AWS D8.9M:2012
An American National Standard

Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials

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Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials

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Prepared by the
American Welding Society (AWS) D8 Committee on Automotive Welding

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This document presents standard test methods for evaluating the resistance spot welding behavior of automotive sheet steels. The document contains a number of tests and test methods useful in determining the resistance spot welding performance of coated and uncoated automotive sheet steels of all strength levels and compositions. The test methods are designed to assess current range, electrode endurance, and weld properties of automotive sheet steels. The weld property tests include tests for hold time sensitivity, weld hardness, shear tension strength, and cross tension strength.

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Foreword

This foreword is not part of AWS D8.9M:2012, *Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials*, but is included for informational purposes only.

Since its publication in 1997, the AWS D8.9 standard has been widely used by steel companies and automotive companies alike to test the weldability of sheet steels for various automotive applications. This document evolved from the Auto/Steel Partnership of the American Iron and Steel Institute's publication, Weld Quality Test Methods Manual. The AWS D8D Subcommittee, which includes members of the Auto/Steel Partnership's Standardized Welding Test Method Task Force, acknowledges the important contributions made by the Auto/Steel Partnership's staff and members in the development and revision of this document.

With the introduction of new advanced high strength steels into automotive production there is a strong need to test these new steels. Therefore, a set of weld schedules has been added in this revision to address this need. Further, a new Design of Experiments (DoE) test method has been included to examine the robustness of advanced high strength steels to variations in welding parameters that typically occur under shop-floor conditions. The procedure outlined in the DoE testing method has been validated at four independent testing laboratories.

This document not only contains test methods for evaluating the welding behavior of sheet steels, but also covers areas essential to using these test methods in obtaining an accurate assessment of the material and its welding attributes.

Listed below are the key test methods described in this document:

Sampling and characterization of test material

Equipment setup and electrode installation

Electrode conditioning and weld size stabilization

Endurance (electrode life) testing

Current level/current range testing

Weld property testing

Current break-through testing

Design of Experiments testing

The sampling and material characterization procedures, equipment setup and electrode installation procedures, and electrode conditioning/weld size stabilization procedures are common to all test methods. In the endurance test, the "endurance limit" (defined as the number of acceptable welds made during the test) is the key welding performance measure that is determined by this test. Other welding behavior measures determined in this test are current levels and current range. Weld button characteristics are assessed by destructive peel testing of weld samples.

The weld property tests are designed to determine hold-time sensitivity, weld button fracture mode, shear tension strength, cross tension strength, metallurgical properties, and hardness of welds made with the test material. The weld property testing is now required at two different weld sizes. Proper judgment should be exercised when interpreting the results of the weld property tests on higher strength steels (such as those with ultimate tensile strength greater than 500 MPa), especially with tests run at the minimum weld size. Welds in such higher strength steels may show interfacial fractures even at short hold times, especially at thicker gauges. The requirement to conduct the tests at the minimum weld size is included to generate more complete information on the behavior of such steels. A fracture classification chart has been added as an Annex D.

Current levels and current range are also determined during the weld property tests. The current break-through test is designed to evaluate the effects that sheet lubricants, conductive paints, or other surface treatments have on the initiation of spot welding current and nugget formation. The types of tests to use shall be specified by the party for whom the testing is to be performed. For some steels, all tests may be specified, while for others, only one test may be specified.

It should be noted that not all of the above tests are required to establish the resistance spot welding behavior of a given grade of steel. The current level/current range testing and weld property testing together generally provide a good indication of the resistance spot welding behavior, whereas the DoE testing is intended to examine the robustness of a given grade of high strength steel to variations in key process variables. The specific tests required to establish the resistance spot welding behavior of a given grade of steel should be agreed upon by the steel supplier (or test laboratory) and the automotive company (or buyer of the steel).

Users of this document have requested that subsequent updates to the document include provisions for the incorporation of other types of welding equipment, electrode caps, and weld schedules than those provided in the document. The inclusion of these alternative methods may permit the testing to be more customer-focused and allow for the determination of specific material and welding performance issues as they relate to a particular manufacturing situation. A commentary and discussion are provided in Annex E and are intended to serve as guidelines should the users of this document desire to utilize alternative test methods for the weld characterization of sheet steels.

It should be noted that, as the weldability evaluation procedures in alternative methods deviate from the procedure described in this document, they may add to the complexity and cost of the material evaluation. The type of evaluations required, and any deviations required to perform them, should be agreed upon between the party for whom the testing is to be performed and the testing laboratory.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D8 Committee on Automotive Welding, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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1. Scope and Applicability

1.1 Scope. This document contains several standardized test methods that are designed to evaluate the resistance spot welding behavior of coated and uncoated sheet steels in a laboratory environment. The test methods allow for uniform testing of automotive sheet steels to determine the following:

(1) The effect of the interaction between a sheet steel's coating (metallic, nonmetallic, or both) and the welding electrodes on electrode deterioration and weld size/quality behavior over an extended number of welds

(2) Current levels and current range

(3) Mechanical properties of welds at different weld sizes and hold times

(4) Metallurgical and hardness properties of welds

(5) The effects of sheet lubricants, conductive paints, or other surface treatment on current break-through

(6) The robustness of a grade of steel to variations in key welding process variables

The test methods are intended for application in a laboratory environment to characterize certain aspects of the welding behavior of sheet steel products under controlled experimental conditions. **They are not intended to simulate production welding practices or to predict welding performance of a given grade of steel in production operations.** The test methods and parameters are designed to be used for sheet steels ranging in thickness from 0.6 mm to 3.0 mm. The tests may be used for sheet steel materials of all yield strengths typically used in automotive applications. In the endurance test, a minimum of two tests per material is recommended to obtain an accurate assessment. The endurance test was developed for low strength (tensile strength less than or equal to 300 MPa) coated steels of lighter gauges. This test is normally used for coated steels with tensile strength less than or equal to 500 MPa and gauges less than 1.2 mm. The weld property tests are designed primarily for gauges of 1.2 mm and heavier.

The specific type and number of tests that are required shall be at the discretion of the specifying party. While the test methods were developed to compare the welding behavior of different steel grades, they can be judiciously applied to evaluate other aspects of welding behavior. Not all of the above mentioned tests are required to establish the resistance spot welding behavior of a given grade of steel. The current level/current range testing and weld property testing together generally provide a good indication of the resistance spot welding behavior, whereas the DoE testing is intended to examine the robustness of a given grade of high strength steel to variations in key process variables.

The specific tests required to establish the resistance spot welding behavior of a given grade of steel should be agreed upon by the steel supplier (or test laboratory) and the automotive company (or buyer of the steel).

A commentary is provided in Annex D on alternative test methods and is intended to serve as a guide should the users of this document desire to utilize alternative test methods for the weld characterization of sheet steels. Because the weldability evaluation procedures in alternative methods deviate from the procedure described in this document, the use of the alternative test methods may add to the complexity and cost of the material evaluation. The type of evaluations required, and any deviations required to perform them, should be agreed upon between the party for whom the testing is to be performed and the testing laboratory.

Resistance spot welding behavior is dependent upon a wide variety of interacting material and weld process factors. To obtain repeatable and reproducible performance data, it is imperative that all experimental variables and the way a test is conducted be closely controlled. Therefore, the instructions for the various sampling and testing procedures in this manual are stated in mandatory language and should be followed as closely as possible. Deviations from the prescribed