

**Recommended Practices
for
Resistance Welding
Coated Low
Carbon Steels**



AMERICAN WELDING SOCIETY

AWS C1.3-70

**Recommended Practices
for
Resistance Welding
Coated
Low Carbon Steel**

Prepared by
AWS Resistance Welding Committee

Price \$2.00

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345 East 47th Street, New York, N.Y. 10017

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FOREWORD

These Recommended Practices have been prepared by the AWS Resistance Welding Committee through the work of the Subcommittee on coated metals. The data has been obtained from users and suppliers of coated metals and also data based on actual tests to confirm weld schedules.

It is important to recognize that these Recommended Practices are not presented as the only possible conditions for welding the materials and thicknesses shown. The data are presented as a guide for setting up welding schedules to be followed in fabrication. The welding schedules may be modified to fit the specific fabricating conditions and production requirements involved.

The AWS Resistance Welding Committee welcomes comments on the Recommended Practices, so that information from industrial sources may be used to keep these practices up to date. Communications should be addressed to the Secretary, AWS Resistance Welding Committee, American Welding Society, 345 East 47th Street, New York, N.Y. 10017.

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RECOMMENDED PRACTICES

FOR

SPOT, SEAM AND PROJECTION WELDING

COATED LOW CARBON STEEL

I. General Provisions

101 Materials

The data contained in these Recommended Practices apply to the types of coated steels and the thickness ranges shown in the respective tables. Specific welding requirements of zinc, aluminum, lead, nickel, tin, copper, cadmium, and chromium coated low carbon steel AISI 1010 are presented in the respective sections.

102 Electrode Diameter and Shape

The electrode shape has a flat face and beveled sides. The flat-faced electrodes are recommended for coated sheets and for thin electrodeposited coatings. Initially the flat-faced electrodes with small diameter (d) should not exceed the value specified in the tables in order to control the contact area. On the other hand, use of a diameter (d) smaller than specified will cause expulsion indentation and a reduction in weld strength. In using the flat-faced electrode, care should be exercised to prevent excessive increase in the diameter (d) beyond the specified value during dressing operations.

The parameter (d) is specified in the appropriate tables for welding conditions.

Large diameter (D) is a minimum; use of a diameter smaller than specified will result in excessive heating and deformation of the electrode face.

The seam welding data for electrodes show the electrode width (W) and the face width (E) rather than the diameter (d).

103 Net Electrode Force

The values shown in the tables refer to the net electrode force between contacting surfaces such as would be obtained in welding test pieces.

104 Time

The values shown for all time intervals are in cycles based on 60 Hertz. Heat Times and Cool Times for seam welding indicate the time during which the current is flowing and when it is interrupted respectively. If a slower welding speed is required, the Cool Time must be increased to maintain the same number of welds per inch of joint. The welds per inch are related to the welding speed and time as shown by the formula:

$$\text{Welds per inch} = \frac{3600}{(\text{Heat} + \text{Cool}) \times \text{Welding Speed}}$$

where: the Heat and Cool times are in cycles welding speed is in inches per minute.

105 Welding Current

The values shown are approximate and are intended to help determine and specify the size of the welding transformer required. The currents should not be used as exact values to obtain a given weld size or strength. The currents may be increased to a point where metal expulsion occurs, then reduced to just below this point; optimum weld strength may thus be obtained. The values reported are root mean square (RMS) current measurements.

106 Minimum Contacting Overlap

These values indicate the required overlap as shown in each table. It is important to avoid using overlaps less than the dimensions specified, otherwise, the weld strengths will be difficult to maintain consistently or distortion of the overlapping sheets may occur.

107 Minimum Weld Spacing

The weld spacing specified should be maintained so that no special precautions need be taken to compensate for the shunted current effect of adjacent welds.

108 Diameter of Weld Nugget

These data are helpful when cross-sectional etch tests are made to measure the penetration of the weld nugget or peel test is made to determine weld nugget diameter¹.

109 Minimum Weld Strength

Tension-shear weld strength tests in a calibrated tensile testing machine with specimen unconfined is the accepted method of measuring these values. Welds made during the setting up of a welding machine should never be used to establish these values of weld strength. Only those welds made after the machine has been properly adjusted should be considered in the evaluation of weld strength².

It should be recognized that variations in individual weld strengths exist no matter how accurately the welding parameters are controlled. Weld strength, which determines the acceptable weld schedule should be above the minimum value indicated. How much above should be determined by test and experience, however, a 10 percent increase is a suggested value so no weld strength falls below the indicated minimum value when tested³.

The data for seam welding are intended to produce joints which will not fail at the weld interface when tested in tension before failure of the base metal. No definite strengths are specified⁴.

¹See "Standard Methods for Testing Resistance Welds" (AWS C1.1-66, Section 504.5).

²See "Standard Methods for Testing Resistance Welds" for procedure (Tension-Shear Test AWS C1.1-66, Section 504.1).

³Control of weld strength is often maintained by statistical analysis as in "Standards for Testing Resistance Welds" (AWS C1.1-66, Section 507).

⁴See "Standard Methods for Testing Resistance Welds" for peel test for seam welds (AWS C1.1-66, Section 504.10).

II. Specific Welding Requirements

200 Galvanized Steel

Zinc coating is applied to low carbon steel by electrodeposition or hot dipping.

201 Zinc Coatings

The zinc coating on low carbon steel is specified by weight (ounces per square foot) for the hot dip product and by weight and/or coating thickness for the electrodeposited product. The continuous hot dip and heavily coated electrodeposited products require a modification of the welding schedule for bare low carbon steel when welding the coated steel. These surfaces may be treated with materials such as light oil, or subjected to a chromate treatment which is to prevent white rust (ZnO) that is detrimental to resistance welding. Welding data for commercial weights of coating are shown in Tables 2.1 (spot welding), 2.2 (seam welding) and 2.3 (projection welding).

Where the zinc coating (0.6 ounces per square foot) is welded, the welding schedule for bare low carbon steel is recommended.

202 Electrode Diameter and Shape

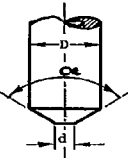
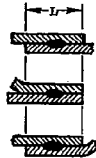
The preferred shape of the RWMA Group A, Class 2 electrode is a truncated cone. Generally, the shape will have a 120 included angle, however, angles of 90 and 140 degrees have been used. This electrode shape will produce many quality welds before dressing is required to reestablish the weld size and strength. Water cooling of spot welding electrodes should be with a flow rate of at least 2 gallons per minute, and the inlet water temperature should not be allowed to rise above 95°F (35°C). A water hole-bottom-to-face dimension (nose thickness) of 3/8 inch with a properly positioned water inlet tube should be used to provide adequate electrode cooling.

Seam welding wheels should have their width (W) approximately equal to the overlap distance. Wheel welding face should be beveled to obtain a face with (E). A knurled drive which will produce a knurled face (E) is recommended. An idling or dressing knurl for a shaft drive machine is satisfactory. External water cooling directed at the weld area is used to minimize surface melting and electrode sticking. The knurled drive prevents excessive buildup on the wheels.

5 | Table 2.1

Appendix A

Table 2.1 – Spot Welding Galvanized Low Carbon Steel

MATERIAL THICKNESS (see par. 101 & 201 and notes 1, 2, & 3 below)	ELECTRODE DIAMETER AND SHAPE (see par. 102 & 202 and note 4 below)			NET ELECTRODE FORCE (see par. 103)	WELDING CURRENT (APPROX.) (see par. 105)	WELD TIME (see par. 104)	WELD NUGGET SIZE (see par. 108)	MINIMUM TENSION-SHEAR STRENGTH (see par. 109)	MINIMUM WELD SPACING (see par. 107)	MINIMUM CONTACTING OVERLAP (see par. 106)
		D	d	α						
INCHES	IN.	IN.	IN.	DEG.	LB.	AMPS.	CYCLES	IN.	LB.	INCHES
0.022	5/8	3/16	120	300	13000	8	0.15	550	5/8	5/8
0.030	5/8	3/16	120	400	13000	10	0.16	1000	5/8	5/8
0.036	5/8	1/4	120	500	13500	12	0.19	1180	3/4	5/8
0.039	5/8	1/4	120	650	14000	13	0.21	1400	3/4	5/8
0.052	5/8	1/4	120	725	14500	18	0.22	1700	7/8	11/16
0.063	3/4	1/4	120	850	15500	22	0.24	2500	1-1/8	3/4
0.078	3/4	5/16	120	1200	19000	24	0.28	3200	1-1/4	7/8
0.093	3/4	3/8	120	1400	21000	30	0.34	4200	1-1/2	1
0.108	7/8	3/8	120	1750	20000	37	0.40	5900	1-3/4	1-1/8
0.123	7/8	3/8	120	2000	20000	42	0.48	7200	2	1-1/8

NOTES:

1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil.
2. Two equal metal thicknesses of each gage.
3. Commercial coating weight is 1.25 oz. per square foot.
4. Electrode Material-RWMA Group A Class 2.
5. Water Cooling: 2 gallons per minute (see par. 202).

203 Seam Welding

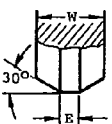
For optimum quality joints in critical applications, the removal of zinc from the weld area prior to welding is recommended.

300 Aluminized Steel

The coating of low carbon steel with aluminum is applied by using the continuous hot dip process, cladding or electrophoresis.

Appendix B

Table 2.2 — Seam Welding Galvanized Low Carbon Steel

MATERIAL THICKNESS (see par.101, 201, 203 & notes 1, 2 & 3 below)	ELECTRODE WIDTH AND SHAPE (see par.102 & 202 and note 4 below)		NET ELECTRODE FORCE (see par. 103)	WELDING CURRENT (APPROX.) (see par. 105)	WELD TIME (see par. 104)		WELDING SPEED (see par. 104)	WELDS PER INCH (see par. 104)	MINIMUM CONTACTING OVERLAP (see par. 106)
					HEAT TIME	COOL TIME			
	W IN.	E IN.			CYCLES	CYCLES			
INCHES	IN.	IN.	LB.	AMPS.	CYCLES	CYCLES	IN./MIN.	W/IN.	INCHES
0.015	3/8	1/4	900	15000	2	2	120	7.5	3/8
0.036	1/2	1/4	1100	18000	4	2	60	10.0	1/2
0.039	1/2	1/4	1200	19000	4	3	60	9.0	1/2
0.052	1/2	1/4	1350	20000	5	1	90	7.0	9/16
0.063	1/2	5/16	1500	19800	8	2	54	7.0	5/8
0.078	5/8	5/16	1850	23000	10	7	30	7.0	11/16

NOTES:

1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil.

2. Two equal metal thicknesses of each gage.

3. Commercial coating weight: 1.25 oz. per square foot.

4. Electrode Material-RWMA Group A, Class 2.

5. Pressure-tight joints require stripping the zinc coating prior to welding.

6. Nominal electrode diameter ranges between 8 to 10 inches.

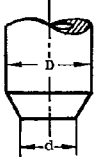
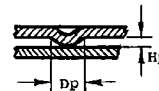
301 Aluminum Coatings

The aluminum coatings applied to steel by the continuous hot dip process are either aluminum with 8% silicon alloy (Type 1) or a pure aluminum (Type 2). Both materials are available in a regular or extra smooth commercial finish. Type 1 coatings are 0.5 ounces per square foot for the regular and 0.35 ounces per square foot for the light. Type 1 coatings are 0.0005 inch to 0.001 inch thick per side for the light and regular designations. Type 2 coatings are one ounce per square foot and have a nominal thickness of 0.002 inch per side. The Type 2 coating is thicker and of relatively lower

7 | Table 2.3

Appendix C

Table 2.3 – Projection Welding Galvanized Low Carbon Steel

MATERIAL THICKNESS (see par.101 & 201 and notes 1, 2 & 3 below)	ELECTRODE DIAMETER AND SHAPE (see par.102 & 202 and note 4 below)		NET ELECTRODE FORCE (see par. 103)	WELDING CURRENT (APPROX.) (see par. 105)	WELD TIME (see par. 104)	WELD NUGGET SIZE (see par. 108)	MINIMUM TENSION-SHEAR STRENGTH (FOR SINGLE PROJECTIONS ONLY) (see par. 109)	PROJECTION SIZE (see note 5 below)	
									
INCHES	D IN.	d IN.	LB.	AMPS.	CYCLES	IN.	LB.	DIAMETER IN.	HEIGHT IN.
0.039	5/8	3/8	250	10000	15	0.15	925	0.187	0.041
0.063	5/8	7/16	400	11500	20	0.25	2050	0.218	0.048
0.078	3/4	1/2	550	16000	25	0.25	2700	0.250	0.054
0.093	3/4	1/2	750	16000	30	0.30	4300	0.250	0.054
0.108	7/8	1/2	950	22000	33	0.31	4900	0.250	0.054
NOTES: 1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil. 2. Two equal metal thicknesses of each gage. 3. Commercial coating weight: 1.25 oz. per square foot. 4. Electrode Material-RWMA Group A, Class 2. 5. Projection forming die and punch dimensions are given in Table 2.3.1.									

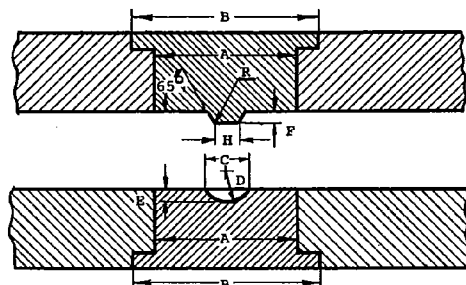
electrical resistivity than the Type 1 coating. Electrode indentation and the reduction of current density are encountered to a greater extent in the case of welding Type 2 coated steel.

The schedules shown in Table 3.1 are for both types of coatings. The welding parameters are essentially the same for equal thicknesses of both materials.

Frequent electrode cleaning and redressing will be necessary. The frequency of dressing is somewhat greater than that for galvanized steel welding.

Appendix C

Table 2.3.1 – Punch and Die Design Data for Projection Welding Galvanized Steel



METAL THICKNESS INCHES	PUNCH AND DIE PARAMETER							
	A	B	C	D	E	F	H	R
			IN.	IN.	IN.	IN.	IN.	IN.
0.039	O P T I O N A L	O P T I O N A L	0.187	0.128	0.041	0.055	0.104	0.010
0.063			0.218	0.148	0.048	0.065	0.115	0.010
0.078			0.250	0.172	0.054	0.075	0.137	0.015
0.093			0.250	0.172	0.054	0.075	0.137	0.015
0.108			0.250	0.172	0.054	0.075	0.137	0.015

302 Electrode Diameter and Shape

The electrode diameter and shape is similar to that used for galvanized steel (Section 202).

400 Terne Coated Steel

The terne coatings are usually applied by the continuous hot dip process.

401 Terne Coatings

The terne coatings are lead-tin (Terne) alloys with the concentrations of tin ranging from 12 to 25% tin.

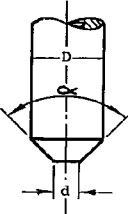
The steel is coated by the continuous hot dip process with four common coating weights; commercial, 0.35, 0.45, and 0.55 ounces per square foot.

The welding data for terne coated steel is presented in Table 4.1.

9 | Table 3.1

Appendix D

Table 3.1 - Spot Welding Aluminized Low Carbon Steel

MATERIAL THICKNESS (see par.101 & 301 and notes 1 & 2 below)	ELECTRODE DIAMETER AND SHAPE (see par.102 & 302 and note 3 below)			NET ELECTRODE FORCE (see par. 103)	WELDING CURRENT (APPROX.) (see par. 105)	WELD TIME (see par. 104)	WELD NUGGET SIZE (see par. 108)	MINIMUM TENSION-SHEAR STRENGTH (see par. 109)	MINIMUM WELD SPACING (see par. 107)	MINIMUM CONTACTING OVERLAP (see par. 106)
										
INCHES	D	d	α	LB.	AMPS.	CYCLES	IN.	LB.	INCHES	INCHES
0.018	5/8	5/32	90	300	8600	8	0.15	500	5/8	5/8
0.021	5/8	5/32	90	350	8800	9	0.16	570	5/8	5/8
0.027	5/8	3/16	90	400	9000	10	0.17	640	5/8	5/8
0.033	5/8	3/16	90	500	9200	11	0.18	1080	5/8	5/8
0.039	5/8	1/4	90	600	11400	14	0.21	1500	3/4	5/8
0.052	5/8	1/4	90	800	11800	18	0.23	2000	7/8	11/16
0.063	3/4	1/4	90	1100	12000	24	0.24	2200	1	3/4
0.078	3/4	5/16	90	1400	16000	30	0.33	4300	1-5/16	7/8
0.093	3/4	3/8	90	1800	19000	36	0.40	4500	1-1/2	1
NOTES: 1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil. 2. Two equal metal thicknesses of each gage. 3. Electrode Material-RWMA Group A, Class 2. 4. Water Cooling: 2 gallons per minute (see par. 202).										

Appendix E

Table 4.1 - Spot Welding Terne Coated Low Carbon Steel

MATERIAL THICKNESS (see par. 101 & 401 and notes 1, 2 & 3 below)	ELECTRODE DIAMETER AND SHAPE (see par. 102 & 402 and note 4 below)			NET ELECTRODE FORCE (see par. 103)	WELDING CURRENT (APPROX.) (see par. 105)	WELD TIME (see par. 104)	WELD NUGGET SIZE (see par. 108)	MINIMUM TENSION-SHEAR STRENGTH (see par. 109)	MINIMUM WELD SPACING (see par. 107)	MINIMUM CONTACTING OVERLAP (see par. 106)
INCHES	D IN.	d IN.	α DEG.	LB.	AMPS.	CYCLES	IN.	LB.	INCHES	INCHES
0.029	5/8	3/16	120	450	11000	12	0.19	900	5/8	1/2
0.036	5/8	1/4	120	500	12000	13	0.22	1000	3/4	9/16
0.052	5/8	1/4	120	650	15000	15	0.24	1500	7/8	11/16
0.063	3/4	1/4	120	700	17500	18	0.27	1900	1-1/4	3/4

NOTES:

1. Material must be free from dirt, grease, paint etc. prior to welding, but may have light oil.
2. Two equal metal thicknesses of each gage.
3. Commercial coating weights; commercial, and 0.35 to 0.45 oz. per square foot.
4. Electrode Material-RWMA Group A, Class 2.
5. Water cooling: 2 gallons per minute (see par. 202).

402 Electrode Diameter and Shape

The electrode diameter and shape is similar to that used for galvanized steel (Section 202).

500 Miscellaneous Coatings for Low Carbon Steel

Several metallic coatings in addition to those presented are applied to low carbon steel. Some of these coatings are used as extensively as zinc, aluminum, and lead but are not resistance welded in large quantities. The

coatings which are applied as electrodeposits are of the copper, tin, nickel, chromium, and cadmium types. Tin is also applied by the continuous hot dip process. Nickel is sometimes applied as a cladding. These coatings are very thin if electrodeposited and usually present no particular problems for resistance welding, although the oxides from cadmium welding may be toxic. The welding currents are usually about 10% higher than those for bare low carbon steel. These coatings have electrical resistivities and thermal conductivities that are between low carbon steel and the other metallic coatings already presented. Generally, the dome shaped electrodes are used to minimize breaking through the thin coatings as is possible with the truncated cone shape. Electrode face radii from 2 to 4 inches are recommended for high current densities.

Electrode sticking is common with tin and cadmium coatings. Frequent cleaning will be necessary to remove any pickup on the electrode face. The copper, nickel and chromium coatings are not so prone to electrode sticking since these coatings do not alloy as readily with the copper base electrodes. Chromium plated metals are probably welded less frequently than other coated metals since the inclusion of small amounts of chromium in the nugget will result in substantial hardening. Usually, the material can be welded with light oil coating but other foreign materials must be removed.

600 Zinc-Rich Weld Primers

The zinc rich primers are paints containing approximately 90% by weight of zinc powder with the remainder consisting of binder and vehicle. The primer should be applied to the faying surfaces and overspray should be minimized on the electrode side. Coating thickness should be approximately from 2 to 3 mils thick.

The welding schedule for galvanized steel should be used (See Tables 2.1 and 2.2).