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Instruction
Hardware Engineering

No. LMS 7-3

SUBJECT: Resistance Spot Welding

APPROVED BY Manager, Hardware Engineering

STATUS Maintenance Revision

PURPOSE Establishes the requirements for resistance spot welding of Group 2 metals and their alloys as defined in AWS D17.2/D17.2M.

AFFECTED FUNCTIONS Hardware Engineering
Manufacturing

REFERENCES ANSI/AWS A2.4-86 Standard Symbols for Welding, Brazing and Nondestructive Examination
RWMA Bulletin 14 Maintenance Manual for Resistance Welding Machines
AWS D17.2/D17.2M Specification for Resistance Welding for Aerospace Applications

DEFINITIONS Class C spot weld. A spot-welded joint which is considered noncritical and for which no stress analysis is considered.

Design Allowable Certification. The Design Allowable Certification method is intended to routinely permit the use of smaller welds where the design stress allows and to permit stronger welds where required and weld conditions allow. For a given joint, a guaranteed strength value and class must be specified on the drawing. The provisions of the Design Allowable Certification method may be used to certify a weld schedule when unusual conditions apply, for example, when welds are made through adhesives or protective finishes.

Mode Value (Ac). The most frequently appearing value, this value will be developed when a Design Allowable Certification is done.

Nugget. The weld metal (cast) joining the parts in a spot weld.

Nugget Size. The diameter of a spot-weld nugget measured at the plane of the faying surface.

Production Witness Specimens. Weld of specimens made in production setups and destructively tested to provide data on the qualities of production welds which cannot be tested.

Resistance Spot Welding (RSW). A process which produces coalescence at the faying surface in one spot by heat obtained from resistance to electrical current through the work parts held together under pressure by electrodes.

Sheet material. A thickness of material within the range of .006 inch (#38 ga.) and .239 inch (#3 ga.).

Standard Certification. The Standard Certification method shall be for a weld schedule that certifies that the requirements of Table I and all other applicable weld property requirements have been met. The Design Allowable Certification method shall be a weld schedule that certifies that a guaranteed strength value has been met.

Weld conditions. Weld conditions are all circumstances surrounding the making of a given weld, including material kind and configuration, material preparation, electrode shape, machine number, and all weld parameters. Weld parameters. Weld parameters are machine settings or adjustments such as, but not limited to, weld current, weld time, and electrode force.

Weld Schedule. A Weld Schedule is a document that lists the relevant weld conditions required to produce a given resistance spot weld.

**Table I Shear Strength Requirements
for Spot Weld Sheet Specimens**

GROUP 2 ALLOYS (AWS D17.2/D17.2M)								
Nominal Thickness of Thinner Sheet inch	Ultimate Strength above 185,000 psi		Ultimate Strength 150,000 to 185,000 psi		Ultimate Strength 90,000 to 149,000 psi		Ultimate Strength below 90,000 psi	
	lb. per spot		lb. per spot		lb. per spot		lb. per spot	
	min.	min.avg.	min.	min.avg.	min.	min.avg.	min.	min.avg.
.018	590	725	490	600	340	415	250	305
.020	635	785	530	655	390	480	280	345
.022	730	905	610	755	450	550	330	405
.025	870	1,075	725	895	530	655	400	495
.028	1,025	1,260	855	1,055	635	785	465	575
.032	1,250	1,545	1,045	1,280	775	955	565	695
.036	1,500	1,850	1,255	1,545	920	1,140	690	860
.040	1,750	2,150	1,460		1,065	1,310	815	1,000
.045	2,100	2,600	1,795	2,210	1,285	1,585	1,005	1,240
.050	2,450	3,000	2,125	2,620	1,505	1,855	1,195	1,475
.056	2,880	3,550	2,550	3,145	1,770	2,185	1,460	1,800
.063	3,550	4,375	3,090	3,815	2,110	2,595	1,760	2,170
.071	4,200	5,150	3,730	4,595	2,535	3,125	2,080	2,560
.080	4,850	6,000	4,410	5,440	3,005	3,705	2,455	3,045
.090	5,600	6,900	5,090	6,275	3,515	4,335	2,885	3,560
.100	6,300	7,750	5,720	7,050	4,000	4,935	3,300	4,070
.112	7,000	8,600	6,365	7,855	4,545	5,610	3,795	4,675
.125	7,785	9,600	7,080	8,730	5,065	6,250	4,300	5,310

INSTRUCTION

1. Requirements

1.1 General

- a. All resistance spot welding shall be performed in accordance with the requirements of AWS D17.2/D17.2M.
- b. When engineering drawings indicate spot welding by use of a spot welding symbol, the vendor shall employ the standard spot welding techniques specified herein. When the use of standard spot welding equipment is impractical, Link Engineering shall be notified.

- c. All weld symbols shall be interpreted in accordance with ANSI/AWS A2.4.

1.2 Detail Requirements

- a. All spot welds shall be made in accordance with a certified weld schedule.
- b. Weld class. Unless otherwise designated on the specification or drawing, all spot welds shall conform to class "C" requirements of AWS D17.2/D17.2M.
- c. Certification of weld schedules shall be accomplished in accordance with AWS D17.2/D17.2M.

1.3 Methods of surface preparation.

Surface conditions. The surface of the parts to be welded shall be free of objectionable visible films. Scale or oxide coatings may be removed by mechanical treatment (sanding or wire brushing). Other contaminants such as ink, grease, dirt, or similar substances detrimental to the welding process may be wiped down with a clean shop rag.

1.4 Equipment requirements.

- a. Welding machines. Spot welding equipment shall consist of a suitable source of electrical energy, means of adequately cooling the electrodes, and a means of reliably controlling and indicating the relative magnitude of the current, the welding force, and the time of current flow in order to fulfill the requirements of this instruction. The force and current controls shall operate such that no current can flow until the welding force is applied by the welding electrode. The equipment shall not allow a reduction in welding force before current termination.
- b. Set up. Spot welding equipment shall be set up in accordance with the certified weld schedule.
- c. Shear-testing machines. All spot weld shear-testing machines shall be accurate within ± 2 percent of the indicated reading. Portable spot weld

- shear-testing machines shall be checked for accuracy at intervals not to exceed two months.
- d. Jigs and fixtures. Whenever possible, tooling that is required to locate welds or assist in the assembly of welded parts which pass through the magnetic field during the welding operation shall be made of nonmagnetic, heat-resistant materials. Jigs and fixtures must be so designed that no welding current can shunt through them instead of passing through the work pieces.
 - e. Maintenance of equipment. Unless otherwise specified, each item of equipment shall be inspected periodically, as recommended by RWMA Bulletin #14.
- 1.5 Qualification of welding machines. Resistance spot welding machines shall be qualified in accordance with the requirements of AWS D17.2/D17.2M.
- 1.6 Weld schedule certification. Weld schedules shall be certified in accordance with the requirements of AWS D17.2/D17.2M.
- 1.7 Weld property requirements.
- a. Machine Qualification. Property requirements for spot welds made during machine qualification will be found in AWS D17.2/D17.2M.
 - b. Schedule Certification. Property requirements for spot welds made during schedule certifications will be found in AWS D17.2/D17.2M.
- 1.8 Production witness testing and production. Property requirements for welds made during production witness tests and production shall be in accordance with AWS D17.2/D17.2M. The following duplicates these requirements.
- a. Sampling. Sampling techniques shall be approved by the procuring activity prior to their use.
 - b. Visible Criteria for spot welds.
 - (1) Applicability. All spot welds made during production witness testing and production shall meet the following visual requirements.

- (2) **Sheet Separation.** Separation between an inner and outer member is excessive when it exceeds .15 times the summed thickness of the outer sheet and the one adjacent to it, or .006 inch, whichever is greater, measured at a distance (radius) from the nugget center equal to three times the radius of the minimum nugget size given in Table II for the thinner member.

Table II Minimum Nugget Size

Nonminal Thickness of Thinner Sheet	Minimum Nugget Size Inch (mm)	Nominal Thickness of Thinner Sheet Inch	Minimum Nugget Size Inch (mm)
.018	.090 (2.29)	.063	.200 (5.08)
.020	.100 (2.54)	.071	.210 (5.33)
.022	.105 (2.68)	.080	.225 (5.72)
.025	.120 (3.05)	.090	.240 (6.10)
.028	.130 (3.30)	.100	.250 (6.35)
.032	.140 (3.56)	.112	.260 (6.60)
.036	.150 (3.81)	.125	.280 (7.11)
.040	.160 (4.06)	.140	.300 (7.62)
.045	.170 (4.32)	.160	.320 (8.13)
.050	.180 (4.57)	.180	.340 (8.64)
.056	.190 (4.83)	.190	.350 (8.89)

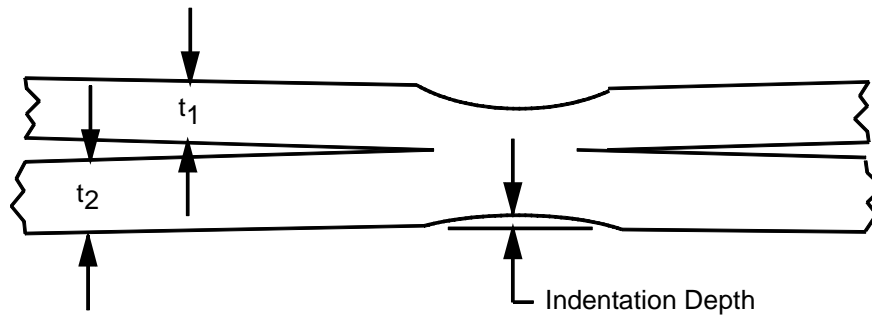
- (a) Excessive separation is not acceptable on production witness specimens.
- (b) Excessive separation is not acceptable on production work if it exceeds .10 times the production welds sampled when the product is rounded off to the next higher whole number.

Example: If the sampling technique required the inspection of 13 spot welds, the quantity of welds that could have excessive separation would be:

$.10 \times 13 = 1.3$
rounded to the next whole number would allow 2 welds.

- (3) **Surface Indentation.** Excessive indentations are not acceptable. Indentations are considered excessive if their depth is greater

than .20 times the thickness of the indented outer member or .005 inch (0.127-mm), whichever is greater. See Figure 1.



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Figure 1 Surface Identification

- (a) Excessive indentation is not acceptable on production witness specimens.
- (b) Excessive indentation is not acceptable on production work if it exceeds .10 times the production welds sampled when the product is rounded off to the next higher whole number.
- (4) Cracks, Pits, and Flash. Crack, pit, or flash type imperfections are limited in quantity by Table III. The number of imperfections shall be calculated by multiplying the factor shown in Table III by the number of welds inspected and rounding off the product to the next higher whole number. Parts or lots with imperfections exceeding the quantity, as determined from Table III, shall be rejected.

Table III Visible External Imperfections for Production Parts

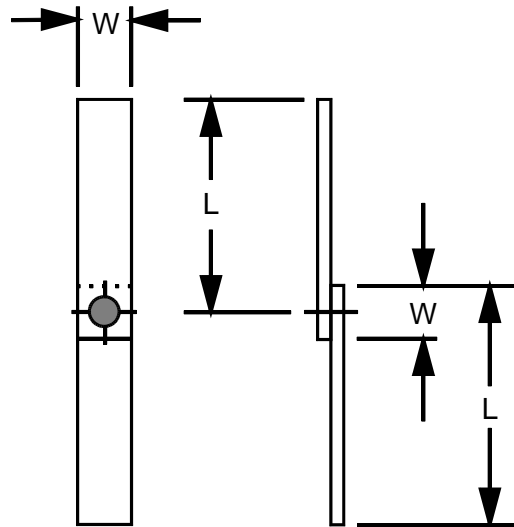
Nature of Weld Imperfections	Acceptance Factor – Class C
Cracks open to surface	.05
Edge bulge cracks	.10
Surface pits over .063 inch (1.60 mm)	.10
Surface pits under .063 inch (1.60 mm)	.10
Flash and surface fusion	.10

- c. Mechanical Criteria for spot welds.
 - (1) Production Witness Test Specimens. All production witness test specimens (see paragraph 2.1) shall be subjected to a shear test in which the specimen shall be pulled until failure occurs (i.e., either the nugget starts to pull out of the parent metal or the nugget breaks apart).
 - (2) Standard Certification. The spread between the lowest and highest specimen shall be less than .35 times the applicable production test lot average. The test lot average for the thinnest sheet of the welded combination shall not be less than the applicable values shown in Table I. (Note: Unless otherwise directed by the drawing, the 90,000-psi data shall be used.)
 - (3) Design Allowable Certification. The average strength of the production test lot shall not be less than .90 times A_c (mode value), without consideration of the provisions of paragraph 2.3. No specimen in a group of 2 consecutive test lots (6 specimens) may be less than .80 A_c .
- 2. Quality Assurance Provisions
 - 2.1 Production Witness Welds. The following test lots shall accompany the welding of production parts to represent properties such as material thickness combinations and surface conditions of production parts not tested. Results of these tests shall be maintained in a Production Witness Test Register adjacent to the welding machine.
 - 2.2 Test lots. Test lots of witness specimens for production parts shall be as noted below. Each test lot shall consist of the number and configuration of test specimens and method of evaluation as specified in Table IV. Any of the quantities specified may be made on a simulation of the production joint as shown in Figure 2.

Table IV Production Witness Welds, Test Lots

Specimen Configuration	Amount of Weld in Test Lot	Mechanical Examination	
		Test	Requirements
Per Figure 2	3 Welds	Shear	paragraph- or paragraph-

- a. Preproduction lot. At the start of each workday or before a new production lot is welded or before welding is resumed after a machine shut down.
 - b. Postproduction lot. At the end of each production workday or after the completion of a production lot.
- 2.3 Deterioration of welding. If investigation of imperfections in welding indicates that quality has deteriorated due to clear causes (e.g., swaged or improperly cleaned tips), and those causes are corrected so that acceptable welds (compared to certification requirements) are made, then a new Certification Weld Schedule will not be required. Under conditions where the Certification Weld Schedule does not produce acceptable welds within the weld schedule latitude (paragraph 2.4), then the certification shall be voided and the machine shall be requalified.



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NOTE 1: Locate weld within $\pm .060$ inch (1.524 mm) of specimen center. Specimen dimensions are subject to a tolerance of $\pm .060$ inch (1.524 mm).

NOTE 2: Nominal Thickness of W

Thinner Sheet, in.
in., Min

Over .008 to .030
.68 (17.27 mm)

Over .030 to .100
1.00 (2.54 cm)

Over .100 to .130
1.25 (3.175 cm)

NOTE 3: L shall not be less than 4W.

NOTE 4: All specimen coupons to be deburred before welding.

Figure 2 Single Spot Shear Specimen

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- 2.4 Control adjustments. When adjustment of the control settings is desirable, the settings may be varied by ± 5 percent from the established certification values, or by ± 10 percent when only one setting is adjusted. Rounded to the nearest unit, this shall be called the permitted schedule latitude adjustment. Production welds must be made within ± 5 percent of the settings used on witness specimens. If satisfactory welding cannot be maintained within these limits of adjustment, welding shall be stopped, and the machine shall be checked for faulty operation. If it can be shown that conditions other than certified welding conditions were the cause of faulty welding, and with the correction of these conditions the original certified welding schedule is capable of producing acceptable welds, the establishment of a new certified welding schedule will not be required.
3. Preparation for Delivery (Not Applicable)
4. Notes
 - 4.1 Parenthetical identities are for reference only.