

MIL-W-46870 (MI)

21 May 1973

SUPERSEDING

MIS-13851B

3 December 1970

MILITARY SPECIFICATION

WELDING OF ELECTRONIC CIRCUITRY, PROCESS FOR

This specification is approved for use by all activities of the Department of the Army.

1. SCOPE

1.1 Scope. This specification covers resistance welding of electronic component leads of functionally oriented electronic circuitry.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

QQ-W-343	Wire, Electrical and Non-electrical, Copper, (Uninsulated)
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Military

MIL-I-22129	Insulation Tubing, Electrical, Polytetrafluoroethylene Resin, Nonrigid
MIL-G-45204	Gold Plating (Electrodeposited)
MIL-N-46025	Nickel Bar, Flat Wire (Ribbon) and Strip
MIL-N-46026	Nickel Rod and Wire (Round) (For Electronic Use)

FSC THJM

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STANDARDS

Federal

FED-STD-151

Metals Test Methods

Military

MIL-STD-1276

Leads, Weldable, for Electronic
Component Parts

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

Aerospace Material Specification

AMS 3655

Tubing, Electrical Insulation
Thin Wall, Extruded Polytetra-
fluorethylene

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., Department 010, Two Pennsylvania Plaza, New York, New York 10001.)

Resistance Welder Manufacturers Association

RWMA Electrode Material Standards Electrodes,
Resistance Welding

(Copies of the above document may be obtained from the Resistance Welder Manufacturers Association, 1900 Arch Street, Philadelphia, Pennsylvania 19103.)

3. REQUIREMENTS

3.1 Finished product

3.1.1 Joint strength. The average joint strength of each 5-specimen test group shall be not less than that determined by the weld schedule

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certification and shall be within the process control limits established for the particular combination of materials being welded. Joint strength is the value in pounds (recorded to the nearest 0.1 lb) resulting from a tension-shear pull test of a welded specimen representing a particular material combination.

3.1.2 Workmanship

3.1.2.1 External defects. All welds shall be free of external visible defects such as cracks, crevices, excessive burns (see 6.2), blow holes, tip pickup, insufficient or no evidence of a weld, excessive deformation, e.g., conductor flattening in excess of 10 percent, (solder coating are not to be construed as base metal indentation), or other defects detrimental to the quality of the weld.

3.1.2.2 Criteria illustrations. The illustrations and standards as shown in figures 1 and 2 shall be used as general criteria for the visual examination of welds.

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Component lead welds



Nickel ribbon welds



(a) Fused protrusion (both sides)



(b) Fused protrusion (one side)



(c) Apparent penetration (90 percent maximum)

(Apparent penetration is the visual appearance of the weld - not as determined by metallographic sectioning)

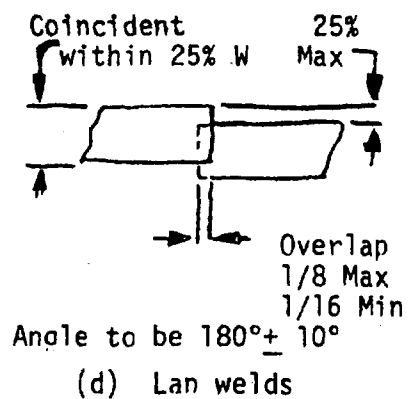
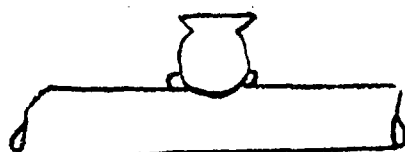


Figure 1. Illustrations of acceptable welds

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Component lead welds



(a) Excessive surface melt



(c) Coral effect

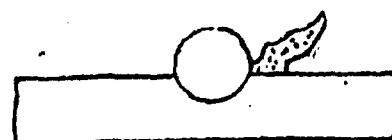


(e) Heat, pressure, or grain cracks

Nickel ribbon welds



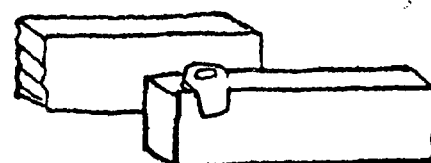
(b) No penetration



(d) Slag effect



(f) Burned through or 100 percent penetration



(g) Insufficient lap weld; at least 3/4 of available area must be in contact



(h) Lap weld; excessive expulsion must be removed, blow hole must not exceed 10 percent of overlap

Figure 2. Illustrations of unacceptable welds

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3.2 Materials

3.2.1 Test specimen materials. The test specimen materials shall be as specified in Table I.

TABLE I. TEST SPECIMEN MATERIALS

ITEM NO.	MATERIAL	SIZE, inches	SPECIFICATION
1	Nickel bus ribbon	0.010 by 0.030	MIL-N-46025
2	Nickel wire	0.020 diameter	MIL-N-46026
3	Copper wire, oxygen free, high conductivity, solder plated	0.025 diameter	QQ-W-343, Type S
4	Iron-nickel-cobalt wire, gold plated with nickel underplate	0.017 diameter	MIL-STD-1276, Type K MIL-G-45204
5	Iron-nickel wire, copper clad, gold plated, unborated, nickel underplate	0.020 diameter	MIL-STD-1276, Type D MIL-G-45204

3.3 Equipment

3.3.1 Welding equipment. The welding equipment shall be as specified below.

3.3.1.1 Power Supply. The power supply shall be of the stored energy, capacitor discharge type possessing the following electrical characteristics:

- a. Charging voltage regulation shall be plus or minus 3 percent.
- b. Power output repeatability at electrodes shall be plus or minus 5 percent.

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- c. Total energy storage capacitance at 25 degrees centigrade (C) (77 degrees Fahrenheit (F)) shall be within plus or minus 4 percent of rated value.
- d. All meter indicators on welding power supplied shall have an accuracy of plus or minus 2 percent, full scale.
- e. Energy output polarity shall be clearly identified.

3.3.1.2 Welding heads. Welding heads shall be of the force-feed type with a linear actuating motion (ram or press type). Electrode clamping force shall be adjustable over a range of 1 to 20 pounds. At any setting, the force shall be repeatable within plus or minus 4 ounces of that setting. Measurement shall be made with a external force gage having a full scale capacity of 25 pounds maximum and having an accuracy of plus or minus 2 percent, full scale.

3.3.1.3 Electrodes. Electrode materials shall be in accordance with the classification established by the Resistance Welder Manufacturer's Association (RWMA).

3.3.1.4 Interconnecting cables. Interconnecting cables shall be such that will produce welds meeting the requirements specified herein.

3.3.2 Testing equipment. Tensile test equipment shall conform to Federal Test Method Standard No. 151, Method 211.1, capable of providing a cross-head speed of 20 inches per minute or less.

3.3.3 Magnification equipment. Magnification equipment for welding and visual examination shall have not less than a 10-power magnification or more than a 25-power magnification.

3.4 Qualification of equipment

3.4.1 Welding equipment qualification. Welding equipment shall be initially qualified as a complete weld station, including power supply, welding head, electrodes and interconnecting cables. Once qualified, equipment may be used in whatever combination of power supply, heads, etc. is deemed necessary providing process control limits are met and no significant operational changes are made.

3.4.2 Qualification test procedure

3.4.2.1 Test specimens. The test specimen material combination shall be as specified in Table II.

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TABLE II. TEST SPECIMEN MATERIAL COMBINATION TO BE USED IN MACHINE QUALIFICATION TESTS

*Reference Code	Material against RWMA Class 1 electrode 1/	Material against RWMA Class 2 electrode 1/
1030N/N20	Item 1	Item 2
1030N/TC25	Item 1	Item 3
1030N/GD20	Item 1	Item 5
1030N/GK20	Item 1	Item 4
<p>NOTE: *Reference Code for Material:</p> <p>1st 2 Digits is thickness in thousandths of an inch.</p> <p>2nd 2 Digits is width in thousandths of an inch.</p> <p>Letters are material types.</p> <p>Last 2 Digits is diameter in thousandths of an inch.</p> <p>1/ See Table I for material description.</p>		

3.4.2.2 Welding electrodes and polarity. A set of welding electrodes consisting of one RWMA Class 1 electrode connected to the negative (-) output terminal and one RWMA Class 2 electrode connected to the positive (+) output terminal of the power supply shall be employed.

3.4.2.3 Welding schedules. Welding schedules developed to meet requirements of table III shall be used in fabricating the qualification test specimens.

3.4.2.4 Test method Five test specimens of each material combination specified in Table II shall be prepared and tested. The mean strength of each material test group (group of 5 test specimens) shall be computed and must exceed the minimum value for the particular material combination given in Table III. The range of each test group shall be computed and must be less than the corresponding maximum given in Table III.

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TABLE III. ACCEPTANCE LIMITS FOR MACHINE QUALIFICATION TEST

Material combination Reference code (see Table II)	Acceptance limits for test groups of 5 Specimens 1/	
	Minimum mean strength, pounds (lbs)	Maximum range, lbs
1030N/N20	13.0	5.1
1030N/TC25	7.6	6.1
1030N/GD20	10.3	4.2
1030N/GK17	11.8	5.1
1/ Observed values shall also conform to applicable approved production process control limits when such control limits require a greater mean or smaller range.		

3.4.3 Qualification approval. Qualification approval of the welding equipment and welds authorized by this specification shall be based on the consistent properties of the welds as shown on the weld schedule certification. The signatures of Process Engineering and Quality Assurance representatives on the certification constitutes qualification.

3.5 Maintenance of equipment. Unless otherwise specified, each item of equipment shall be inspected periodically as recommended by the manufacturer. Adequate maintenance shall be furnished, and defective parts affecting machine operation shall be replaced before production is resumed.

3.6 Qualification of operators

3.6.1 Welding operator. Welding shall be performed only by certified operators who have met the production weld requirements specified herein.

3.6.2 Test material. Test material for operator certification shall consist of 25 test specimens of the weld material used in production. The operator certification data shall include the information indicated by the weld schedule certification.

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3.6.3 Certification approval. Certification approval of the welding operator and welds authorized by this specification shall be based on the consistent properties of the welds as shown on the weld schedule certification. The authorized signatures on the certification constitutes operator certification approval.

3.6.4 Recertification. Once the welder has been certified, he need not be recertified provided his last production welds have not exceeded a three-month period.

3.7 Procedure

3.7.1 Establishment of welding schedules and process control limits. Weld schedules consisting of specific electrode clamping force and welding energy settings, electrode combination, configurations, polarity, and visual characteristics shall be established for each material combination, size and joint design to be welded in production. Weld schedules and specific process control limits shall be developed by the block diagram or other acceptable method.

3.7.1.1 Selection of optimum weld schedules and determination on process control limits. The standard deviation of each of the test lots shall be computed and an estimated $3\bar{\sigma}$ lower control limit on strength calculated for each test lot. The schedule or schedules with the highest estimated lower control limit and least standard deviation shall be scheduled for further sampling. Additional sampling shall consist of welding and testing at least one lot of 5 test specimens on each of 10 qualified weld stations, or each station if less than 10 are available. The resulting test lots data are used to calculate dispersion control limits from mean strength, range and standard deviation for the production sampling required. These control limits shall be established according to the following procedures:

$$\text{Lower control limit on mean strength} = \bar{X}_{LCL} = \bar{X} - 3.29\bar{\sigma} \cdot (\bar{x})$$

$$\text{Standard deviation of means} = \bar{\sigma}(\bar{x}) = \sqrt{\frac{N\sum \bar{x}^2 - (\sum \bar{x})^2}{N(N-1)}}$$

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Upper control limit on range = $R_{UCL} = 4.87 \bar{\sigma}$

Where N = Number of test groups of 5 samples each

\bar{X} = Average pull strength of each 5-samples each

$$\bar{\sigma} = \sqrt{\frac{5 \sum x^2 - (\sum x)^2}{20}} = \text{Standard deviation of each 5-sample group}$$

x = Individual pull strength readings

$\bar{\sigma}$ = Average of standard deviations

Range = Difference between highest and lowest pull strengths (group of 5)

The factor 3.29 for lower control limit on mean strength above is based on N (number of test groups) approaching infinity. The control limits shall be recalculated periodically using the results of process control tests until a minimum of 150 test groups are included. Process control limits may be calculated with factors other than 3.29 which reflect the smaller sample size, as follows:

<u>Number of test groups</u>	<u>Factor</u>
30	3.65
40	3.55
60	3.46
120	3.37
∞	3.29

Note: Existing weld schedules. If certified weld schedules have been established for the same material combinations and only minor differences in finish or size prevail, as determined by the cognizant Materials and Process activity, the existing certified weld schedule may be used so long as the process control limits can be maintained.

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3.7.2 Surface preparation. Prior to welding, all component leads and bus material shall be clean and free from grease, dirt, and other foreign matter or contamination which could degrade the weld joint.

3.7.3 Conductor spacing and insulation. Interconnecting conductors spaced less than 0.020 inch apart, shall be covered with an insulating sleeving conforming to MIL-I-22129 or AMS-3655. Unsupported lengths over 0.75 inch in length shall be covered with an insulating sleeving conforming to MIL-I-22129. Circuitry shall be fabricated in accordance with the engineering drawing.

3.7.4 Metal penetration and protrusion. The applied pressure of the weld electrodes forces each conductor to penetrate into the other displacing a portion of the molten metal to the outer weld area. The molten metal protrusion need not be fused to the surface of the two conductors provided no voids appear within the weld area and penetration conforms to the standards and requirements specified herein. Any protrusion that can be readily removed and any particles that could cause a short shall be removed.

3.7.5 Production welding and inspection. Production welding shall be so accomplished as to obtain welds meeting or exceeding the minimum strength requirement as established in the weld schedule. All test specimens selected for checking production welding shall be representative of the materials and configuration specified in the weld schedule.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order. The supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Inspection system. The supplier shall prepare and maintain a written detailed system of inspection which will be utilized as a basis for acceptance. The system shall include and identify inspection stations necessary for proper maintenance of continued quality.

4.1.2 Qualified personnel. Qualified personnel who have been duly certified, shall be responsible for the control of machine settings and all welding schedules.

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4.2 Lot formation. A lot shall consist of all units welded at one time, by the same processing facility, using the same batch of materials in accordance with this specification and submitted for inspection at one time.

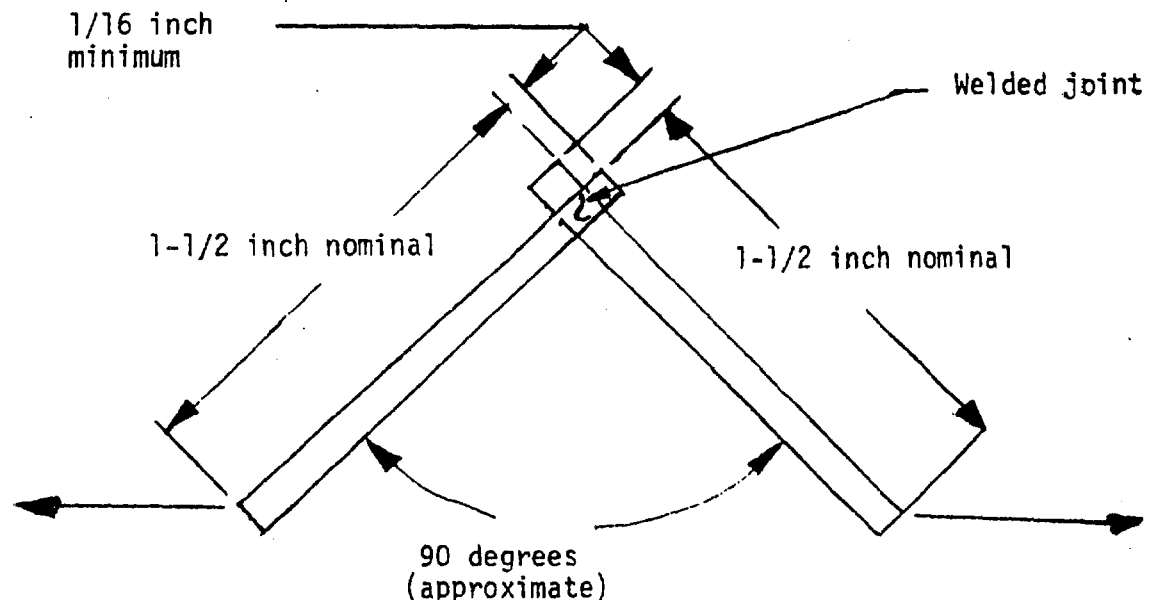
4.3 Test methods and procedures

4.3.1 Test conditions. Unless otherwise specified herein, the following conditions shall be used to establish performance requirements:

- | | |
|----------------|---|
| a. Temperature | Room ambient (15 to 32 degrees C
(60 to 90 degrees F)) |
| b. Altitude | Facility ground |
| c. Humidity | Facility ambient up to 95
percent relative humidity |

4.3.2 Test specimen preparation

4.3.2.1 Machine qualification. Machine qualification test specimens shall be "L" shaped as depicted in Figure 3.



Note: Direction of testing indicated by arrows

Figure 3. Design and method of test of "L" shaped specimens

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4.3.2.2 Production and operator qualification. Production or operator qualification test specimens shall be of materials and configurations representing production welded joints.

4.3.3 Tests

4.3.3.1 Joint strength

4.3.3.1.1 Testing specimen. Five test specimens prepared as specified in 4.3.2 shall be tested for conformance to 3.1.1 using a tensile testing machine conforming to Federal Test Method Standard No. 151, Method 211.1, at a maximum cross-head speed of 20 inches per minute.

4.3.3.1.2 Testing production parts. Normally, production welded components will not be tested. When deemed necessary by the authorized inspector, a sample of actual production work shall be destructively tested. If the sample is found to be unacceptable, production shall be stopped and the previous 10 welds shall be re-examined. If a second sample destructively tested is acceptable and the previous 10 welds are visually acceptable, production may proceed without rejection of the entire lot.

4.3.3.1.3 Testing frequency. The frequency of testing shall be as follows:

- a. At the beginning of each production welding shift and every 4 hours thereafter.
- b. When the electrode or electrode angle is changed.
- c. At the request of the authorized inspector.

Records of the test results shall be kept on file for examination by the authorized inspector.

4.3.3.2 Examination and inspection. Production welds shall be visually examined using 10 to 25 power magnification for conformance to the workmanship requirements in 3.1.2. Any component containing welds with defects over and above the limits as defined herein shall be re-examined for disposition by the cognizant engineering authority.

5. PREPARATION FOR DELIVERY (Not applicable)

6. NOTES

6.1 Intended use. The process in accordance with this specification is intended to be used for welding micromodule circuitry where a high density of interconnecting conductors precludes soldering.

6.2 Ordering data. Procurement documents should specify the following:

Title, Number and Date of this specification

6.3 Discoloration. A narrow band of discoloration may be noted. Within the weld area on conductors. This discoloration is permissible to the point of total discoloration of the weld area. Total discoloration is defined as a blackened or burned area. A light color of blue-green is an acceptable condition.

6.4 Supersession data. This specification includes the requirements of missile interim specification MIS-13851 dated 3 December 1970.

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Preparing Activity:
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Project No. THJM-A050

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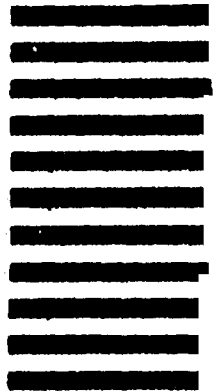
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