEDULE GUIDE

FOR ONE PROJECTION:
CURRENT = 1T + .045 x 100,000 AMPS
TIME = 2T x 100 HERTZ (CYCLES)
= 2T x 6,000 LBS.

FOR MORE THAN ONE PROJECTION:
CURRENT = 1T + .045 x 100,000 + 30% FOR EACH ADDITIONAL PROJECTION
TIME = 2T x 100 HERTZ (CYCLES)
PRESSURE = 2T x 6,000 + 50% FOR EACH ADDITIONAL PROJECTION

TUFFALOY HELPFUL SUGGESTIONS

Many factors affecting electrode cost and useful electrode life are briefly outlined below.

PART TO BE WELDED

Lay out the part for resistance welding. Designing engineer, welding engineer and production man in charge of welding should cooperate in securing a better product at lowest cost.

Correct design permits the use of standard straight electrodes: or standard offset or standard angular holders if the straight approach is not possible. Special shaped electrodes cost more, and the difficulty of cooling the electrode is amplified. Single spot, multiple spot, projection, or other method may be accurately chosen to achieve lowest cost. Consult the R.W.M.A Manual.*

MATERIAL TO BE WELDED

The weldability of the materials can be determined by consulting your material supplier, and by reviewing recommendations covered in the R.W.M.A Manual.*

Surface conditions, rust, oil, dirt, and, on many articles, oxide film and even handling marks have a decided effect on weld quality. Cleaning may have to be a part of the welding job in some cases.

WELDING EQUIPMENT AND CONTROL

A welding machine of reputable quality purchased for a particular application will be correctly designed both electrically and mechanically, and will be supplied the correct control equipment and electrodes for the work.

On machine change-overs make sure of adequate electrical and mechanical capacity, and see that the necessary controls are provided. Consult us when redesigning or revising your choice of electrodes.

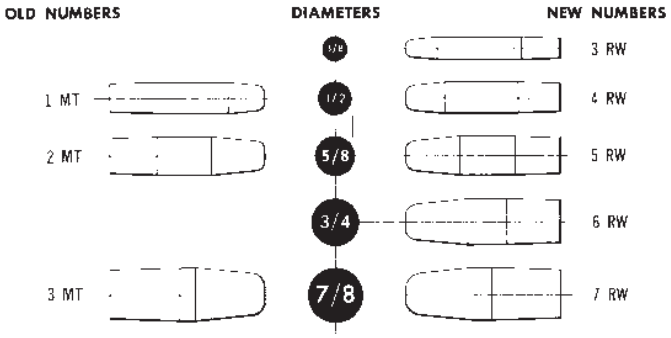
STANDARD GAGE CHART

Thickness in Decimals of an Inch

Gage No.	Manufacturer's Standard	Gage No.	Manufacturer's Standard	Gage No.	Manufacturer's Standard
3	0.2391	12	0.1046	22	0.0299
4	0.2242	13	0.0897	23	0.0269
5	0.2092	14	0.0747	24	0.0239
6	0.1943	15	0.0673	25	0.0209
7	0.1793	16	0.0598	26	0.0179
8	0.1644	17	0,0538	27	0.0164
9	0.1495	18	0.0478	28	0.0149
10	0.1345	19	0.0418	29	0.0135
11	0.1196	20	0.0359	30	0.0120
		21	0.0329		

** Resistance Welding Manual, published by the Resistance Welder Manufacturers Association.*

The RWMA tip numbering system has generally replaced the old Morse taper numbers with new "RW" numbers, and has added two new sizes, as the chart illustrates.



ELECTRODE LIFE SAVERS

1. Use standard Tuffaloy electrodes with Tuffaloy ejector type, self-adjusting tube, water-cooled electrode holders wherever possible. Avoid special or irregular shapes for lowest cost.
2. Use ample cold cooling water as close as practical to the welding contact surface, properly circulated at a minimum of 30-psi pressure, and supplied at a rate of at least 1-1/2 gallons per minute.
3. Be sure to select the proper type and size of electrode, taking into consideration electrode pressure, contact area of electrode, gauge, and nature of material to be welded. Consult the RWMA Manual* or your Tuffaloy field engineer regarding recommended practices. Overloading as well as overheating shortens electrode life.
4. Good welds depend upon properly maintained electrodes which assure an accurate surface contact. Keep tapers clean and dress electrode faces with lathe, emery paddle or fine file. Use castor oil or graphite grease to facilitate tip removal, and avoid application of insulators such as teflon tape and other materials.

RESISTANCE WELDING MACHINE SETUP

TO DETERMINE SPOT WELDING SCHEDULE

CURRENT = 2T x 100,000 = AMPERES

TIME = 2T x 100 = CYCLES

PRESSURE = 2T x 6000 (LB) = FORCE REQUIRED (LB)

T = THICKNESS OF THE THINNEST PIECE

APPROXIMATE PRESSURE EXERTED BY AIR CYLINDER SIZE

DIAMETER		CYLINDER AREA SQ. INCHES				
4″	=	12.5	x	WELDER GUAGE PRESSURE	=	ELECTRODE FORCE PRESSURE
5″	=	19.5	x		=	
6″	=	28.0	x		=	
8″	=	50.0	x		=	

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.

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.