

MIL-E-23765/3A(SH)
11 March 1986

SUPERSEDING
MIL-E-23765/3(SHIPS)
28 November 1972
(See 6.5)

MILITARY SPECIFICATION

ELECTRODES AND RODS - WELDING, BARE, SOLID COPPER ALLOY

This specification is approved for use within the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers solid bare copper alloy electrodes and cut-length rods for use with the gas metal-arc (GMA) and gas tungsten-arc (GTA) welding processes.

1.2 Classification. Electrodes and rods shall be furnished in the types specified in table I and in forms 3a, 3b, 3c, 3d, and 6 with sizes in accordance with MIL-E-23765, and table II herein.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 5523, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 3439

DISTRIBUTION STATEMENT A Approved for public release; distribution unlimited

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TABLE I. Chemical composition (weight and percent). 1/ 2/

Type	Common name	Copper including silver	Zinc	Tin	Manganese	Iron	Silicon	Nickel including cobalt	Phosphorus	Aluminum	Lead	Total other elements
MIL-CuSi	Copper-silicon alloy (silicon bronze)	Remainder	*	3/ 1.50	3/ 1.50	0.50	2.80-4.00	*	*	0.010*	0.020*	0.50
MIL-CuSn-C	Copper-tin alloy (phosphor bronze)	Remainder	*	7.00-9.00	*	*	*	*	0.10-0.35	.010*	.020*	.50
MIL-CuAl-A2	Copper-aluminum alloy (aluminum bronze)	Remainder	0.020	---	---	0.75-1.50	0.10	---	---	9.0-11.0	.020	.50
MIL-CuMnNiAl	Copper-manganese-nickel-aluminum alloy (manganese, nickel, aluminum bronze)	Remainder	*	*	11.0-14.0	2.00-4.00	*	1.50-3.00	*	7.00-8.50	.020	.50
MIL-CuNiAl	Copper-nickel-aluminum alloy (nickel, aluminum bronze)	Remainder	*	*	0.60-3.50	3.00-5.00	*	4.00-5.50	*	8.50-9.50	.020	.50

1/ Analysis shall be made for the elements indicated by an asterisk (*) and those for which specific values are shown in this table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made to determine their content. The total of these other elements and the elements indicated by an asterisk (*) shall not be present in excess of the limits specified for the "total other elements" in the last column in the table.

2/ Unless otherwise specified, single values are maximum.

3/ One or both of these elements may be present within the limits specified.

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TABLE II. Form, size, and weight.

Form	Electrode diameter (inch)	Weight ^{1/} (pounds)
3a	All	1-1/2 and 2-1/2
3b	All	10 or 15
3b	All	25 or 30
3c	All	25 or 30
3d	All	25 or 30
6	All	10 or 50

^{1/} Tolerances on net weight shall be plus or minus 10 percent.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

- BB-H-1168 - Helium, Technical.
- QQ-B-750 - Bronze, Phosphor; Bar, Plate, Rod, Sheet, Strip, Flat Wire, and Structural and Special Shaped Sections.
- QQ-C-450 - Copper-Aluminum Alloy (Aluminum Bronze) Plate, Sheet, Strip, and Bar (Copper Alloy Numbers 606, 610, 613, 614, and 630).
- QQ-C-591 - Copper-Silicon, Copper-Zinc-Silicon, and Copper-Nickel-Silicon Alloys: Rod, Wire, Shapes, Forgings, and Flat Products (Flat Wire, Strip, Sheet, Bar, and Plate).

MILITARY

- MIL-A-18455 - Argon, Technical.
- MIL-S-22698 - Steel Plate and Shapes, Weldable Ordinary Strength and Higher Strength: Hull Structural.
- MIL-E-23765 - Electrodes and Rods - Welding, Bare, Solid, General Specification for.
- MIL-B-24480 - Bronze, Nickel-Aluminum (UNS No. C95800), Castings, for Seawater Service.

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STANDARD

FEDERAL

FED-STD-151 - Metals; Test Methods.

(Copies of specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- B 96 - Standard Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels.
- B 103 - Standard Specification for Phosphor Bronze Plate, Sheet, Strip, and Rolled Bar. (DoD adopted)
- B 148 - Standard Specification for Aluminum-Bronze Sand Castings.
- B 150 - Standard Specification for Aluminum Bronze Rod, Bar, and Shapes. (DoD adopted)
- B 169 - Standard Specification for Aluminum Bronze Plate, Sheet, Strip, and Rolled Bar. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Electrodes and rods furnished under this specification shall be in accordance with MIL-E-23765 and as specified herein.

3.2 Chemical composition. The chemical composition of the bare electrode or rod shall be as specified in table I.

3.3 Mechanical properties. The mechanical properties of deposited weld metal shall be as specified in table III.

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TABLE III. Mechanical properties of deposited weld metal.

Type	Minimum tensile strength (lb/in ²)	Brinell hardness number (standard ball, 3000 kg load)	Transverse side bend
MIL-CuSi	50,000	-	<u>1/</u>
MIL-CuSn-C	40,000	-	<u>1/</u>
MIL-CuAl-A2	75,000	130 to 170	
MIL-CuMnNiAl	90,000	-	<u>1/</u>
MIL-CuNiAl	85,000	-	<u>1/</u>

1/ The convex surface of the specimen after bending shall have no visual cracks exceeding 1/8 inch. Cracks occurring on corners of a specimen during testing shall not be considered.

3.4 Cast and helix. The cast and helix of spooled and coiled electrodes shall be such as to have imparted to the electrode a curvature such that a specimen sufficient in length to form one loop when cut therefrom and placed on a flat surface shall form an unrestrained circle within diametrical limits specified in tables IV and V.

TABLE IV. Cast requirements.

Form (all alloy types)	Wire diameter (inch)	Cast	
		Minimum (inches)	Maximum (inches)
3a	All	6	15
3b	0.030	7	17
	.035	10	20
	.045	15	25
	1/16 and over	20	40
3c and 3d	All	<u>1/</u>	<u>2/</u>

1/ Not less than original inside coil diameter.

2/ Not greater than 2.5 times original inside coil diameter.

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TABLE V. Helix requirements.

Alloy type (all forms and diameters)	Helix ^{1/} (inches, maximum)
MIL-CuSi MIL-CuSn-C	10
MIL-CuMnNiAl MIL-CuNiAl	6
MIL-CuAl-A2	4

^{1/} Vertical separation between overlapped ends.

3.5 Dimensional tolerances. The diameter of the electrodes or rods and the length of the rods shall be within the limits specified in table VI.

TABLE VI. Dimensional tolerances.

Form	Nominal diameter (inch)	Diameter tolerance (inch)	Length and tolerance (inch)
3a, 3b, 3c, 3d	Under 1/16	Plus 0.001, or minus 0.002	--
	1/16 and over	Plus or minus 0.002	--
6	All	Plus or minus 0.003	^{1/} 36 plus 0, minus 1/2

^{1/} Ten percent of the rods in any container may be shorter but no shorter than 24 inches.

4. QUALITY ASSURANCE PROVISIONS

4.1 The quality assurance provisions shall be as specified in MIL-E-23765 and as specified herein.

4.2 First article tests. Electrodes selected in accordance with 4.6.2 of MIL-E-23765 shall be used for the tests specified in table VII.

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TABLE VII. Summary of tests required for first article inspection.

MIL- types	Form	Tests required for first article inspection							Test procedure	Require- ments	
		Visual and dimen- sional	Cast	Helix	Chemi- cal	X-ray	Ten- sile	Bend			Over- lay
All	3b or 3d	X								1/4.6.1	1/3.5.1 3.6 (herein)
			X	X						4.2.2 (herein)	3.4 (herein)
					X					1/4.7.3	3.2 (herein)
						X				1/2/4.7.2.1	1/3.5.4
							X	X		1/2/4.7.2.2	3.3 (herein)
							X ^{3/}	4.2.1 (herein)	3.3 (herein)		

1/ See MIL-E-23765.

2/ Welds shall be prepared in accordance with figure 1 herein and the notes thereto.

3/ The overlay weld test applies only to type MIL-CuAl-A2.

4.2.1 Overlay weld test. In addition to the tests specified in MIL-E-23765 and table VII herein, an overlay weld test shall be conducted in accordance with the following:

- (a) Base plate material shall be as specified in 4.4.
- (b) Base plate size shall be approximately 3/4 by 3 by 6 inches.
- (c) Scale and other contaminants shall be removed from the test surface prior to welding.
- (d) Preheat and interpass temperature shall be as recommended by the manufacturer.
- (e) The overlay area approximately 1-1/2 by 4-1/2 inches shall be built up with layers of overlapping stringer beads to a height of $1/2 + 1/16$ inch.
- (f) The weld surface shall be ground smooth and the test specimen radiographed as specified in MIL-E-23765.
- (g) Three hardness determinations shall be made on the weld metal surface in accordance with FED-STD-151 for compliance with table III.

4.2.2 Cast and helix. Cast and helix shall be determined as specified in 3.4.

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4.3 Quality conformance inspection.

4.3.1 Lot. For the purpose of sampling and inspection, a lot of electrodes or rods shall be the quantity of one type alloy produced as specified in either 4.5.1.1.1 or 4.5.1.1.2 of MIL-E-23765 or 4.3.1.1 herein.

4.3.1.1 Lot identification by heats of metal. When manufacturing processes are such that the rod is identified by a code traceable to specific heats of metal, the lot of electrodes or rods being tested shall consist of 2000 pounds or less of one alloy, size and form produced from a single extrusion lot of chemically conforming heats of mill coils.

4.3.2 Electrodes or rods selected in accordance with 4.5 of MIL-E-23765 shall be used for the tests specified in table VIII.

TABLE VIII. Summary of tests required for quality conformance inspection.

MIL- types	Form	Sizes	Quality conformance inspection						Test procedure	Require- ments
			Visual and Dimen- sional	Cast	Helix	Chemical	X-ray	Ten- sile		
All	All	All	X						1/4.6.1	1/3.5.1 3.6 (herein)
				x ^{3/}	x ^{3/}				4.2.2 (herein)	3.4 (herein)
						X			1/4.7.3	3.2 (herein)
							X		1/2/4.7.2.1	1/3.5.4
								X	1/2/4.7.2.2	3.3 (herein)

1/ See MIL-E-23765.

2/ Welds shall be prepared in accordance with figure 1 herein and the notes thereto.

3/ This test not applicable to form 6.

4.3.3 Unsatisfactory test results. If the first results of any of the specified tests are determined to be unsatisfactory due to welding operator error, two retests for each one that failed shall be permitted. The results of all retests shall be satisfactory for lot acceptance.

4.3.3.1 If the test results are determined to be unsatisfactory due to material deficiency, the whole lot may be reprocessed to correct the cause of the unsatisfactory test results and then be quality conformance inspected as a new lot.

4.3.4 Certification of tests. Results of the examination and tests required for quality conformance inspection specified in table VIII shall be certified by a responsible company official and furnished to the consignee. The quality conformance inspection shall provide the information shown on figure 2.

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4.4 Base metals for groove weld test plates. The base metals for the groove weld test plates (including the backing straps) shall be as specified in table IX. MIL-S-22698 grade B shall be used for overlay welds.

TABLE IX. Base metals for groove weld test plates.

Electrode type	Plate metal composition	Document
MIL-CuSi	Copper alloy no. C65500	QQ-C-591 or ASTM B 96
MIL-CuSn-C	Composition A or copper alloy no. C51000	QQ-B-750 or ASTM B 103
MIL-CuAl-A2	Copper alloy no. C61400	QQ-C-450 or ASTM B 169
MIL-CuMnNiAl	Alloy 1 C95700	ASTM B 148
MIL-CuNiAl	Alloy 1 or copper alloy no. C63000	MIL-B-24480 or ASTM B 150

4.5 Inspection of packaging. Sample packages and packs, and the inspection of the preservation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

5.1 Packaging shall be as specified in MIL-E-23765.

6. NOTES

6.1 Intended use. The copper and copper alloy solid bare welding electrodes and rods covered by this specification are capable of depositing sound weld metal that meets the mechanical properties specified herein when welding on similar composition base metal using the gas metal-arc process with direct current, reversed polarity, or the gas tungsten arc process with direct current, straight polarity, as applicable.

6.1.1 Type MIL-CuSi. Type MIL-CuSi is intended for use in welding copper-silicon alloys (silicon bronze).

6.1.2 Type MIL-CuSn-C. Type MIL-CuSn-C is intended for use in welding copper-tin alloys (phosphor bronze).

6.1.3 Type MIL-CuAl-A2. Type MIL-CuAl-A2, an iron bearing alloy, is intended for use in joining copper-aluminum alloys (aluminum bronze), copper-silicon alloys (silicon bronze), many ferrous metals and alloys, and combinations of dissimilar metals. This type is also suitable for surfacing bearing, wear-resistant and corrosion-resistant surfaces.

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6.1.4 Type MIL-CuMnNiAl. Type MIL-CuMnNiAl is intended for use in welding copper-manganese-nickel-aluminum alloy (manganese, nickel, aluminum bronze) castings.

6.1.5 Type MIL-CuNiAl. Type MIL-CuNiAl is intended for use in welding copper-nickel-aluminum (nickel, aluminum bronze) castings in accordance with MIL-B-24480.

6.2 Ordering data. Acquisition documents should specify the ordering data required in 6.2 of MIL-E-23765.

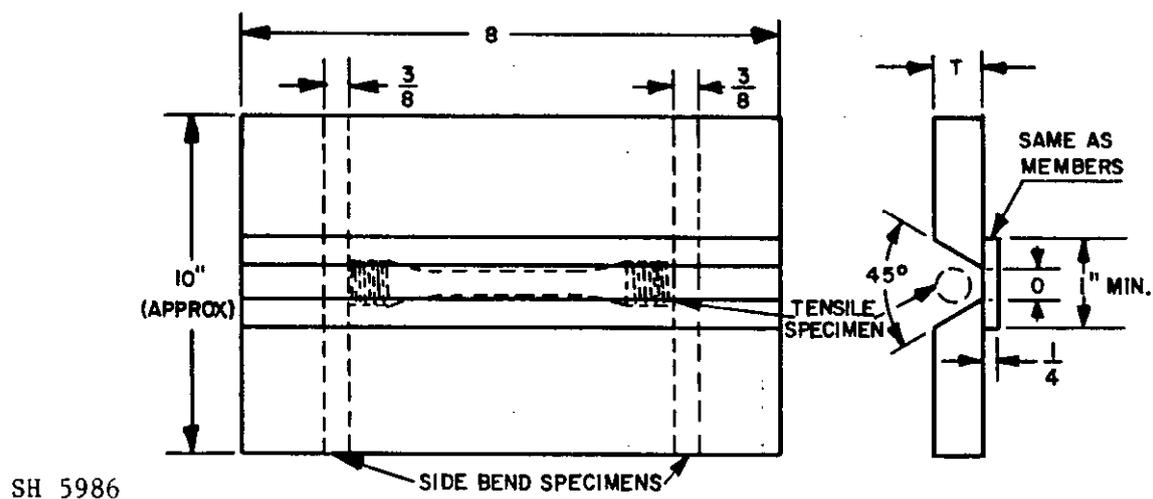
6.3 It is the responsibility of the consignee to determine whether or not electrodes or rods are satisfactory for the intended application.

6.4 Inspection after delivery. Post delivery inspection of electrodes to determine conformity to this specification and for acceptance thereof is the responsibility of the consignee.

6.5 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 3439-N551)

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TABLE X. Weld test details.

Test classification	Form	Type	Wire, rod diameter (inch)	T (min) (inch)	$\frac{1}{0}$ (inch)	Tensile specimen (inch, diameter)	Welding process
First article inspection	3b or 3d	All	1/16	3/4	1/2	0.505	Gas metal arc
Quality conformance inspection	3a,3b 3c,3d	All	less than 1/16	1/2	1/4	0.252	
			1/16 and larger	3/4	1/2	0.505	
	6	All	All	3/4	1/2	0.505	Gas tungsten arc

1/ Root opening "0" tolerance plus or minus 1/16 inch.

FIGURE 1. Weld joint for soundness and for mechanical tests.

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Notes to figure 1:

1. Base plate shall be as specified in table IX.
2. Test shall be conducted in the flat position.
3. The preheat and interpass temperature shall be 450°F maximum. Water quenching between passes shall not be used.
4. For the gas metal arc process, direct current reverse polarity shall be used. For the gas tungsten arc process, direct current straight polarity shall be used. Weld layers shall be made of stringer beads having a maximum thickness of 3/16 inch.
5. Arc shielding shall be helium in accordance with grade A of BB-H-1168 or argon in accordance with MIL-A-18455 or mixtures of the two gases.
6. After completion of the weld, it shall be allowed to cool, the weld reinforcement and backing strip shall be removed flush with the base plate on both surfaces and the weld X-rayed, as specified in MIL-E-23765. The weld test assembly shall be cut as shown resulting in a tensile coupon suitable for 0.505 inch diameter specimens (or 0.252 inch diameter specimen when 1/2 inch base plate thickness is used) and two side bend coupons. The side bend coupons shall be used only for the first article inspection. No base metal shall be removed within 1/2 inch of the edges of the face of the weld by flame cutting. Only sawing or machining shall be used.
7. The tensile coupon shall be machined into a 0.505 tensile specimen (0.252 inch diameter specimen when 1/2 inch plate thickness is used). Two side bend specimens shall be prepared and tested as specified in MIL-E-23765.
8. Grinding (or burring) during welding of a test plate shall be limited to grinding of weld starts and grinding to correct operator error. Grinding of weld starts shall be limited to the immediate start area (first 1/2 inch length of weld bead deposit maximum) only and shall be done only when considered necessary by the welder. Grinding to correct operator error shall be limited to a maximum of 1 inch of weld bead length for a test plate. The amount of grinding employed (weld start and operator error) for each test plate shall be recorded by the welder on the test plate work sheet record. The record shall indicate the total number of weld starts that were ground and the length and location by weld layer of any grinding employed to correct operator error conditions.

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1. Manufacturer or distributor _____

2. Address _____

3. Mill order no. _____

4. Customer _____

5. Customer order no. _____

6. Identification:

Specification MIL-_____ Type _____

Deposition process _____

Form _____ Size _____

Lot no. _____ Heat _____ Melter ^{1/} _____

7. Alloy identity check: in process splice _____
at spooling _____

8. Chemical analysis:

Copper _____

Manganese _____

Silicon _____

Phosphorus _____

Aluminum _____

Nickel _____

Lead _____

Zinc _____

Tin _____

Iron _____

9. X-ray _____

10. Ultimate tensile strength _____

11. Visual _____

12. Dimensional _____

13. Cast _____

14. Helix _____

15. Radiography _____

13. We hereby certify that the above material has been inspected and tested in accordance with the listed specification and is in conformance with all requirements.

Signature of responsible company official _____

Date _____

Those items not applicable to the particular MIL-type shall be marked "NA".

^{1/} See 4.6.3 of MIL-E-23765.

FIGURE 2. Certification of quality conformance.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER MIL-E-23765/3A(SH)		2. DOCUMENT TITLE ELECTRODES AND RODS - WELDING, BARE, SOLID COPPER ALLOY	
3a. NAME OF SUBMITTING ORGANIZATION		4. TYPE OF ORGANIZATION (Mark one)	
b. ADDRESS (Street, City, State, ZIP Code)		<input type="checkbox"/> VENDOR <input type="checkbox"/> USER <input type="checkbox"/> MANUFACTURER <input type="checkbox"/> OTHER (Specify): _____	
5. PROBLEM AREAS			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation:			
6. REMARKS			
7a. NAME OF SUBMITTER (Last, First, MI) - Optional		b. WORK TELEPHONE NUMBER (Include Area Code) - Optional	
c. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional		8. DATE OF SUBMISSION (YYMMDD)	