

MIL-E-24403/2B(SH)
28 August 1985
SUPERSEDING
MIL-E-24403/2A(SH)
30 August 1983
(See 6.3)

MILITARY SPECIFICATION

ELECTRODES - WELDING, FLUX CORED, LOW-ALLOY STEEL

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 low-alloy steel flux cored welding electrodes for the fabrication of HY-80 steel weldments for as-welded applications.

1.2 Classification. Electrodes shall be of the types specified in table I and of the forms and sizes in accordance with MIL-E-24403. In addition to the sizes as specified in MIL-E-24403, the 0.035-inch size may be used for MIL-101TC and MIL-101TM type electrodes and the 0.068- and 0.072-inch sizes may be used for self-shielded electrodes.

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.

FSC 3439

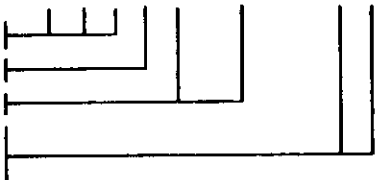
DISTRIBUTION STATEMENT A Approved for public release; distribution unlimited

TABLE I. Type designation and chemical composition of deposited weld metal.

MIL-type ^{1/}	Chemical composition (percent) ^{2/}									
	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Nickel	Chromium	Molybdenum	Vanadium	Copper
MIL-110TC ^{3/}	0.10	1.20 to 1.80	0.60	0.010	0.010	2.00 to 2.50	0.60	0.25 to 0.50	0.05	0.02
MIL-100TC ^{3/} MIL-100TM ^{4/} MIL-100TS ^{5/} MIL-101TC ^{3/} MIL-101TM ^{4/} MIL-101TS ^{5/}	0.10	0.50 to 1.50	0.60	0.020	0.017	1.30 to 3.75	0.20	0.50	0.05	0.06

1/ An illustration of the method of classification of flux cored electrodes is shown below.

X X X T X



C for carbon dioxide shielding gas.

M for 75 percent argon and 25 percent carbon dioxide gas mixture shielding.

S for self shielding.

T for flux-cored electrode.

C for electrodes used in the flat and horizontal welding position and tested in the flat position (see figure 1 herein).

1 for electrodes designed primarily for all welding positions. Sizes 5/64 and smaller are used in all positions and tested in the vertical position (see figure 1 herein and MIL-STD-2149).

11 for 110,000 pounds per square inch (lb/in²) tensile strength classification.

10 for 100,000 lb/in² tensile strength classification.

2/ Single values are maximum percentages.

3/ The shielding gas shall be carbon dioxide.

4/ The shielding gas shall be a mixture of 75 percent argon and 25 percent carbon dioxide.

The carbon dioxide (CO₂) shall be in accordance with grade B of BB-C-101.

The argon (Ar) shall be in accordance with MIL-A-18455.

5/ The aluminum content of the weld metal for self shielding electrodes shall be 0.50 to 1.10 percent.

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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-C-101 - Carbon Dioxide (CO₂): Technical and U.S.P.

MILITARY

MIL-P-116 - Preservation, Methods of.

MIL-S-16216 - Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100).

MIL-A-18455 - Argon, Technical.

MIL-E-24403 - Electrodes - Welding, Flux Cored, General Specification for.

MIL-S-24645 - Steel Plate, Sheet or Coil, Age-Hardening Alloy, Structural, High Yield Strength (HSLA-80).

STANDARDS

MILITARY

MIL-STD-271 - Nondestructive Testing Requirements for Metals.

MIL-STD-2149 - Standard Procedures for Explosion Testing Ferrous and Non-Ferrous Metallic Materials and Weldments.

2.1.2 Government publication. The following Government publication forms a part of this specification to the extent specified herein.

PUBLICATION

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

0900-LP-003-9000 - Radiographic Standards for Production and Repair Welds.

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

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 non-government documents which is current on the date of the solicitation.

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AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- A 710 - Standard Specification for Low-Carbon Age-Hardening Nickel-Copper-Chromium-Molybdenum-Columbium and Nickel-Copper-Columbium Alloy Steels.
- E 83 - Standard Method of Verification and Classification of Extensometers. (DoD adopted)
- E 604 - Standard Test Method for Dynamic Tear Testing of Metallic Materials. (DoD adopted)

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

AMERICAN WELDING SOCIETY (AWS)

- B4.0 - Standard Methods for Mechanical Testing of Welds. (DoD adopted)

(Application for copies should be addressed to the American Welding Society, Inc., 550 NW LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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 furnished under this specification shall conform to the requirements of MIL-E-24403 and as specified herein.

3.2 Finish. The electrode finish shall be as specified in MIL-E-24403.

3.3 Chemical composition. Chemical composition of the deposited weld metal shall be as specified in table I.

3.4 Mechanical properties. The mechanical properties of deposited weld metal shall be as specified in table II.

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TABLE II. As-welded mechanical properties.^{1/}

MIL-type	Yield strength ^{2/} (lb/in ²)	Elongation in 1.4 inches or 2 inches minimum (percent)	Transverse side bend	Impact ^{3/}				Explosion crack- starter
				Charpy V-notch ^{4/}		Dynamic tear ^{5/}		
				Energy (ft-lb) minimum average	Temperature (°F)	Energy (ft-lb) minimum	Temperature (°F)	
MIL-110TG	95,000 to 110,000	18	6/	60 35	0 minus 60	425 300	30 minus 20	7/
MIL-100TC MIL-100TM MIL-100TS MIL-101TC MIL-101TM MIL-101TS	82,000 to 97,000	18	6/	60 35	0 minus 60	425 300	30 minus 20	7/

See footnotes at top of next page.

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- 1/ The ultimate tensile strength and percentage reduction of area shall be recorded for information only.
- 2/ The yield strength shall be the average of duplicate specimens measured at 0.2 percent offset by using a class B extensometer in accordance with ASTM E 83, or better.
- 3/ Requirements of either Charpy V-notch or dynamic tear shall be met.
- 4/ For each testing temperature, the average values of five tests shall be greater than the minimum average value specified. No two specimens shall have values below the minimum average specified. One specimen can have a value of 10 foot-pounds (ft-lb) below the minimum average specified.
- 5/ Test procedure for 5/8-inch dynamic tear test shall be in accordance with ASTM E 604.
- 6/ The convex surface of the specimen after bending shall have no visual cracks exceeding 1/8 inch. The corners of the specimen shall have no visual cracks exceeding 3/16 inch. The bend radius shall be 2t and the tests conducted in accordance with AWS B4.0.
- 7/ Explosion crack-starter test results shall meet the following criteria when tested at 0 degrees Fahrenheit (°F):

- (a) First shot - Crack-starter bead shall crack.
Percent reduction in thickness obtained for information only.
No piece shall be thrown out of weldments.
No through-thickness cracks shall be present.
No crack shall extend into hold-down area.
Crack shall remain within 12-1/2 inch radius measured from center of weldment.
- (b) Second shot - Percent reduction in thickness obtained for information only.
No piece shall be thrown out of weldment.
Through-thickness cracks are acceptable.
No cracks shall extend into hold-down area.
Crack shall remain within 12-1/2 inch radius measured from center of weldment.

3.5 Soundness. Welds shall meet the acceptance standards for radiographic inspection in accordance with class 1 of NAVSEA 0900-LP-003-9000.

3.6 Hydrogen. The diffusible hydrogen levels in milliliters (mL) per 100 grams of deposited weld metal shall not exceed 5.0 mL per 100 grams maximum average value nor 5.8 mL per 100 grams maximum single value. Electrodes with an LH suffix added to the designation shall not exceed 2.0 mL per 100 grams maximum average value nor 2.3 mL per 100 grams maximum single value.

3.7 Alloy identity. For lots specified in MIL-E-24403, each end of rod or strip to be spliced during processing shall be sampled at the splicing station for alloy identity (see 4.5), except when splicing is done to repair a break without removing the strip from the process line. The sample shall be tested for alloy identity prior to shipment of the lot.

3.7.1 Both ends of each coil rolled to final thickness shall be tested for alloy identity (see 4.5) before further processing into electrodes.

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3.7.2 When specified (see 6.2), each electrode shall be tested for alloy identity in accordance with 4.5 after final marking. Identification marking of each spool, coil, or container of electrodes tested after final marking and meeting the acceptance criteria of 4.5.2 shall include the words "ALLOY TESTED".

4. QUALITY ASSURANCE PROVISIONS

4.1 The quality assurance provisions shall be in accordance with MIL-E-24403 and as specified herein.

4.2 Qualification tests. Electrodes selected in accordance with MIL-E-24403 shall be used for tests specified in table III. Schedule A tests shall be conducted by the manufacturer, and upon successful completion of these tests, schedule B welding and testing will be conducted by the Government.

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TABLE III. Summary of weld metal tests required for qualification.^{1/}

Sched- ule	Chemical	Alloy Identity	Hydrogen	Sound- ness	Tensile	Bend	Impact ^{2/}		Explosion crack- 3/ starter	Test procedures	Require- ments
							Charpy V-notch	Dynamic tear			
	X									MIL-E-24403	Table I herein
A		X								4.5 herein	3.7 herein
			X							MIL-E-24403	3.6 herein
				X	X		X			4.4.1 and figure 1 herein MIL-STD-271	3.5 herein Table II herein
								X		4.4.1 and figure 1 herein and ASTM E 604	Table II herein
B ^{4/}									X	MIL-STD-2149 and 4.4.2.1 herein	Table II herein
				X						4.4.2.2 herein and MIL-STD-271	3.5 herein
					X	X	X	X		4.4.2.2 herein and MIL-STD-2149	Table II herein

See footnotes at top of next page.

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- 1/ Types and sizes of electrodes shall be qualification tested in accordance with schedule A of table III. Test weldments shall be made in the welding position and with the type of shielding specified in the classification requirements (see notes to table I).
- 2/ The Charpy V-notch and the dynamic tear tests shall be conducted for compliance with the impact requirements of table II.
- 3/ Types and sizes of electrodes shall be qualification tested in accordance with schedule B of table III for compliance with the requirements of table II herein, except that the smaller size flat or vertical welding electrodes (of the same type previously qualified) shall be evaluated on the basis of Charpy V-notch and dynamic tear tests conducted at temperatures specified in table II, and the explosion crack-starter test shall be omitted.
- 4/ When a single electrode formulation is being qualification tested for use with both shielding gases (MIL-100TC and MIL-100TM or MIL-101TC and MIL-101TM), the schedule A tests shall be conducted for each shielding gas using one sample of the electrode. Schedule B tests shall be conducted using the same sample of the electrode and only the shielding gas that produced the lower impact test results.

4.3 Quality conformance tests. Electrodes selected in accordance with MIL-E-24403 shall be used for tests specified in table IV.

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TABLE IV. Summary of tests required for quality conformance testing.

Chemical	Alloy identity	Hydrogen	Soundness	Tensile	Impact ^{1/}		Test procedures	Requirements
					Charpy V-notch	Dynamic tear		
X							MIL-E-24403	Table I herein
	X						4.5 herein	3.7 herein
		X					MIL-E-24403	3.6 herein
			X	X	X		4.4.1 and figure 1 herein	3.5 herein
						X	4.4.1 and figure 1 herein and ASTM E 604	Table II herein

1/ Either the Charpy V-notch test at 0°F and minus 60°F or the dynamic tear test at minus 20°F shall be conducted in accordance with the impact requirements of table II.

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4.4 Weld metal test procedures.

4.4.1 Groove-weld metal test. The dimensions of the test weldment and the location of the tensile and impact specimens are shown on figure 1. The test assembly shall be welded, machined and tested as outlined below. Tests conducted shall be in accordance with table III, schedule A, for qualification or table IV for quality conformance testing.

- (a) The base-plate material shall be HY-80 steel in accordance with MIL-S-16216 when dynamic tear tests are being conducted. When dynamic tear tests are not being conducted, the base-plate material shall be HY-80 steel in accordance with the chemical composition requirements of MIL-S-16216. The plate material can be in the as-rolled condition without being quenched and tempered nor tested for mechanical properties. When specified (see 6.2), a second test weldment shall be made and quality conformance tested in accordance with ASTM A 710, grade A, or MIL-S-24645 steel base-plate material.
- (b) The welding position and type of shielding shall be in accordance with the classification requirements (see notes to table I).
- (c) Direct current shall be used with the polarity recommended by the electrode manufacturer. The welding current shall be within plus or minus 10 percent of the values as specified in table V.
- (d) All testing shall be of the as-welded condition.
- (e) The preheat and interpass temperature shall be $250 \pm 25^{\circ}\text{F}$, except steel in accordance with MIL-S-24645 or ASTM A 710 shall be 60°F minimum for HY-80 steel.
- (f) The welding-heat input shall be 50,000 to 55,000 joules per inch.
- (g) Peening of weld beads shall not be permitted.
- (h) The test assembly shall be prepared by using welding sequence and techniques recommended by the electrode manufacturer.
- (i) Welding may be continuous except for interpass cooling. No postweld heat treatments shall be employed. Time delays per pass beyond that necessary for interpass cooling shall be reported.
- (j) When 48 hours have elapsed after completion of welding, the weldment shall have the reinforcement and backing strip removed, flush with the base plate on both surfaces, and shall be examined for soundness.
- (k) The weld shall be inspected radiographically in accordance with level 2-2T of MIL-STD-271 and 3.5 herein.
- (l) Tension test specimens shall be machined and tested in accordance with AWS B4.0. Tension testing shall be conducted at room temperature.
- (m) Charpy V-notch impact testing, if selected, shall have specimens machined and tested in accordance with AWS B4.0. Five Charpy V-notch specimens shall be tested at each of the specified testing temperatures.
- (n) Dynamic tear testing, if selected, shall have specimens machined and tested in accordance with ASTM E 604. Two dynamic tear specimens shall be tested at the specified testing temperature.

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TABLE V. Electrode size and welding current.

MIL-101TC and MIL-101TM						
Electrode size diameter (inch)	<u>1</u> /0.035	0.045	0.052	1/16	5/64	---
Welding current (amperes)	180	190	200	220	230	---
MIL-100TC and MIL-100TM						
Electrode size diameter (inch)	---	0.045	0.052	1/16	5/64	---
Welding current (amperes)	---	265	290	330	380	---
MIL-100TC and MIL-100TM						
Electrode size diameter (inch)	---	3/32	7/64	1/8	5/32	---
Welding current (amperes)	---	450	500	550	<u>2</u> /	---
MIL-101TS						
Electrode size diameter (inch)	0.068	0.072	5/64	3/32	---	---
Welding current (amperes)	180	190	200	230	---	---
MIL-100TS						
Electrode size diameter (inch)	0.068	0.072	5/64	3/32	0.120	5/32
Welding current (amperes)	210	230	250	310	400	525

1/ The 0.035-inch size may be used for MIL-101TC and MIL-101TM type electrodes, and the 0.068- and 0.072-inch sizes may be used for self-shielding electrodes.

2/ Not specified.

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4.4.2 Explosion crack-starter.

4.4.2.1 Welding parameters. Fabrication of the explosion crack-starter and mechanical property prolongation assemblies shall be as follows:

- (a) The base plate shall be HY-80 steel in accordance with MIL-S-16216.
- (b) Dimensions of the test assemblies shall be in accordance with MIL-STD-2149.
- (c) The welding position and type of shielding shall be in accordance with the classification requirements (see notes to table I).
- (d) Direct current shall be used with the polarity recommended by the electrode manufacturer. The welding current shall be plus or minus 10 percent of the values specified in table VI.
- (e) The preheat and interpass temperature shall be $225 \pm 25^{\circ}\text{F}$.
- (f) The welding-heat input shall be 50,000 to 55,000 joules per inch.
- (g) Peening of weld beads shall not be permitted.
- (h) The test assembly shall be prepared by using welding sequence and techniques recommended by the electrode manufacturer which shall be reported.
- (i) The joint surfaces shall not be clad or buttered.
- (j) Welding may be continuous except for interpass cooling. No postweld heat treatments shall be employed. Time delays per pass beyond that necessary for interpass cooling shall be reported.

4.4.2.2 The prolongation assembly shall be tested in accordance with schedule B of table III.

4.5 Alloy identity.

4.5.1 Procedure. The alloy identity test method may include chemical analysis, metal sorting devices, other approved methods or a combination of methods. The test methods shall be prepared for approval by NAVSEA.

4.5.2 Rejection criteria. If the test demonstrates that the material is not of the type specified, the material shall be rejected.

4.6 Certificate of test. A certificate of quality conformance of the weld tests as specified in 4.3 (that is, X-ray, mechanical, and chemical analysis), containing actual quantitative test and examination results (including the range of amperage employed in making the required welds for quality conformance inspection for each accepted lot, included in a particular shipment) shall be furnished to the consignee with the shipment. The minimum quality conformance test result data required shall be listed and prepared on the form as shown on figure 2.

4.7 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.

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5. PACKAGING

5.1 Packaging shall be as specified in MIL-E-24403, except that electrodes in the forms specified (see table VI) shall be individually preserved-packaged in accordance with method IIe of MIL-P-116.

TABLE VI. Unit package sizes, weights and tolerances.

Form	Package size (inches)	Weight (pounds) ^{1/}
3a	4 od	1-1/2 or 2-1/2
3b	12 od	25
	14 od	50 or 60
	22 od	250
	24 od	300
	30 od	600 or 750
3d	12 id	25, 50, or 60
3e	As specified (see 6.2)	As specified (see 6.2)
4	15-1/2 od 20 od 23 od	As specified (see 6.2)

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

6. NOTES

6.1 Intended use.

6.1.1 General. This specification is intended to cover low-alloy steel flux cored welding electrode capable of depositing radiographic quality weld metal that in the as-welded condition meets the mechanical properties specified herein when welded on HY-80 steels.

6.1.1.1 MIL-type 110TC. This classification covers electrodes primarily designed for welding in the flat and horizontal positions using gas shielding.

6.1.1.2 MIL-types 100TC and 100TM. These classifications cover electrodes primarily designed for welding in the flat and horizontal positions using gas shielding.

6.1.1.3 MIL-type 100TS. This classification covers electrodes primarily designed for welding in the flat and horizontal positions, and are self shielding.

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6.1.1.4 MIL-type 101TC and 101TM. These classifications cover electrodes primarily designed for welding in all positions using gas shielding.

6.1.1.5 MIL-type 101TS. This classification covers electrodes primarily designed for welding in all positions, and are self shielding.

6.1.1.6 The above electrodes with an LH suffix are used with substantially reduced preheat.

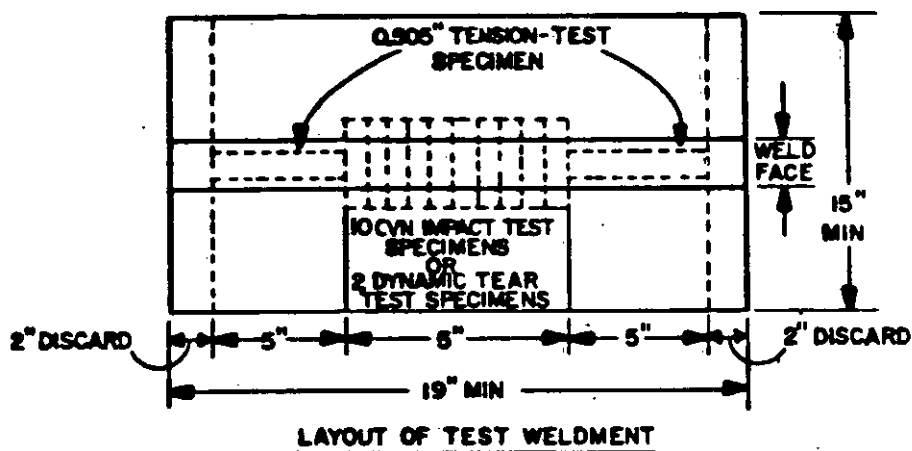
6.2 Ordering data. Acquisition documents should specify the ordering data required in MIL-E-24403 and the following:

- (a) Whether alloy identity testing of each electrode after final marking is required (see 3.7.2).
- (b) Whether a second test weldment as specified in ASTM A 710, grade A, or MIL-S-24645 steel base-plate material is required (see 4.4.1).
- (c) Unit package size and weight required for electrode form 3e, and unit package weight required for electrode form 4 (see table VI).

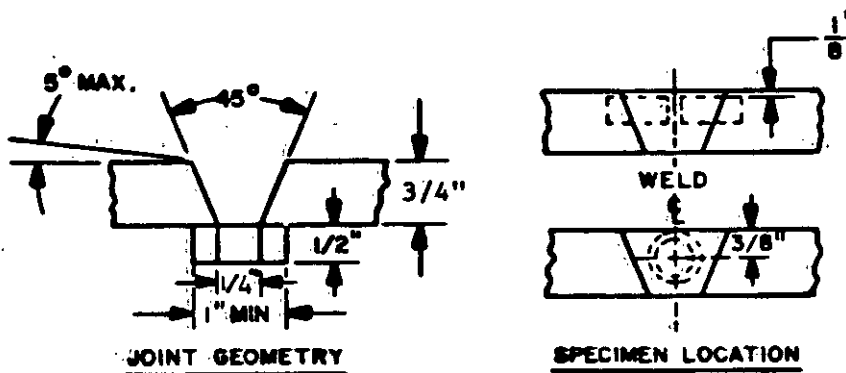
6.3 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 3439-N575)

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Base plate size shall be increased to provide additional Charpy (or dynamic tear) test specimens as required.



Maximum weld reinforcement shall not exceed 1/8 inch.

SH 12064

FIGURE 1. Groove weld metal test.

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CERTIFICATION OF QUALITY CONFORMANCE TESTS

Manufacturer or

Distributor _____

Customer's name _____

Address _____

Date _____

Customer's order no. _____

Specification MIL- _____

Type MIL- _____

Sheathing strip heat no. _____

Diameter _____

Lot identification no. _____

Chemical analysis

Carbon _____

Manganese _____

Silicon _____

Phosphorus _____

Sulfur _____

Nickel _____

Chromium _____

Molybdenum _____

Vanadium _____

Mechanical tests

Tensile test _____

Yield strength (0.2 percent offset,
lb/in²) _____Tensile strength (lb/in²) _____

Elongation (percent in 2 inches) _____

Impact (foot-pounds)Dynamic tearCharpy V-notch

At minus 20°F

At 0°F

At minus 60°F

1. _____

1. _____

1. _____

2. _____

2. _____

2. _____

3. _____

3. _____

4. _____

4. _____

5. _____

5. _____

Average _____

Chemistry was taken from:

☐

Weld metal pad

☐

Groove weld

☐

Fractured tensile specimen

X-ray results _____

See notes at end of figure.

FIGURE 2. Certification of quality conformance tests.

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CERTIFICATION OF QUALITY CONFORMANCE TESTS (Continued)Hydrogen analysis (mL per 100
grams of weld metal)Welding procedure

1. _____		Groove	Weld metal
2. _____		weld	pad
3. _____			
4. _____	Amperes		
_____ Average	Arc travel		
	speed (inches		
Arc volts _____	per minute)		
Amperes _____	No. passes,		
Arc travel speed (inches per	layer 1		
minute) _____	No. passes,		
	layer 2		
<u>Electrode diameter</u>	No. passes,		
	layer 3		
Maximum _____	No. passes,		
	layer 4		
Minimum _____	No. passes,		
	layer 5		
	No. passes,		
	layer 6		
	No. passes,		
	layer 7		
	No. passes,		
	layer 8		

List additional passes and layers as
necessary._____
Signature of responsible company official_____
Date

NOTES:

1. This form is applicable to the quality conformance tests required for each lot. One copy shall be forwarded to the consignee with each shipment.
2. See 4.6.

FIGURE 2. Certification of quality conformance tests. - Continued

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL*(See Instructions - Reverse Side)***1. DOCUMENT NUMBER**

MIL-E-24403/2B(SH)

2. DOCUMENT TITLE

Electrodes - Welding, Flux Cored, Low-Alloy Steel

3a. NAME OF SUBMITTING ORGANIZATION**4. TYPE OF ORGANIZATION (Mark one)**☐

VENDOR

☐

USER

☐

MANUFACTURER

☐

OTHER (Specify): _____

5. ADDRESS (Street, City, State, ZIP Code)**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)**