Abstract

This Recommended Practices is a collection of data and procedures that are intended to assist the user in setting up resistance welding equipment to produce resistance welded production parts. While the recommendations included are not expected to be final procedures for every production part or every welding machine, they serve as starting points from which a user can establish acceptable welding machine settings for specific production welding applications.

In some cases, recommended machine data is not available. In these instances, some description of the process is given to assist the reader in determining if the process might be suitable for the application.
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This standard is subject to revision at any time by the AWS C1 Committee on Resistance Welding. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS C1 Committee on Resistance Welding and the author of the comments will be informed of the Committee’s response to the comments. Guests are invited to attend all meetings of the AWS C1 Committee on Resistance Welding to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.
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Foreword

This foreword is not part of this standard, but is included for informational purposes only.

The data contained in these Recommended Practices have been compiled by the AWS Committee on Resistance Welding, by reviewing the data in the previous documents, by canvassing users of the resistance welding processes and correlating the data thus obtained. The resulting welding schedules shown in the tables were circulated for comments and, in addition, some tests were conducted to ascertain that welds of the specified strengths could be obtained.

The present edition of Recommended Practices represents an updated combination and extension of data presented in the previous edition of AWS C1.1M/C1.1:2012, Recommended Practices for Resistance Welding. Practices for new materials have been added and practices for materials which are not currently resistance welded in commercial production have been deleted. The new materials include high-strength low-alloy steels, both coated and uncoated.

The AWS C1 Committee on Resistance Welding has prepared these Recommended Practices in the hope that they will serve as an incentive for industry to develop methods and procedures improving upon the practice presented herein; which will permit the raising of quality and performance standards. If this is achieved, the Committee will have been amply repaid for the time and effort it has devoted to this work.

A vertical line in the margin and underlined text in clauses, tables, or figures indicates an editorial or technical change from the 2012 edition.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS C1 Committee on Resistance Welding, American Welding Society, 8669 NW 36 St, Miami, FL 33166.
Amendment

The following Amendments have been identified and are incorporated in this reprint.

Amendment Number: 1
Subject: The minimum weld button shear strength equation found in Tables 1, 4, and 5 (footnote d) has been amended as follows:

\[ ST = \frac{(-6.36 \times 10^{-7} \times S^2 + 6.58 \times 10^{-4} \times S + 14.674) \times S \times 4 \times t^{1.5}}{1000} \]

Has been changed to:

\[ ST = \frac{(-8.83 \times 10^{-7} \times S^2 + 1.34 \times 10^{-3} \times S + 1.514) \times S \times 4t^{1.5}}{1000} \]

Tables 1, 4, and 5 (footnote d) now reads:

Minimum weld button shear strength determined as follows:

\[ ST = \frac{(-8.83 \times 10^{-7} \times S^2 + 1.34 \times 10^{-3} \times S + 1.514) \times S \times 4t^{1.5}}{1000} \]

ST = Shear Tension Strength (kN)
S = Base Metal Tensile Strength (MPa)
t = Material Thickness (mm)
Amendment Number: 2
Subject: Table 1 header has been amended as follows:
• [72 ksi] has been changed to [50 ksi]

<table>
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<th>Table 1</th>
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<tr>
<td>Spot-Welding Parameters for Bare, Galvanneal, and Galvanized Low-Carbon Steel &lt;350 MPa [50 ksi] Ultimate Tensile Strength&lt;sup&gt;a,b,c,d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Amendment Number: 3
Subject: Table of Contents: List of Tables: Table 4 title has been amended as follows:
• “350–700 MPa” has been changed to “350-700 MPa”

Title now reads:
“Spot-Welding Parameters for Bare, Galvanneal, and Galvanized Low-Carbon Steel 350-700 MPa [50–100 ksi] Ultimate Tensile Strength”

Amendment Number: 4
Subject: Table 4 header has been amended as follows:
• “[50–108 ksi]” has been changed to “[50–100 ksi]”

<table>
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<tr>
<td>Spot-Welding Parameters for Bare, Galvanneal, and Galvanized Low-Carbon Steel 350–700 MPa [50–100 ksi] Ultimate Tensile Strength&lt;sup&gt;a,b,c,d,g&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Amendment Number: 5
Subject: Table of Contents: List of Tables: Table 5 title has been amended as follows:
• “>700 MPa Ultimate Tensile Strength [<101 ksi]” has been changed to “>700 MPa [>100 ksi] Ultimate Tensile Strength”

Title now reads:
“Spot-Welding Parameters for Bare, Galvanneal, and Galvanized Low-Carbon Steel >700 MPa [>100 ksi] Ultimate Tensile Strength”

Amendment Number: 6
Subject: Table 5 header has been amended as follows:
• “[102 ksi]” has been changed to “[>100 ksi]”

Table 5
Spot-Welding Parameters for Bare, Galvanneal, and Galvanized Low-Carbon Steel >700 MPa [>100 ksi] Ultimate Tensile Strengtha, b, c, d, e
**Amendment Number:** 7

**Subject:** Several Table 15 headers have been amended as follows:
- “Base Metal Tensile Strength Below 1.03 MPa [150 ksi]” has been changed to “Base Metal Tensile Strength Below 1030 MPa [150 ksi]”
- “Base Metal Tensile Strength Above 1.03 MPa [150 ksi]” has been changed to “Base Metal Tensile Strength 1030 MPa [150 ksi] and higher”
- “From 480 MPa [70 ksi] Up To 300 MPa [90 ksi]” has been changed to “From 480 MPa [70 ksi] Up To 620 MPa [90 ksi]”
- “From 620 MPa [90 ksi] Up To 1.03 MPa [150 ksi]” has been changed to “Above 620 MPa [90 ksi] Up To 1030 MPa [150 ksi]”
- “1.03 MPa [150 ksi] and Higher” has been changed to “1030 MPa [150 ksi] and Higher”

---

**Table 15**

**Spot-Welding Parameters for Stainless Steels**

<table>
<thead>
<tr>
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<tr>
<td></td>
<td>mm [in]</td>
<td>min</td>
<td>max</td>
<td>Base Metal Tensile Strength Below 1030 MPa [150 ksi]</td>
<td>Base Metal Tensile Strength 1030 MPa [150 ksi] and Higher</td>
<td>From 480 MPa [70 ksi] Up To 620 MPa [90 ksi]</td>
<td>From Above 620 MPa [90 ksi] Up To 1030 MPa [150 ksi] and Higher</td>
</tr>
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</table>
Amendment Number: 8
Subject: Table 16 values have been amended as follows:
- “Below 1034 MPa [150 ksi]” has been changed to “Below 1030 MPa [150 ksi]”
- “1034 MPa [150 ksi] and Higher” has been changed to “1030 MPa [150 ksi] and Higher”
- “Below 1034 MPa” has been changed to “Below 1030 MPa [150 ksi]”
- “[150 ksi] 1034 MPa [150 ksi] and Higher” has been changed to “1030 MPa [150 ksi] and Higher”

### Table 16

Pulsation Spot-Welding Parameters for Stainless Steels

<table>
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<tr>
<th>Electrode Diameter and Shape</th>
<th>Weld Time</th>
<th>Welding Current (Approximate)</th>
<th>Minimum Weld Diameter</th>
<th>Minimum Shear Strength</th>
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<tr>
<td></td>
<td>Heat</td>
<td>Cool</td>
<td>Base Metal Tensile Strength</td>
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<td></td>
<td>15 [250]</td>
<td>6 [100]</td>
<td>mm [in]</td>
<td>Base Metal Tensile</td>
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<td></td>
<td>Cycles</td>
<td>Cycles</td>
<td>mm [in]</td>
<td>Strength</td>
</tr>
<tr>
<td></td>
<td>[ms]</td>
<td>[ms]</td>
<td>mm [in]</td>
<td></td>
</tr>
<tr>
<td>Minimum Weld Spacing</td>
<td>mm [in]</td>
<td></td>
<td></td>
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<tr>
<td>Minimum Contracting Overlap</td>
<td>mm [in]</td>
<td></td>
<td></td>
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<tr>
<td>Number of Pulsations</td>
<td></td>
<td></td>
<td>mm [in]</td>
<td></td>
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</table>

|-------------------------|------|------|-------------------------|----------------------------|-----------------------------|-------------------------------|-----------------------------|
Amendment Number: 9
Subject: Note under Table 49 has been amended as follows:
• Figure 29 reference has been changed to Figure 32

<table>
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<th>Table 49</th>
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<tr>
<td>Data for Flash Welding of Tubing and Flat Sheets</td>
</tr>
<tr>
<td>[See Figure 32 for Assembly of Parts]</td>
</tr>
</tbody>
</table>

Amendment Number: 10
Subject: Header and note in Table 50 have been amended as follows:
• “Falsh” typo was corrected to “Flash”
• Figure 30 reference has been changed to Figure 33

<table>
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<tr>
<td>Data for Flash Welding of Solid Round, Hex, Square, and Rectangular Bars</td>
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<tr>
<td>See Figure 33 for Assembly of Parts</td>
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Recommended Practices for Resistance Welding

1. General Requirements

1.1 Scope. It is the intent of this publication to present current concepts and practices for resistance welding (and related processes) of ferrous and nonferrous metals including coated and dissimilar metals. Where practical, welding schedules are included. In other instances where schedules are too varied or the state-of-the-art is not sufficiently developed, descriptive guidelines are included to enable the user to establish welding procedures to meet its requirements.

It is important to recognize that these recommended practices are not the only means to weld the materials and thickness shown. When developing a welding schedule(s) for a particular application, the workpiece geometry, equipment employed, and production requirements will all influence the parameters and effectiveness of the process.

In using the data shown in the tables, it is imperative that reference be made to the appropriate text. Failure to refer to the text may result in misinterpretation of the data in the tables. The text has been kept as brief as possible and all extraneous comments have been omitted.

For more detailed information on the fundamentals of the resistance welding processes and the types of equipment utilized for the different processes, consult the current AWS Welding Handbook.

1.2 Units of Measurement. This standard makes use of both the International System of Units (SI) and U.S. Customary Units. The latter are shown within brackets [ ] or in appropriate columns in tables and figures. The measurements may not be exact equivalents; therefore, each system shall be used independently.

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard, and therefore are not fully addressed herein.

Safety and health information is available from the following sources:

American Welding Society:
ANSI Z49.1, Safety in Welding, Cutting, and Allied Processes;
AWS Safety and Health Fact Sheets; and

Other safety and health information on the AWS website.

Material or Equipment Manufacturers:
Safety Data Sheets supplied by materials manufacturers
Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies:

Work performed in accordance with this standard may involve the use of materials having been deemed hazardous, and may involve operations or equipment which may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.