

**Recommended Practices
for
Automotive Weld Quality —
Resistance Spot Welding**

Keywords — Automotive, inspection requirements, resistance spot welding, low carbon steel sheet, peel test, recommended practice, spot weld requirements

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Recommended Practices for Automotive Weld Quality — Resistance Spot Welding

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**Prepared by
AWS/SAE Joint Committee on Automotive Welding**

**Under the Direction of
AWS Technical Activities Committee
SAE Materials, Processes and Parts Division**

**Approved by
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Abstract

This document presents recommended practices for resistance spot weld quality. It is intended to cover common automotive sheet steel systems excluding high strength low alloy steel (HSLA). Definitions, spot weld requirements, and inspection requirements are provided.



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Foreword

(This Foreword is not a part of ANSI/AWS/SAE D8.7-88, *Recommended Practices for Automotive Weld Quality — Resistance Spot Welding*, but is included for information purposes only).

This recommended practice was prepared by the Subcommittee on Automotive Weld Quality — Resistance Spot Welding of the AWS/SAE Joint Committee on Automotive Welding to assist the smaller suppliers of automotive parts who do not, in general, have specifications of their own. It is an update of the original document published in 1978.

This publication is issued under the auspices of the AWS/SAE Joint Committee on Automotive Welding. The Society of Automotive Engineers will list this specification as an SAE Recommended Practice but will not include it in the SAE Handbook. However, it will be referenced in the SAE Information Report J1147 and listed as J1188. This publication is available from either the American Welding Society or the SAE, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

Comments or inquiries concerning this specification are welcome. They should be sent to the Technical Director, American Welding Society, 550 NW LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

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Recommended Practices for Automotive Weld Quality — Resistance Spot Welding

1. Scope

These recommended practices define the structural classifications and establish the minimum acceptable quality levels for welds in each structural classification. Only bare and coated low carbon steels having less than 40 ksi (276 MPa) yield strength are covered. These practices are the minimum acceptable for automotive resistance spot welding.

The criteria used to evaluate weld quality are intended to be applied only under static conditions encountered during manufacturing. Any attempted application of this document or the evaluation method used herein to other uses, as for example post-crash weld quality assessment, may lead to an erroneous result.

2. Definitions for Automotive Spot Welding

2.1 Contact Overlap. Contact overlap shall be an effective flange width measured from a line through the origin of the bend to the edge of the shortest flange or for a lap joint as the overlap between the two parts. (Reference Table 1.)

2.2 End Weld. An end weld is a weld that is common to two lines of welds at their intersection or a weld at the extremity of a line of welds.

2.3 Fit-Up. A measure of the closeness or degree of contact between mating parts.

2.4 Minimum Welds. A spot weld is minimum, when tested, if a pulled button or fused nugget at the faying surface is equal to or greater than that shown for a minimum weld in Table 2. Maintenance should be initiated when the minimum diameter is reached.

2.5 Set-Up Weld Diameter. A set-up weld diameter is that obtained when the electrodes are new. As production continues, the weld diameters will vary, first increasing above the set-up diameter and then decreasing below.

3. Introduction

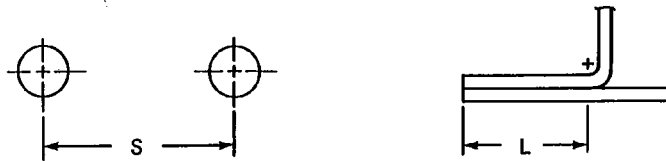
Production-welded parts being joined by the resistance spot welding process have continually changing weld quality characteristics. Some tolerance must be established for the required quality so as to be consistent with process capabilities. The welding process must be controlled so as to attain the minimum weld quality level which meets the product requirements.

The content of this standard practice is considered to be realistic and tempered with the knowledge of what the resistance spot welding process is capable of accomplishing in a production environment when using acceptable welding techniques.

Welds are considered satisfactory when they meet design intent. Service loads on a weldment in an automobile body are of great variety in both type and magnitude, but the inspection techniques and evaluation criteria are the same for all welds regardless of the severity of service loading.

A satisfactory weld has a nugget or pulled button diameter above the minimum (Table 2) and satisfies the other criteria in section 6, Spot Weld Requirements. Tool design and setup are based on a nugget or pulled button diameter larger than the minimum. As production welding continues, the weld diameter can vary down to the minimum diameter. When deterioration becomes apparent, adjustment of the equipment or electrode maintenance, or both, is required to re-establish

Table 1
Minimum Spot Weld Spacing and Contact Overlap
for Automotive Resistance Spot Welding



Material Thickness		Weld Spacing				Contacting Overlap	
		2 Pieces		3 Pieces			
in.	mm	in.	mm	in.	mm	in.	mm
0.015–0.024	0.38–0.62	0.38	9.7	0.62	15.7	0.44	11.2
0.025–0.034	0.63–0.87	0.62	15.7	0.88	22.4	0.47	11.9
0.035–0.044	0.88–1.13	0.75	19.1	1.06	26.9	0.53	13.5
0.045–0.054	1.14–1.38	0.94	23.9	1.18	30.0	0.59	15.0
0.055–0.064	1.39–1.64	1.06	26.9	1.31	33.3	0.63	16.0
0.065–0.074	1.65–1.89	1.18	30.0	1.50	38.1	0.66	16.8
0.075–0.084	1.90–2.14	1.38	35.1	1.68	42.7	0.72	18.3
0.085–0.099	2.15–2.52	1.56	39.6	1.88	47.8	0.78	19.8
0.100–0.114	2.53–2.91	1.68	42.7	2.00	50.8	0.84	21.3
0.115–0.129	2.92–3.29	1.81	46.0	2.12	53.8	0.88	22.4
0.130–0.144	3.30–3.67	1.94	49.3	2.25	57.2	0.94	23.9
0.145–0.159	3.68–4.05	2.06	52.3	2.38	60.5	1.00	25.4
0.160–0.174	4.06–4.42	2.18	55.4	2.50	63.5	1.06	26.9

Notes:

1. S = Weld Spacing
2. L = Contacting Overlap

the weld diameter at the *setup weld diameter*. For structural qualifications of the product, prototypes should be built to the minimum applicable weld specifications.

The values stated in this recommended practice in U.S. customary units are to be regarded as the standard. The metric (SI) equivalents of U.S. customary units given may be approximate.

4. General

4.1 Material Limitations. This recommended practice is limited to resistance spot welding applications using low carbon steel having a maximum yield strength of 40 ksi (276 MPa) and a maximum carbon equivalent of 0.23 (this corresponds to SAE 1010 steel of 0.13 percent maximum carbon content). The carbon equivalent (C.E.) is calculated by the following formula:

$$\text{C.E.} = \%C + \%Mn/6 \quad \text{Eq (1)}$$

4.2 Coating Limitations

4.2.1 Metallic Coatings. The following metallic coatings can be resistance spot welded. Thicker coatings require more careful attention to processing and equipment maintenance. Weldability decreases in the thinner base metal gages as the ratio of the coating to base metal thickness increases.

(1) Electrolytic or hot dip galvanized, or related alloy coatings

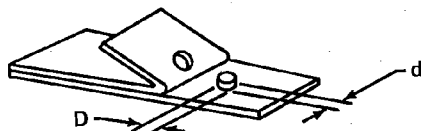
(2) Terne plate

(3) Aluminum-coated steel

4.2.2 Paint Coatings. Paint coatings, such as zinc-rich primers and certain proprietary zinc-rich coatings, are acceptable provided welds meet the requirements of this recommended practice.

4.3 Surface Condition. The surface of the material at the time of welding should be free of all contaminants, such as rust, dirt, and contaminated drawing oils and

Table 2
Minimum Weld Diameter for
Automotive Resistance Spot Welds



Material Thickness		Weld Diameter	
in.	mm	in.	mm
0.015–0.024	0.38–0.62	0.12	3.0
0.025–0.034	0.63–0.87	0.15	3.8
0.035–0.044	0.88–1.13	0.17	4.3
0.045–0.054	1.14–1.38	0.20	5.1
0.055–0.064	1.39–1.64	0.21	5.3
0.065–0.074	1.65–1.89	0.22	5.6
0.075–0.084	1.90–2.14	0.24	6.1
0.085–0.099	2.15–2.52	0.26	6.6
0.100–0.114	2.53–2.91	0.28	7.1
0.115–0.129	2.92–3.29	0.29	7.4
0.130–0.144	3.30–3.67	0.30	7.6
0.145–0.159	3.68–4.05	0.32	8.1
0.160–0.174	4.06–4.22	0.33	8.4

Notes:

1. Average diameter = $\frac{D + d}{2}$ as obtained from a peel test.
2. The minimum weld diameter is intended as a point to initiate maintenance. There can be useful engineering properties below this point.

compounds, that would adversely affect weld quality. The use of weld-through primers and sealers is acceptable where the limitations and special requirements imposed by the specific primer or sealer are recognized. The suitability of a particular primer and sealer should be ascertained in pre-production testing.

4.4 Contact Overlap and Spot Weld Spacing. Overlap and spot weld spacing should equal or exceed the minimum standards listed in Table 1 so as to minimize shunting conditions.

4.5 Part Fit-Up

4.5.1 The accuracy and the surface conditions of mating parts should be such that contact at the faying surface can be obtained with adequate fixturing and clamping without increases in electrode force.

4.5.2 To assure good joint fit-up, all parts must be properly positioned and accurately located. Where clamping fixtures are used for this purpose, all clamps must be properly closed.

5. Structural Classifications

5.1 Critical Locations. Locations are classified as critical where weld failure would seriously affect the function of the motor vehicle or induce rapid deterioration of its structural integrity. These locations and welds within them should be noted on the product drawings.

5.2 Federal Safety Locations. Certain weld locations require compliance with Federal Motor Vehicle Safety Standards (MVSS). These locations and the welds within them are designated on the product drawings by a symbol or the initials MVSS.

5.3 Normal or Ordinary Locations. Certain weld locations are not subject to severe stresses and their failure would not seriously affect performance of the product. These locations and the welds should be noted on product drawings.

6. Spot Weld Requirements

6.1 Satisfactory Welds. A satisfactory weld is one that meets the design requirements.

6.2 Substandard Welds

6.2.1 A spot weld is substandard, when peel tested, if an averaged pulled button diameter is smaller than that shown for a minimum weld in Table 2 or has no fusion at the faying surface.

6.2.2 A spot weld is substandard if the weld is mislocated at spots outside the dimensional tolerance allowed on the drawing or in the specifications.

6.2.3 A spot weld is substandard if the electrode indent (1) is over 25 percent of any piece in the stack-up, (2) is more than 30 degrees out of plane, or (3) overhangs the edge of the flange.

6.3 Tolerances. The typical conditions for weld acceptance of an inspected product are listed in 6.3.1 through 6.3.5.

6.3.1 Normal tolerance for location should be plus or minus 0.25 in. (6.4 mm) of that indicated on the part drawing unless otherwise specified. All welds on one flange, even when staggered, are to be considered as a single row of consecutive welds.

6.3.2 The minimum number of welds in a group required by design is to be noted on the product drawing. This number should be established in conjunction with manufacturing and should reflect manufacturing capabilities.

6.3.3 No adjacent welds should be substandard.

6.3.4 No end welds should be substandard.

6.3.5 Weld methods, tooling, equipment, etc, should be processed to meet the quality control requirements for various weld structural classification.

6.4 Weld Surface Finishes

6.4.1 Class I Weld Finish. This weld classification covers sheet metal surfaces that should be free of markings, indentations, or imperfections in either as-welded or after-metal finishing, to the extent that they are not apparent after painting. Metal finishing should not remove more than ten percent of the surface sheet thickness. This finish classification is not applicable to metallic or paint-coated surfaces contacting the welding electrode. A Class I weld generally is specified for normally visible exterior sheet metal surfaces (the body, front end sheet metal, doors, deck-lid, and hood) which remain exposed after installation of ornamental moldings.

6.4.2 Class II Weld Finish. This weld classification covers a minimally marked welded surface without metal finishing and is to be used where a minimum amount of metal displacement is acceptable within the following limits:

6.4.2.1 A maximum of 10 percent above and a maximum of 15 percent below normal surface is permitted. Surface expulsion is not acceptable on the show side.

6.4.2.2 The finish classification is not applicable to metallic or paint-coated surfaces contacting the welding electrode.

6.4.2.3 When Class II welds are specified, the outside surface finish of sheet metal assemblies is usually controlled by specific visual samples.

6.4.3 Class III Weld Finish. This weld classification covers normally marked surfaces and is intended to be used where surface marking is not critical. The weld indentation should not exceed 25 percent of the specified thickness of either of the sheets in the as-welded condition.

Where metal expulsion or excessive metal displacement (above the normal surface) is unacceptable because of fit, appearance, or other reasons on a Class III drawing, the assembly drawing shall specify each such weld with a note. This notification will require removal of the metal expulsion or displacement wherever it is found on the specified spot weld.

7. Inspection Requirements

7.1 Visual Requirements. Visual inspection should not be a substitute for the required peel or chisel test.

7.1.1 Excessive Indentation. The depth of depression on sheet surfaces caused by welding electrodes should not exceed 25 percent of the sheet metal thickness unless otherwise specified by a weld surface finish requirement on the drawing.

7.1.2 Distortion. The base metal must not be distorted to the extent that the face of the weld is more than 30 degrees out of the plane of the metal surface or the sheet is pulled out of line by more than twice its thickness immediately around the weld.

7.1.3 Missing and Mislocated Welds. Welds that are not made at locations specified on the drawings or welds that are located at spots outside the tolerance limits of the drawings are classified as substandard welds.

7.2 Destructive Testing

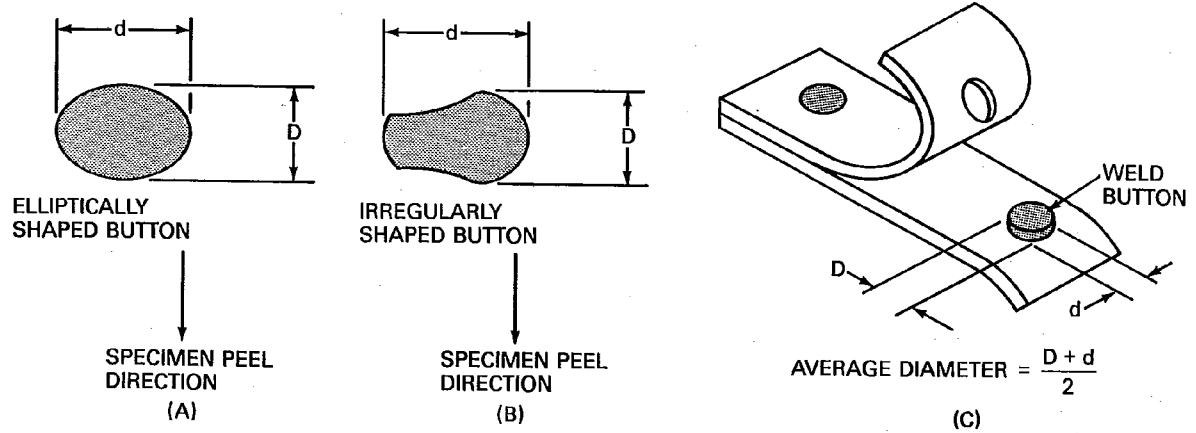
7.2.1 Spot welds should be tested for the required size after the completion of all spot welding on the assembly or subassembly. Destructive testing should be made on as small a spot-welded production unit as is practical to obtain significant data. It is not the intent of this recommended practice to destructively test an entire automotive body or any other large completed assembly.

7.2.2 The destructive tests described in 7.3 and 7.4 shall be made on actual production parts selected at random in accordance with the manufacturer's sampling plan.

7.2.3 Destructive testing should consist of either the peel test (7.3), the chisel test (7.4), a laboratory examination (7.5) when required, or a combination of these.

7.3 Peel Test. This test consists of completely peeling apart a welded lap joint on a production item, as shown in Figure 1. Where feasible, the direction of peel should be in the direction of the joint line or line of welds. The resultant buttons should normally be measured at the faying surface of the weld button and the average diameter should be calculated as shown in Figure 1.

7.4 Chisel Test. A chisel test (Figure 2) consists of forcing a tapered chisel into the lap on each side of the weld being tested until the weld or base metal fails. The edges of the chisel must not touch the weld being tested. This type of test is to be used when the peel test is not feasible. The button size is determined in the same manner described for the peel test, as shown in Figure 1.



NOTE: Use knife edge dial caliper to measure button size.

Figure 1 — Measurement of a Weld Button Resulting from the Peel Test

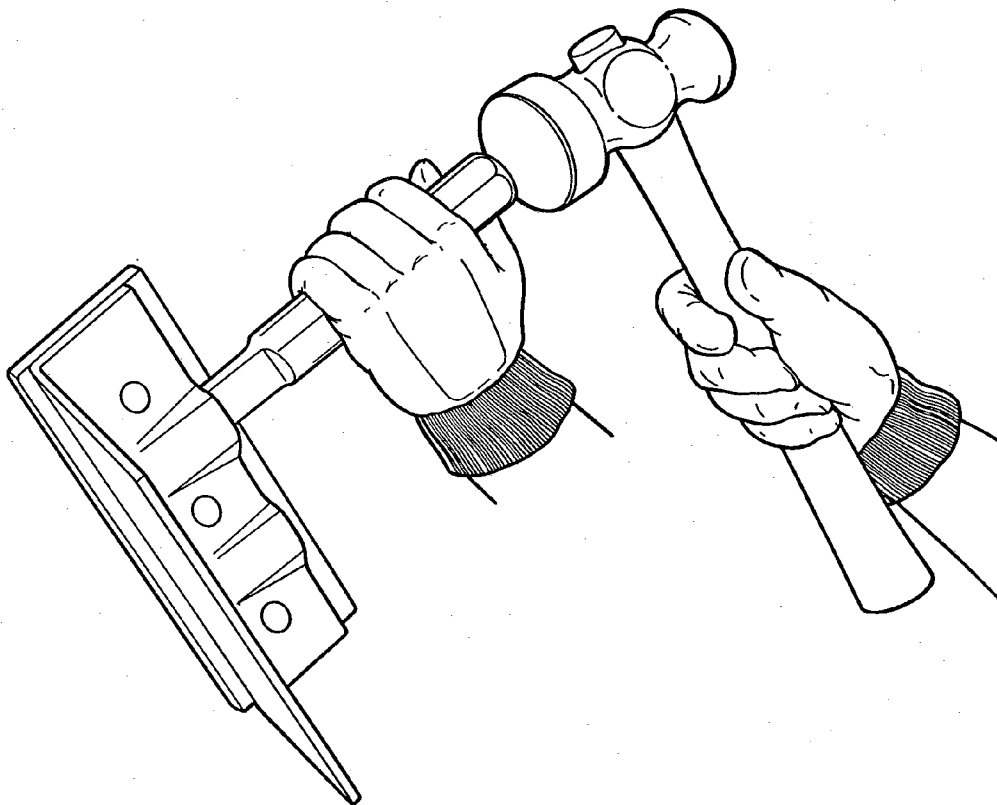


Figure 2 — Spot Weld Chisel Test

7.5 Safety. Safety procedures shall conform as applicable, to the practices defined in ANSI/AWS Z49.1, *Safety in Welding and Cutting*.¹

7.6 Laboratory Examination. Any requirements for laboratory examination of spot welds should be specified on the drawing or in the specifications.

8. Disposition of Substandard Products

Products that do not conform to the requirements of this recommended practice should be rejected. The disposition or method of repair of these products should be approved by the manufacturer's quality control, other approvals the manufacturer may designate, or some combination of these.

¹ This standard may be obtained from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.