INCH-POUND

MIL-E-23765/2E(SH)
22 April 1994
SUPERSEDING
MIL-E-23765/2D(SH)
18 August 1987
(See 6.4)

MILITARY SPECIFICATION

ELECTRODES AND RODS - WELDING, BARE, SOLID, OR ALLOY CORED; AND FLUXES, 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 solid bare welding electrodes for use with the gas metal arc welding (GMAW) process and the submerged arc welding (SAW) process employing a neutral granular flux, low alloy steel alloy cored bare welding electrodes for use with the GMAW process and the SAW process employing a neutral granular flux, and low alloy steel solid bare electrodes and cut length rods for use with the gas tungsten arc welding (GTAW) process.

1.2 Classification.

1.2.1 Electrode and rod types, forms and sizes. Electrodes and rods shall be provided in the types specified in table I in forms 3a, 3b, 3c, 3d, 3e, 4, and 6 with sizes as specified in MIL-E-23765 and table II herein.

1.2.2 Neutral granular flux types. Neutral granular flux for as-welded or stress relieved SAW applications shall be provided in the types qualified (see 3.2.3).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, SEA 03R42, Naval Sea Systems Command, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 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

Table I. Electrode and rod type designation and chemical composition.

Chemical composition (percentage) 1/	MIL-type 2/						
	80S-1	80S-2	80S-3	100S-1 100S-2	100S-1C 100S-2C	120S-1 120S-2	120S-1C 120S-2C
Welding Process	SAW	SAW	GMAW GTAW	ALL	GMAW SAW	ALL	GMAW SAW
Carbon	0.10- 0.15	0.10- 0.17	0.07- 0.12	0.07 3/	0.07 3/	0.070 3/ 4/	0.070 3/ 4/
Manganese	1.75- 2.40	1.70- 2.20	1.60- 2.10	1.25- 1.8	1.25- 2.5	0.90- 2.35	1.4-3.8
Silicon	0.10	0.05	0.50- 0.80	0.20- 0.55	0.20- 0.55	0.60	0.20- 0.55
Phosphorus	0.025	0.025	0.025	0.012	0.012	0.012	0.012
Sulfur	0.020	0.020	0.020	0.008	0.010	0.008	0.010
Nickel	0.55- 1.10	0.15	0.15	1.40- 2.10	1.40- 2.10	1.00- 3.0	1.00- 3.5
Molybdenum	0.35- 0.55	0.45- 0.60	0.40- 0.60	0.25- 0.55	0.25- 0.55	0.30- 1.00	0.30- 1.10
Chromium	0.15	0.15	0.15	0.30	0.30	0.80	0.60
Vanadium	0.03	0.03	0.03	0.05	0.04	0.03	0.04
Aluminum	0.07	0.07	0.02	0.10	0.05	0.10	0.05
Titanium	----	----	----	0.10	0.10	0.10	0.10
Zirconium	----	----	----	0.10	0.10	0.10	0.10
Copper	5/ 6/	5/ 6/	5/ 6/	5/ 6/	5/ 6/	5/ 6/ 7/	5/ 6/ 7/
Boron	----	----	----	----	----	7/	7/

1/ Wherever single values are shown, they are maximum values. Values apply to bare electrode, rod or weld deposit as specified in 3.3.

2/ Including applicable suffixes (see 3.2).

3/ Addition of the suffix SA to MIL-100S and MIL-120S designation, for example MIL-120S-1SA, indicates a special MIL-type electrode intended for SAW only. Other requirements of this specification which apply to a

basic MIL-type shall also apply to the special MIL-type counterpart with higher carbon content, except the maximum carbon content for MIL-100S-1SA and MIL-100S-2SA shall be 0.08 percent; for MIL-120S-1SA, MIL-120S-2SA and MIL-120S-1CSA shall be 0.084 percent; and for MIL-120S-2CSA shall be 0.090 percent.

4/ Check analysis after purchase must be not greater than 0.003 percent higher.

5/ When the basic MIL-type electrode or rod has a copper coating in accordance with 3.2.1 herein, the maximum weight percent of copper in the electrode or rod due to the coating and the residual copper content in the steel shall be 0.30 percent maximum. When more than one production line is being used to deposit copper coating on a single lot of electrodes or rods, the sampling plan for chemical analysis shall be in accordance with MIL-E-23765.

6/ Addition of the suffix RC to any basic MIL-type designation, for example, Type MIL-100S-1RC, indicates a special MIL-type of electrode or rod which is not copper coated and for which the copper is 0.10 percent maximum. Other requirements of this specification which apply to a basic MIL-type shall also apply to the special MIL-type counterpart with the restricted copper content (see 6.2).

7/ Copper (except for copper coated and suffix RC electrodes) and boron shall be reported for information only.

Table II. Electrode and rod form, size, and weight.

Form	Electrode and rod diameter (inches)	Weight 1/ (pounds)
3a	All	1-1/2, 2 or 2-1/2
3b	All	25, 30, 35, 44, 50, 60, 250, 300, 600, 750
3c	All	25, 50, or 60
3d	All	60 or 65
3e	All	150, 200, or 250
4	All	As specified by the purchaser
6	All	10 or 50

1/ Tolerance 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-C-101	- Carbon Dioxide (CO_2), Technical and U.S.P.
BB-O-925	- Oxygen, Technical, Gas and Liquid.

MILITARY

MIL-S-16216	- Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100).
MIL-A-18455	- Argon, Technical.
MIL-S-23194	- Steel Forgings, Carbon and Low Alloy.
MIL-E-23765	- Electrodes and Rods - Welding, Bare, Solid and Alloyed Cored, General Specification for.
MIL-S-24238	- Steel Plate, Carbon and Low Alloy.
MIL-S-24645	- Steel Plate, Sheet, or Coil Age-Hardening Alloy, Structural, High Yield Strength (HSLA-80 and HSLA-100).

STANDARDS

MILITARY

MIL-STD-147	- Palletized Unit Loads.
MIL-STD-271	- Requirements for Nondestructive Testing Methods.
MIL-STD-2035	- Nondestructive Testing Acceptance Criteria
MIL-STD-2149	- Standard Procedures for Explosion Testing Ferrous and Non-Ferrous Metallic Materials and Weldments.

(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 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)

A 302 - Standard Specification for Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel. (DoD adopted)

A 508 - Standard Specification for Quenched and Tempered Vacuum-Treated Carbon and Alloy Steel Forgings for Pressure Vessels. (DoD adopted)

A 533 - Standard Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel. (DoD adopted)

A 710 - Standard Specification for Low-Carbon Age-Hardening Nickel-Copper-Chromium-Molybdenum-Columbium and Nickel-Copper-Columbium Alloy Steels.

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)

A4.3 - Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic and Ferritic Steel Weld Metal Produced by Arc-Welding.

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.)

UNIFORM CLASSIFICATION COMMITTEE AGENT

Uniform Freight Classification Ratings, Rules and Regulations

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

(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 General. Electrodes and rods provided under this specification shall be in accordance with MIL-E-23765 and as specified herein. Neutral granular flux provided under this specification shall be in accordance with the requirements specified herein.

3.2 MIL-types.

3.2.1 Basic MIL-type. Basic MIL-type electrodes and rods shall have either a clean bright finish or a uniform continuous well-bonded smoothly drawn copper coating on a clean surface. Diameters 3/32 inch and smaller may be coated with other types of rust preventatives provided such coatings do not impair usability of the electrodes and rods or the quality or soundness of weld metal deposits.

3.2.2 Special MIL-type with suffix RC. Special MIL-type electrodes and rods designated by the suffix RC shall not be copper coated but may have either a bright finish or a special protective coating provided the coating does not impair usability of the electrodes or rods or the quality and soundness of the weld metal deposits.

3.2.3 MIL-type with suffix F. For as-welded or stress relieved applications, the MIL-type designation of a qualified flux consists of the MIL-type designation of the electrode it was qualified with, plus the suffix F (for example, MIL-100S-1F).

3.2.4 Special MIL-120 types with suffix X. MIL-120 electrodes, rods or alloy cored electrodes qualified using alternating current (ac) shall be designated by the suffix X.

3.2.5 Special MIL-100 and MIL-120 types with suffix SR. MIL-100 and MIL-120 electrodes, rods or alloy cored electrodes tested in the stress relieved condition shall be designated with the suffix SR.

3.2.6 MIL-types with suffix C. Alloy cored electrodes shall be designated by suffix C.

3.2.7 MIL-types with suffix SA. MIL-100S and MIL-120S electrodes with higher carbon content intended only for SAW shall be designated with suffix SA.

3.3 Chemical composition. Chemical composition of unwelded electrodes and rods or deposited weld metal, as specified below, shall be in accordance with table I. For solid electrodes and rods, chemical analysis shall be made on unwelded electrodes. For alloy cored electrodes used for GMAW, the chemical analysis shall be made on weld metal deposited in accordance with 4.8. For alloy cored electrodes used for SAW (see 4.2.4), chemical analysis shall be made on weld metal deposited in accordance with 4.8 using the same brand flux used for qualification.

3.4 Mechanical properties. The mechanical properties of weld metal in the as-welded condition shall be in accordance with table III. The mechanical properties of weld metal in the stress relieved condition shall be in accordance with table IV.

Table III. Mechanical properties for as-welded SAW, GMAW and GTAW welds. 1/

MIL-type 2/			100S-1 100S-1F 100S-2 100S-2F		120S-1 120S-1F 120S-2 120S-2F	
Yield strength (1000 pounds per square inch (ksi))			82 to 120 3/		102 to 123 3/ 4/	
Elongation in 2 inches minimum (percent)			16		15	
Transverse side bend			5/		5/	
Impact	Charpy V-notch	Energy ft-lb minimum average	6/ 35	6/ 60	6/7/ 45	6/ 60
		Temperature (degrees Fahrenheit (°F))	Minus 60	0	Minus 60	0
	Dynamic tear	Energy ft-lb minimum average	8/ 9/ 300	9/ 10/ 450	8/ 9/ 400	9/ 10/ 575
		Temperature °F	Minus 20	30	Minus 20	30
Explosion test series			11/		11/	

1/ The ultimate tensile strength and percentage reduction of area shall be recorded for information only.

2/ Including applicable suffixes (see 3.2).

3/ These values are minimum and maximum averages determined by testing all specimens required from each qualification and conformance test weld.

4/ Maximum yield strength shall be 125 ksi when specified (see 6.2). Single values shall not be less than 100 ksi or greater than 125 ksi, or, when specified (see 6.2), 130 ksi.

5/ Transverse side bend specimens after bending shall have no cracks or other indications greater than 1/8 inch in any direction on a convex surface. Tears less than 1/8 inch on the corners of the bend specimen are acceptable.

6/ For each testing temperature, the average value of five tests shall be equal to or 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 below the minimum average specified.

7/ For high cooling rate tests of MIL-120S types, the average Charpy V-notch toughness at -60°F shall be not less than 40 foot-pounds.

8/ For each testing temperature, the average value of two tests shall be equal to or greater than the minimum average value specified. One specimen can have a value of 50 foot-pounds below the minimum average specified.

9/ For high cooling rate tests, dynamic tear test results shall be reported for information only.

10/ For each testing temperature, the average value of two tests shall be equal to or greater than the minimum average value specified. One specimen can have a value of 25 foot-pounds below the minimum average specified.

11/ Acceptance criteria shall be in accordance with MIL-STD-2149.

(see 4.2, 4.3 and 6.2): (a) for not less than 50 hours as specified (see 6.2) or (b) held at temperature for 1 hour per inch of weld thickness (for weld thicknesses less than 1 inch, the minimum holding time shall be proportional to the weld thickness but shall be not less than 30 minutes). The test plates treated by either method (a) or (b) shall be cooled at a maximum rate of 10°F per hour from the stress relief temperature to 600°F.

3.5 Nondestructive testing.

3.5.1 Magnetic particle inspection. Welds deposited with type MIL-100S-1, MIL-100S-2, MIL-120S-1 and MIL-120S-2 electrodes or rods shall be in accordance with class 1 acceptance criteria as specified in MIL-STD-2035 for magnetic particle inspection.

3.5.2 Radiography. Radiographs of welds deposited with all types electrodes shall be in accordance with class 1 acceptance criteria as specified in MIL-STD-2035.

3.6 Diffusible hydrogen. For MIL-100S and MIL-120S, the diffusible hydrogen levels in milliliters per 100 grams (mL/100 grams) of deposited weld metal shall be not greater than the values specified in table V.

Table V. Diffusible hydrogen values.

MIL-type 1/	Welding process	Maximum average	Maximum single value
100S-1	GMAW	4.0	4.8
100S-1 100S-1F	SAW	5.5	6.7
100S-2	GMAW	2.0	2/
100S-2 100S-2F	SAW	3.0	2/
120S-1	GMAW	4.0	2/
120S-1 120S-1F	SAW	5.5	2/
120S-2	GMAW	2.0	2/
120S-2 120S-2F	SAW	3.0	2/

1/ Including applicable suffixes (see 3.2).

2/ See 4.6.1.1.

Table IV. Mechanical properties for stress relieved welds. 1/

MIL-type 2/			80S-1 80S-1F 80S-2 80S-2F 80S-3	100S-1 100S-2	120S-1 120S-2
Ultimate tensile strength (minimum) (ksi)			80	90	3/
Yield strength (minimum) (ksi)			50	80	3/
Elongation in 1.4 or 2 inches (minimum) (percent)			20	18	3/
Transverse side bend			4/	4/	4/
Impact	Charpy V-notch	Energy ft-lb minimum average	5/ 30	5/ 35	3/ 5/
		Temperature °F	10	10	10

1/ See 3.4.1.

2/ Including applicable suffixes (see 3.2).

3/ Stress relief thermal treatment of welds deposited with MIL-120S-1 or MIL-120S-2 electrodes or rods is not permitted unless specifically approved by NAVSEA. The required mechanical properties after stress relief on MIL-120S type weld metal shall be as specified (see 6.2).

4/ Transverse side bend specimens after bending shall have no cracks or other indications greater than 1/8 inch in any direction on a convex surface. Tears less than 1/8 inch on the corners of the bend specimen are acceptable.

5/ For each testing temperature, the average value of five tests shall be equal to or 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 below the minimum average specified.

3.4.1 Stress relief. Type MIL-80S weld metal test plates and, when specified (see 6.2), types MIL-100S and MIL-120S weld metal plates shall be stress relieved at 1125 ± 25°F for one of the following periods as specified

3.7 Moisture content of MIL-100 and MIL-120 type fluxes. The total water content of MIL-100S-1F, MIL-100S-2F, MIL-120S-1F or MIL-120S-2F flux shall be not greater than 0.05 percent by weight. For MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F, flux lots exhibiting total moisture content between 0.05 and 0.10 percent by weight shall be accepted provided diffusible hydrogen testing confirms the lot meets the requirements of Table V.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Qualification tests. Qualification tests shall be in accordance with table VI. For MIL-80S, the test sample of electrodes, rods or flux selected in accordance with MIL-E-23765 shall be used for these tests. For MIL-100S and MIL-120S, the test sample of electrodes, rods or flux selected in accordance with MIL-E-23765 shall be used for these tests and the test sample shall be increased in size to accommodate the number of tests required. For all MIL-types, schedule A tests shall be conducted by the contractor. For MIL-100S and MIL-120S electrodes and rods, upon successful completion of schedule A tests, schedule B welding and testing will be conducted by the Government.

Table VI. Summary of tests required for qualification. 1/ 2/ 3/

Test		Schedule A	Schedule B	Test Procedures	Requirements
				MIL-80S-1 MIL-80S-2 MIL-80S-3 4/ MIL-80S-1F 4/ MIL-80S-2F	
Cast 5/		X	--	MIL-E-23765	MIL-E-23765
Helix 5/		X	--	MIL-E-23765	MIL-E-23765
Chemical analysis		X	--	4.8 herein	Table I herein
Alloy identity		X	--	MIL-E-23765	MIL-E-23765
Welded test assembly		X	--	4.2 herein	Figure 1 herein
Radiography		X	--	4.10.2 herein	3.5 herein
Tensile		X	--	MIL-E-23765	Table IV herein
Transverse side bend		X	--	MIL-E-23765	Table IV herein
Impact	Charpy V-notch	X	--	4.9.1 herein	Table IV herein

Table VI. Summary of tests required for qualification. 1/ 2/ 3/ (cont'd)

Test		Schedule A	Schedule B	Test Procedures	Requirements
				MIL-100S-1 MIL-100S-2 MIL-120S-1 MIL-120S-2 6/ MIL-100S-1F 6/ MIL-100S-2F 6/ MIL-120S-1F 6/ MIL-120S-2F	
Flux packaging		X	--	4.2.3.1 herein	3.7 herein
Cast 5/		X	--	MIL-E-23765	MIL-E-23765
Helix 5/		X	--	MIL-E-23765	MIL-E-23765
Chemical analysis		X	--	4.8 herein	Table I herein
Alloy identity		X	--	MIL-E-23765	MIL-E-23765
Diffusible hydrogen		X	--	4.6 herein	3.6 herein
Welded test assembly		X	X	4.2 herein	Figure 1 or figures 2 and 3 herein
Nondestructive testing		X	X	4.10 herein	3.5 herein
Tensile		X	X	MIL-E-23765	Table III herein
Transverse side bend		X	X	MIL-E-23765	Tables III and IV herein
Impact	Charpy V-notch	X	X	4.9.1 herein	Table III herein
	Dynamic tear	X	X	4.9.2 herein	Table III herein
Explosion test series		--	X	4.5 herein	Table III herein

1/ The brand name of flux used in Schedule A and B testing shall be specified in the qualification test reports.

2/ Including applicable suffixes (see 3.2).

3/ When unsatisfactory test results are obtained, retest shall be performed in accordance with 4.11.

4/ Use SAW with a qualified electrode to qualify these neutral granular flux types for the stress relieved condition.

5/ Not applicable to Form 6.

6/ Use SAW with a qualified electrode to qualify these neutral granular flux types for the as-welded condition.

4.2.1 Stress relieved applications. For electrodes and rods for stress relieved applications, welding parameters, welding position and welding process shall be in accordance with figure 1 and table VII. Weldments shall be tested in the stress relieved condition in accordance with 3.4.1 for both the 50-hour total and 1-hour per inch of thickness holding times.

Table VII. Welding parameters for stress relieved applications.

Electrode size range (inches)	Welding process and position
0.020 through 0.045	Pulsed-arc GMAW in vertical position
0.052 through 5/64	Spray-transfer GMAW in flat position
3/32 through 1/4	SAW in flat position

4.2.2 MIL-100S-1, MIL-100S-2, MIL-120S-1, and MIL-120S-2. For MIL-100S-1, MIL-100S-2, MIL-120S-1, and MIL-120S-2 electrodes and rods, welding parameters, welding position and welding process shall be in accordance with figures 2 and 3 and table VIII.

Table VIII. Welding parameters. 1/ 2/ 3/ 4/

Welding Parameters for **QUALIFICATION** tests				
MIL-type	100S-1 100S-2			
Electrode size tested (inches) 5/	0.045		1/16	
Size range qualified (inches)	0.02 to 0.045		0.052 to 5/64	
Welding process	Pulsed arc GMAW		Spray GMAW	
Position	Vertical up		Flat	
Cooling rate 6/	High	Low	High	Low
Heat input (kiloJoules per inch (kJ/in)) 7/	35	110	30	110
Preheat and interpass temperature (°F) 7/	125 to 150	225 to 275	125 to 150	225 to 275
MIL-type	100S-1 100S-1F 100S-2 100S-2F			
Electrode size tested (inches) 5/	3/32		1/8 or 1/16 8/	
Size range qualified (inches)	3/32		1/16 to 1/4	
Welding process	SAW		SAW	
Position	Flat		Flat	
Cooling rate 6/	High	Low	High	Low
Heat input (kJ/in) 7/	40	110	40	110
Preheat and interpass temperature (°F) 7/	125 to 150	225 to 275	125 to 150	225 to 275

Table VIII. Welding parameters. 1/ 2/ 3/ 4/ (continued)

MIL-type	120S-1 120S-2					
Electrode size tested (inches) 5/	0.045				1/16	
Size range qualified (inches)	0.02 to 0.045				0.052 to 5/64	
Welding process	Pulsed arc GMAW		Spray GMAW		Spray GMAW	
Position	Vertical up	Flat	Flat		Flat	
Cooling rate 6/	High	Low	High	Low	High	Low
Heat input (kJ/in) 7/	49	55	40	45	40	45
Preheat and interpass temperature (°F) 7/	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325

MIL-type	120S-1 120S-1F 120S-2 120S-2F			
Electrode size tested (inches) 5/	1/16		3/32	
Size range qualified (inches)	0.052 to 5/64		3/32 to 1/4	
Welding process	SAW		SAW	
Position	Flat		Flat	
Cooling rate 6/	High	Low	High	Low
Heat input (kJ/in) 7/	40	50	40	50
Preheat and interpass temperature (°F) 7/	200 to 225	300 to 325	200 to 225	300 to 325

Table VIII. Welding parameters. 1/ 2/ 3/ 4/ (continued)

Welding Parameters for **HEAT** quality conformance tests						
MIL-type	120S-1 120S-2		120S-1 120S-1F 120S-2 120S-2F			
Electrode size tested (inches)	Any size		Any size			
Size range certified (inches)	N.A.		N.A.			
Welding process	Spray GMAW		SAW			
Position	Flat		Flat			
Cooling rate 6/	High	Low	High	Low		
Heat input (kJ/in) 7/	40	45	40	50		
Preheat and interpass temperature (°F) 7/	200 to 225	300 to 325	200 to 225	300 to 325		
Welding Parameters for LOT quality conformance tests						
MIL-type	100S-1 100S-2				100S-1 100S-1F 100S-2 100S-2F	
Electrode size tested (inches)	Each size 0.045 and smaller		Each size 0.052 and larger		Each size	
Size range certified (inches)	Size tested		Size tested		Size tested	
Welding process	Spray GMAW	Pulsed arc GMAW	Spray GMAW		SAW	
Position	Flat	Vertical up	Flat		Flat	
Cooling rate 6/	High	Low	High	Low	High	Low
Heat input (kiloJoules per inch (kJ/in)) 7/	30	110	30	110	40	110
Preheat and interpass temperature (°F) 7/	125 to 150	225 to 275	125 to 150	225 to 275	125 to 150	225 to 275

Table VIII. Welding parameters. 1/ 2/ 3/ 4/ (continued)

MIL-type	120S-1 120S-2			120S-1 120S-1F 120S-2 120S-2F
Electrode size tested (inches)	Each size 0.045 and smaller		Each size 0.052 and larger	Each size
Size range certified (inches)	Size tested		Size tested	Size tested
Welding process	Spray GMAW	Pulsed arc GMAW	Spray GMAW	SAW
Position	Flat	Vertical up	Flat	Flat
Cooling rate 6/	High 9/	Low	Low	Low
Heat input (kJ/in) 7/	35	55	45	50
Preheat and interpass temperature (°F) 7/	200 to 225	300 to 325	300 to 325	300 to 325

1/ For qualification testing and heat quality conformance testing of MIL-120S types, electrodes or rods representing the highest carbon equivalent (see 4.8.2.3) in the heat shall be used for high cooling rate tests and electrodes representing the lowest carbon equivalent shall be used for low cooling rate tests. Test weld assemblies shall be fabricated using electrodes representing the extremes of measured carbon equivalent.

2/ Weldments shall be tested in the as-welded condition without any heat soaking for hydrogen removal.

3/ Alternate welding parameters may be used for qualification or quality conformance testing when approved by NAVSEA.

4/ Including applicable suffixes (see 3.2).

5/ Qualification of the qualification size will qualify all of the electrodes in the size range specified.

6/ For MIL-100S types, test plates shall be in accordance with figure 2 for both low cooling rate tests and high cooling rate tests. For MIL-120S

types, test plates shall be in accordance with figure 2 for the low cooling rate test and in accordance with figure 3 for high cooling rate tests. For high cooling rate MIL-120S test assemblies,results from each side shall be reported separately, with side 1 depicting results from the first side welded. Failure of either side shall constitute failure of the entire test assembly. Alternatively, high cooling rate quality conformance testing of type MIL-120S may be performed using test assemblies in accordance figure 2 when approved by NAVSEA provided:

(a) Test data from both figure 2 and figure 3 test plates demonstrate comparability with respect to cooling rate and performance.

(b) Written test quality conformance procedures submitted for approval establish welding parameter controls and comparative differences in acceptance criteria for figure 2 test plates.

(c) When both test plates are tested, results from the figure 3 test plates shall be the authoritative results.

In all cases, weldments shall be fully restrained by clamps or other means during heating, welding, and cooling to room temperature. The table or other supporting device shall be stiff enough to prevent weldment distortion.

7/ Operational heat input shall be the actual heat input recorded or calculated for individual passes during welding of the test assemblies. Average heat input shall be the average of the operational heat input of all passes in the test assembly and shall fall within plus or minus 2 kJ/in of the heat input specified. Not greater than 20 percent of the individual passes shall be 2 to 5 kJ/in greater than the heat input specified for the high cooling rate test, or 2 to 5 kJ/in less than the heat input specified for the low cooling rate test. The root layer may be excluded from all heat input calculations. A weld pass shall be defined as one bead extending from the beginning to the end of the test assembly. Each weld pass shall be completed prior to commencing any other weld pass. Specified heat inputs reflect minimum acceptable ranges and qualification or quality conformance testing at values beyond the specified range shall be accepted. Heat input (kJ/in) shall be calculated using the following formula:

$$\text{Heat Input} = \frac{\text{Arc Voltage} \times \text{Welding Amperage} \times 60}{\text{Rate of Travel (inches per minute)} \times 1000}$$

8/ The 1/16 inch diameter electrode is intended for twin arc SAW.

9/ This test shall be conducted in accordance with the requirements of figure 2 on one inch thick plate at the high cooling rate.

4.2.3 MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F. MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F flux types shall be used in combination with a corresponding MIL-type electrode to deposit weld metal by the SAW process, and the weldments tested in the as-welded condition. For MIL-100S-1F, MIL-100S-2F, MIL-120S-1F, and MIL-120S-2F fluxes, welding parameters, welding position and welding process shall be in accordance with figures 2 and 3 and table VIII.

4.2.3.1 Sampling for qualification of flux packaging.

4.2.3.1.1 Flux packaged in bags. The flux used to qualify flux packaging shall be from a lot sample package as defined in MIL-E-23765 and the following:

(a) The sample package shall be placed next to another package of the same type.

(b) The stack of packages shall be sprayed with water for not less than five minutes using a shower head attached to a garden hose. All exposed surfaces shall be wetted. The sample package shall be placed on top of the other package, wet side down.

(c) The stack shall be still air dried at room temperature for a period of seven days.

(d) All the flux from the sample package shall be mixed, then subdivided by successive quartering and by not less than four passes through a riffle into the amount of flux required for the water content test of 4.7 herein. The flux water content shall meet the requirements of 3.7 herein.

(e) Any change in package material, type or method of construction shall be requalified. One retest is permitted. Results of both tests shall be reported.

4.2.3.1.2 Flux packaged in other containers. The flux used to qualify flux packaging shall be from a lot sample package as defined in MIL-E-23765 and the qualification method shall be approved by NAVSEA.

4.2.4 Electrode/flux combinations. When qualification testing MIL-120S type electrodes and all alloy cored electrodes for the SAW process, each specific brand name electrode and flux combination shall be tested and listed as a unique combination on the QPL (see 6.1.2).

4.3 Quality conformance inspection. Quality conformance inspection tests shall be performed in accordance with table IX. For MIL-80S, the test sample of electrodes, rods or flux selected in accordance with MIL-E-23765 shall be used for these tests. For MIL-100S and MIL-120S, the test sample of electrodes, rods or flux selected in accordance with MIL-E-23765 shall be used

for these tests and the test sample shall be increased in size to accommodate the number of tests required. For all MIL-types, quality conformance tests shall be conducted by the contractor.

Table IX. Summary of tests required for conformance inspection. 1/ 2/ 3/

Test		Test Procedures	Requirements
		4/ MIL-80S-1 4/ MIL-80S-2 MIL-80S-3	
Cast 5/		MIL-E-23765	MIL-E-23765
Helix 5/		MIL-E-23765	MIL-E-23765
Chemical analysis		4.8 herein	Table I herein
Alloy identity		MIL-E-23765	MIL-E-23765
Welded test assembly		4.3 herein	Figure 1 herein
Radiography		4.10.2 herein	3.5 herein
Tensile		MIL-E-23765	Table IV herein
Impact	Charpy V-notch	4.9.1 herein	Table IV herein

Table IX. Summary of tests required for conformance inspection. 1/ 2/ 3/ (continued)

Test		Test Procedures	Requirements
		MIL-100S-1 MIL-100S-2 MIL-120S-1 MIL-120S-2 6/ MIL-100S-1F 6/ MIL-100S-2F 6/ MIL-120S-1F 6/ MIL-120S-2F	
Cast 5/		MIL-E-23765	MIL-E-23765
Helix 5/		MIL-E-23765	MIL-E-23765
Chemical analysis		4.8 herein	Table I herein
Alloy identity		MIL-E-23765	MIL-E-23765
Diffusible hydrogen		4.6 herein	3.6 herein
Welded test assembly		4.3 herein	Figure 1 or figures 2 and 3 herein
Nondestructive testing		4.10 herein	3.5 herein
Tensile		MIL-E-23765	Table III herein
Impact	Charpy V-notch 7/	4.9.1 herein	Table III herein
	Dynamic tear 7/	4.9.2 herein	Table III herein

1/ When a heat of metal is processed into electrodes and rods, weld metal tests are required only with electrodes.

2/ Including applicable suffixes (see 3.2).

3/ When unsatisfactory test results are obtained, retest shall be performed in accordance with 4.11.

4/ Use SAW with qualified MIL-80S-1F or MIL-80S-2F flux for quality conformance inspection of a lot of these qualified electrode types for the stress relieved condition.

5/ Not applicable to Form 6.

6/ Use SAW with a qualified electrode for quality conformance inspection of a lot of these qualified neutral granular flux types. A lot of electrodes and a lot of qualified neutral granular flux can be quality conformance inspected by the same set of tests.

7/ Either Charpy V-notch or dynamic tear testing shall be performed.

4.3.1 Bare solid electrodes and rods.

4.3.1.1 Lot. For purposes of sampling and quality conformance inspection, a lot of electrodes or rods shall be the quantity of one size and type alloy produced as specified in MIL-E-23765.

4.3.1.2 Stress relieved applications. Test weldments for electrodes and rods for stress relieved applications shall be made in accordance with figure 1 and table VII. The stress relief treatment shall be in accordance with 3.4.1(a) or 3.4.1(b) as specified (see 6.2).

4.3.1.3 MIL-100S and MIL-120S types. Test weldments for MIL-100S and MIL-120S types shall be made in accordance with figures 2 and 3 and table VIII

4.3.2 Alloy cored electrodes.

4.3.2.1 Lot. For purposes of sampling and quality conformance inspection, a lot of alloy cored electrodes shall be the quantity of one size and type as specified in MIL-E-23765.

4.3.2.2 Test weldments. Test weldments shall be made in accordance with 4.3.1.2 or 4.3.1.3, as applicable. When alloy cored electrodes are tested using the SAW process, the same brand name flux that was used in qualification shall be used.

4.3.3 Flux.

4.3.3.1 Lot. For purposes of sampling and quality conformance, a lot shall be as defined in MIL-E-23765.

4.3.3.2 Test weldments. Test weldments shall be made in combination with a corresponding MIL-type electrode in accordance with 4.3.1.2 or 4.3.1.3, as applicable.

4.3.4 Lot sampling for diffusible hydrogen. Every lot of material offered for acceptance under this specification, except MIL-80S types, shall be tested for diffusible hydrogen content in accordance with 4.6 herein.

4.3.5 Electrode/flux combinations. For conformance testing of MIL-120S

type electrodes with the SAW process and all alloy cored electrodes with the SAW process, the specific brand name electrode and flux combination(s) specified (see 6.2) shall be used for conformance testing.

4.4 Base metal. Unless otherwise specified (see 6.2), the base metal steel used for the tests required herein shall be in accordance with table X.

Table X. Base metal requirements.

MIL-types 1/2/	Base metal
80S-1 80S-2 80S-3	Ni-Cr-Mo steel in accordance with MIL-S-23194, composition A, ASTM A 508, class 2, or equivalent, or Mn-Ni-Mo steel in accordance with MIL-S-24238, composition A, ASTM A 302, ASTM A 533, grade B or C, class 1, or equivalent
3/ 100S-1 100S-1F	4/ HY-80 steel in accordance with MIL-S-16216
3/ 100S-2 100S-2F	4/ HY-80 or HY-100 steel in accordance with MIL-S-16216 or HSLA-80 or HSLA-100 in accordance with MIL-S-24645 when specified (see 6.2).
120S-1 120S-1F 120S-2 120S-2F	4/ HY-100 steel in accordance with MIL-S-16216 and an optional additional test with HSLA-100 in accordance with MIL-S-24645 when specified (see 6.2).

1/ For quality conformance testing in the stress relieved condition to the requirements as specified in table IV, other base metal steels may be specified (see 6.2).

2/ Including applicable suffixes (see 3.2).

3/ For quality conformance testing, if specified (see 6.2), MIL-S-24645 or ASTM A 710 grade A steel may be specified for a second test weldment in addition to the HY-80 steel test weldment required (see 6.2).

4/ These grades of steel are required (see figures 2 and 3) when dynamic tear tests are to be conducted. Steel in the as-rolled condition as specified in MIL-S-16216 may be used as shown on figures 2 and 3 for quality conformance tests, when dynamic tear tests are not being conducted.

4.5 Explosion test series.

4.5.1 Welding parameters. Fabrication of the weldments shall be as follows:

(a) The base plate shall be as specified in table X.

(b) Dimensions of the test assemblies shall be as specified in MIL-STD-2149.

(c) The weldments shall be fabricated using the welding position and electrode diameter specified in table XI. The number of weldments required shall be as specified in 4.5.2.

(d) The preheat and interpass temperature shall be 250 ± 25°F.

(e) The welding heat input shall be 110 kJ/in minimum for MIL-100S and 50 to 60 kJ/in for MIL-120S.

(f) Peening of weld beads shall not be permitted.

(g) The test assembly shall be prepared by using welding sequence and techniques recommended by the manufacturer which shall be reported.

(h) The joint surface shall not be clad or buttered.

(i) Welding should be continuous except for interpass cooling. Heat soaking for hydrogen removal is prohibited. Time delay per pass beyond that necessary for interpass cooling shall be reported.

Table XI. Welding parameters for explosion test series. 1/

Qualification electrode size (inches)	Welding process	Position	Size range qualified (inches)
0.045	Pulsed-arc GMAW	Vertical up	0.020 - 0.045
1/16	Spray-arc GMAW	Flat	0.052 - 5/64
1/8	SAW	Flat	3/32 - 1/4

1/ Qualification of each of the above sizes will qualify all of the electrodes in each of the size ranges specified above.

4.5.2 Test requirements. The tests shall be conducted at zero °F in accordance with MIL-STD-2149. Two crack starter tests shall be conducted.

4.6 Diffusible hydrogen test.

4.6.1 Procedure. The diffusible hydrogen test shall be performed in accordance with AWS A4.3. One set of specimens shall be prepared and tested.

4.6.1.1 Diffusible hydrogen control plan (MIL-100S and MIL-120S). The manufacturer must have a NAVSEA approved test plan to verify uniformity of diffusible hydrogen in each lot. The test plan must exhibit a 95 percent confidence level, based on statistical analysis of actual test data, that not less than 95 percent of the spools from each lot will meet the diffusible hydrogen limits of 3.6.

4.7 Flux total water content. The total water content shall be determined as specified on figure 4 and the notes pertaining thereto. Alternate methods such as titration or infrared methods may be used when approved by NAVSEA.

4.8 Chemical analysis. Chemical analysis shall be performed as specified in MIL-E-23765. When chemical analysis of the weld deposit is required (see 3.3), the sample shall be taken from a weld pad (see 4.8.1), or from a low dilution area in the groove weld or all weld metal tensile specimen. In case of dispute, the weld pad shall be the referee method.

4.8.1 Weld pad specifications. The weld pad shall be deposited in even layers in the flat position and shall be built up to not less than 4 layers, with three passes per layer as shown on figure 5. The final weld surface shall be ground flat for the chemical analysis and not less than 3 full surface layers shall remain after grinding. The welding parameters for the weld pad shall be selected to minimize weld dilution.

4.8.2 Chemical range limits. The chemical compositions specified in table I are minimum and maximum limits. However, this specification does not imply and it should not be inferred that each of the possible chemistry compositions defined by these limits will meet the full requirements of this specification, for example, mechanical properties. Once a formulation is developed and qualified, and the aim values for each element have been established, changes to the formulation or aim values shall require requalification. NAVSEA may waive requalification for minor changes.

4.8.2.1 Chemical range limits for MIL-80S. At the time of qualification, the aim values and typical ranges shall be reported for each element which represent expected variations due to manufacturing tolerances.

4.8.2.2 Chemical range limits for MIL-100S and MIL-120S. At the time of qualification, or for products qualified to previous revisions of this specification, the aim values and maximum and minimum limits for each major

alloying element (C, Si, Mn, Cr, Cu, Ni, Mo, and V) and related maximum and minimum carbon equivalent on formulations shall be established for acceptance of this product, shall be reported to NAVSEA and shall represent statistically determined variations due to manufacturing tolerances. The carbon equivalent shall be determined using the formula specified in 4.8.2.3. The maximum and minimum chemical range limits and related carbon equivalents shall be supported by data to demonstrate that mechanical properties can be achieved with the range established. It is not intended that data be provided to support the maximum and minimum limit for each element. The data must demonstrate that material with high and low carbon equivalent due to the elements promoting hardenability at the high limits or low limits of the composition range for the formulation will meet the mechanical properties requirements.

4.8.2.2.1 Uniformity of composition plan for MIL-100S and MIL-120S types. The manufacturer must have a NAVSEA approved test plan to verify uniformity of chemical composition in each lot. The plan shall include testing of intermediate and final products other than chemical analysis of deposited weld metal. The test plan must exhibit a 95 percent confidence level, based on statistical analysis of actual test data, that not less than 95 percent of the material from each lot will be within the chemistry range specified for each element in accordance with 4.8.2.2. The plan shall identify how any material found to fall outside the 95 percent confidence limits established during qualifications shall be discarded or subjected to additional conformance testing to confirm that mechanical properties are acceptable.

4.8.2.3 Carbon equivalent control for MIL-100S and MIL-120S only. The manufacturer shall establish the chemical uniformity of the heat and shall calculate the high and low carbon equivalent (C.E.) based on actual chemical analysis using the following formula:

$$C.E. = \%C + \frac{\%Si}{30} + \frac{(\%Mn + \%Cr + \%Cu)}{20} + \frac{\%Ni}{60} + \frac{\%Mo}{15} + \frac{\%V}{10} + 5(\%B)$$

where:

%	is percent
C	is carbon
Si	is silicon
Mn	is manganese
Cr	is chromium
Cu	is copper
Ni	is nickel
Mo	is molybdenum
V	is vanadium
B	is boron

Carbon content may be used in place of carbon equivalent if chemistry is demonstrated to be adequately uniform.

4.9. Impact test requirements.

4.9.1. Charpy V-Notch testing. The Charpy V-notch specimens shall be machined to dimensions as specified in AWS B4.0. The notch shall be perpendicular to the plate surface. Impact properties for five specimens shall be obtained at each test temperature specified in table III or IV, as applicable, plus or minus 3°F.

4.9.2. Dynamic tear testing. Dynamic tear testing shall have specimens machined and tested in accordance with ASTM E 604. Two dynamic tear specimens shall be tested at each temperature as specified in table III.

4.10. Nondestructive testing.

4.10.1 Magnetic particle. Both surfaces of the weld shall be magnetic particle inspected in accordance with MIL-STD-271.

4.10.2 Radiography. The weld shall be inspected radiographically to level 2-2T as specified in MIL-STD-271. Radiographic inspection is not required for MIL-120S weldments made at high cooling rates.

4.11 Unsatisfactory test results. When unsatisfactory test results are obtained, retests shall be performed in accordance with the requirements of MIL-E-23765, except as noted below.

4.11.1 Weld metal tests. Retests involving weld metal shall be in accordance with MIL-E-23765. When the original test assembly has specimens removed from both sides, the retest shall be performed on the same side(s) which failed.

4.11.2 Diffusible hydrogen tests. Retest involving diffusible hydrogen shall be in accordance with MIL-E-23765. If the retest also fails to meet the requirements of 3.6, the material shall be rejected. The supplier shall inform in writing all agencies having procured lots of material delivered since the last successfully tested lot of the identity of the intervening lots.

4.11.3 MIL-120S retest utilizing post weld soak. When approved by NAVSEA, MIL-120S filler materials may retested utilizing a post weld soak procedure. Such retesting shall be performed on new test assemblies which are subjected to the post weld soak procedure and shall require retest of all mechanical properties.

4.12 Certification of quality conformance. A certification of quality conformance shall be furnished with each lot of material offered for acceptance. The certification shall include quantitative results of specified chemical and mechanical tests, and qualitative results of nondestructive tests on the lot. The minimum quality conformance test result data required shall be in accordance with 4.12.1. The cause for any retest shall be reported for

information and the results of all tests, including failures, shall be reported. When required to use a specific electrode/flux combination (see 4.3.5), the certification shall report the brand name of flux used in conformance testing.

4.12.1 Quality conformance test data. The minimum quality conformance test data shall include results of all tests required by this specification and MIL-E-23765. Operational parameters for any welded test assemblies shall also be reported. The manufacturer, customer, MIL-type, heat, lot, size and form shall be identified. The certification shall include the statement: "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." and shall bear the signature of the responsible company official.

4.13 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 Preparation for delivery of electrodes and rods. Preparation for delivery of electrodes and rods shall be as specified in MIL-E-23765.

5.2 Preparation for delivery of flux. Preparation for delivery of flux shall be as specified in MIL-E-23765.

5.2.1 Packing. Welding flux shall be packed in containers that meet or exceed the following requirements:

(a) Containers shall comply with the Uniform Freight Classification Rules or other carrier regulations applicable to the mode of transportation.

(b) Containers shall ensure safe delivery, acceptance at destination and they shall protect the stability of the flux during storage in accordance with 3.7 herein.

(c) Containers shall be qualified in accordance with 4.2.3.1 herein.

(d) Containers shall be sealed air tight for all MIL-100S-2F, MIL-120S-1F and MIL-120S-2F flux.

5.2.1.1 Palletization. When specified (see 6.2), bags and drums shall be palletized for shipment in accordance with MIL-STD-147.

5.2.2 Marking. Flux containers shall be marked as specified in MIL-E-23765.

5.2.3 Use of polystyrene (loose-fill) material. The use of polystyrene (loose-fill) material for packing applications such as cushioning, filler and dunnage is prohibited.

6. NOTES

6.1 Intended use.

6.1.1 General. This specification is intended to cover low alloy steel solid bare welding electrodes and rods and alloy cored bare welding electrodes for depositing weld metal, that, in the as-welded condition, meets the mechanical properties specified herein when welded on the applicable base metals as specified in table X using GMAW, GTAW, and SAW processes. This specification also is intended to cover low alloy steel solid bare welding electrodes and rods for depositing weld metal, that in the stress-relieved condition meets the mechanical properties specified herein when welded on the applicable base metals as specified in table X using either SAW welding processes employing a suitable neutral granular flux or GMAW and GTAW processes with a suitable shielding gas. Types MIL-100S-1, MIL-100S-2, MIL-120S-1 and MIL-120S-2 or MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F, are intended only for as-welded applications. If they are conformance tested in the stress-relief condition and bear the SR suffix, they may be used for stress-relief applications as well.

6.1.1.1 Type MIL-80S-1, MIL-80S-2, and MIL-80S-3. Type MIL-80S-1 and MIL-80S-2 electrodes are suitable for welding MIL-S-23194, composition A steels; MIL-S-24238, composition A steels; ASTM A 508, class 2 or 3 steels; and ASTM A 533 or ASTM A 302 steels using the SAW process. Type MIL-80S-3 is suitable for welding the same steels using the GMAW and GTAW processes.

6.1.1.2 Type MIL-100S-1. Type MIL-100S-1 electrode is suitable for welding HY-80 steel.

6.1.1.3 Type MIL-100S-2. Type MIL-100S-2 electrode is suitable for welding HY-80 steel, especially for approved reduced preheat applications.

6.1.1.4 Type MIL-120S-1. Type MIL-120S-1 electrode is suitable for welding HY-100 steel.

6.1.1.5 Type MIL-120S-2. Type MIL-120S-2 electrode is suitable for welding HY-100 steel..

6.1.1.6 Types MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F. MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F are the designations of neutral granular flux to be used with the corresponding type of electrode.

6.1.1.7 Special MIL-type with suffix RC. Restricted copper electrodes and rods will be used when specified (see 6.2 and table I).

6.1.1.8 Special types MIL-120S-1X and MIL-120S-2X. MIL-120S-1X and MIL-120S-2X electrodes are suitable for welding HY-100 steel with the SAW process using ac current only.

6.1.1.9 MIL-types with suffix C. Alloy cored electrodes are intended for use with the GMAW and SAW processes only.

6.1.1.10 MIL-100S and MIL-120S types with suffix SA. MIL-100S and MIL-120S types with higher carbon content are intended for use with SAW only.

6.1.2 Electrode/flux combinations for SAW production welding. For MIL-120S type electrodes with the SAW process and all alloy cored electrodes with the SAW process, only those electrode and flux combinations approved are listed on the QPL.

6.2 Ordering data. Electrodes, rods or flux intended for stress-relief applications shall be so specified in the acquisition documents. Acquisition documents should also specify the following in addition to the ordering data required in MIL-E-23765:

(a) Whether the copper content should be restricted (see footnote 2 to table I and 6.1.1.6).

(b) Whether higher maximum yield strength is allowed (see footnote 4/ of table III).

(c) The required mechanical properties for type MIL-120S test welds which have been stress-relieved (see footnote 3/ to table IV).

(d) Time at the stress relief temperature (see 3.4.1 and 4.3).

(e) Whether type MIL-100S or MIL-120S weld metal test plates should be tested for conformance with stress-relieved requirements (see 3.4.1).

(f) Which specific brand name electrode and flux combination(s) shall be used for conformance testing (see 4.3.5). See current QPL for qualified combinations.

(g) Other base metal steel for use in testing in the stress relieved condition, if required (see 4.4, table X and footnote 1/ thereof).

(h) Whether a second test weldment is required for quality conformance testing in the as-welded condition (see footnote 2/ of table X).

(i) Whether bags and drums shall be palletized for shipment (see 5.2.1.1).

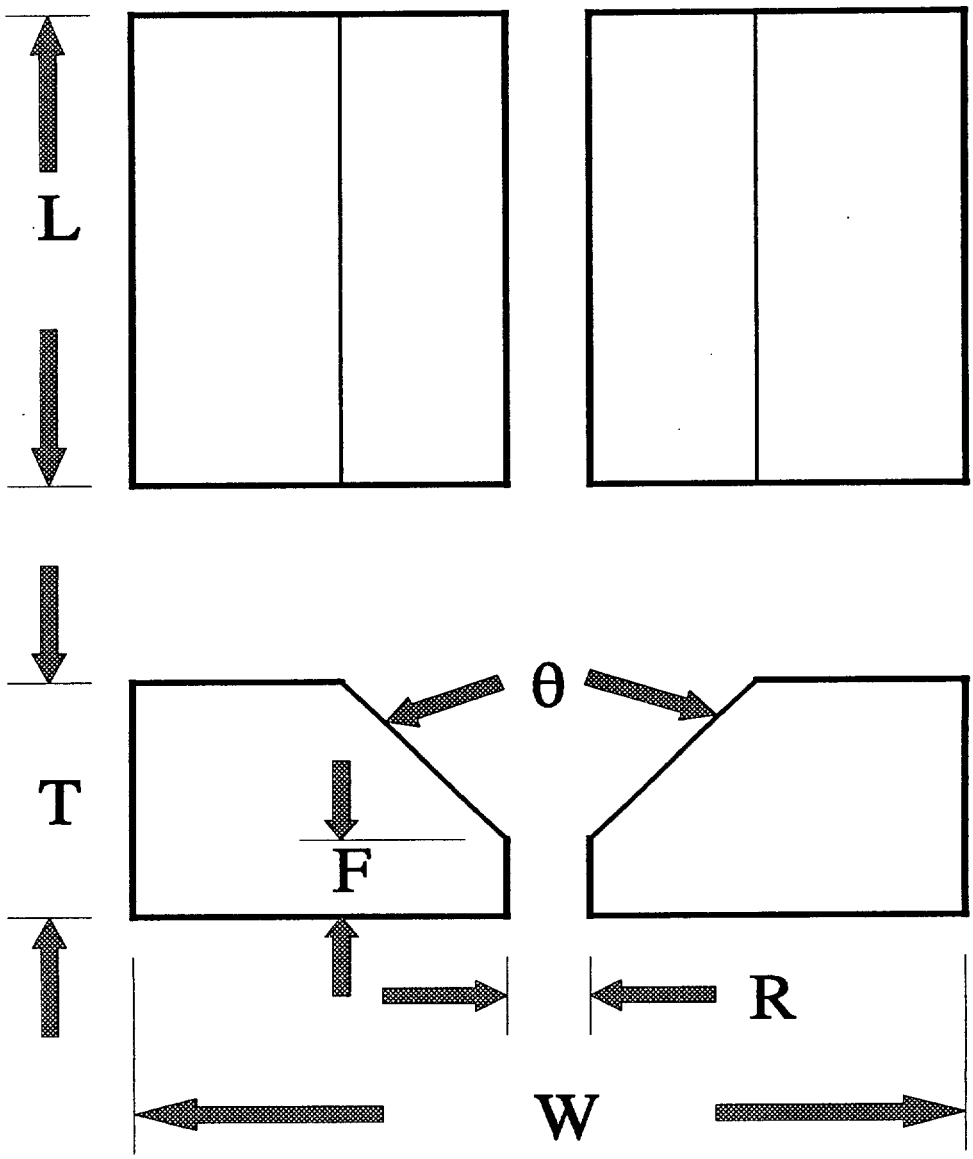
(j) Shielding gas required for GMAW (see note 4 to figure 1, note 3 to figure 2, and note 3 to figure 3).

6.3 Subject term (key word) listing.

Electrodes, welding
Gas metal-arc (GMAW)
Gas tungsten-arc (GTAW)
Rods, welding
Steel, low alloy
Submerged-arc welding (SAW)

6.4 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-N840)



1/ See table XII.

FIGURE 1. Welded test assembly for stress relieved applications. 1/

Table XII. Welded test assembly.

MIL-type	All stress relieved applications (See note 1.)	
Purpose	Qualification	
Welding process	SAW	GMAW
Stress Relief	(See note 2.)	(See note 2.)
Position	Flat	Table VII
Base material	Table X	Table X
Electrode size	1/8	1/16
Welding parameters	(See note 3.)	(See note 3.)
Shielding gas	N.A.	(See note 4.)
Joint configuration	Figure 1	Figure 1
Thickness (T) (inches)	3/4	3/4
Width (W) (inches)	10 minimum	10 minimum
Length (L) (inches)	18 minimum	18 minimum
Root opening (R) (inches)	1/2	1/2
Root face (F) (inches)	0 to 3/16	0 to 3/16
Included angle (θ) (degrees)	45	45
Backing strap dimensions (inches)	1/4 to 3/8 by 1	1/4 to 3/8 by 1
Test specimens (number/type)	2 Tensile 2 Bend 5 Charpy (See note 5.)	2 Tensile 2 Bend 5 Charpy (See note 5.)

Table XII. Welded test assembly. (continued)

MIL-type	All stress relieved applications (See note 1.)	
Purpose	Quality conformance	
Welding process	SAW	GMAW
Stress Relief	(See note 2.)	(See note 2.)
Position	Flat	Table VII
Base material	Table X	Table X
Electrode size	1/8	1/16
Welding parameters	(See note 3.)	(See note 3.)
Shielding gas	N.A.	(See note 4.)
Joint configuration	Figure 1	Figure 1
Thickness (T) (inches)	3/4	3/4
Width (W) (inches)	10 minimum	10 minimum
Length (L) (inches)	12 minimum	12 minimum
Root opening (R) (inches)	1/2	1/2
Root face (F) (inches)	0 to 3/16	0 to 3/16
Included angle (θ) (degrees)	45	45
Backing strap dimensions (inches)	1/4 to 3/8 by 1	1/4 to 3/8 by 1
Test specimens (number/type)	1 Tensile 5 Charpy (See note 5.)	1 Tensile 5 Charpy (See note 5.)

Notes to table XII:

1. These requirements are applicable to MIL-80S-1, MIL-80S-2, MIL-80S-3, MIL-100S and MIL-120S stress relieved applications.

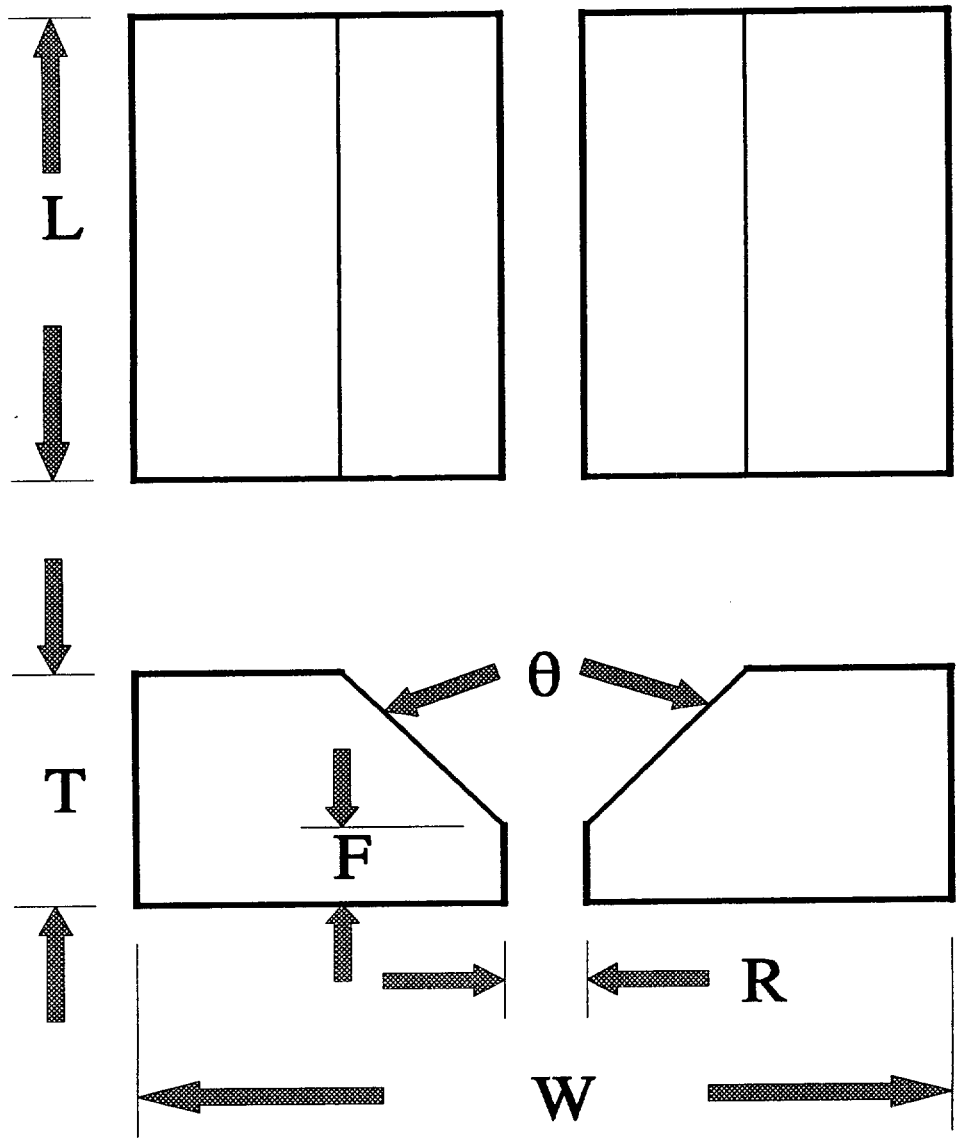
2. Prior to machining specimens or removing backing strip, weldments shall be stress relieved in accordance with 3.4.1.

3. Welding currents and pass sequence shall be in accordance with sound welding practices, and as recommended by the manufacturer. The minimum

preheat and maximum interpass temperatures shall be 250 and 500°F, respectively. Should welding be interrupted, the assembly may be allowed to cool in still air at room temperature, and prior to resumption of welding, the assembly shall be reheated to the minimum preheat temperature.

4. Shielding gas shall be argon for GTAW, and argon plus 2 percent oxygen for GMAW welded electrodes. Argon plus 5 percent CO_2 may also be used for GMAW welded electrodes. For MIL-120S, shielding gas for GMAW shall be either argon plus 2 percent oxygen or argon plus 5 percent CO_2, as specified (see 6.2). The argon, oxygen and carbon dioxide used for this test shall be in accordance with MIL-A-18455, BB-O-925 and BB-C-101, respectively, or equal. The neutral granular flux for the SAW process shall be in accordance with 4.2.1 or 4.2.3 herein which is consistent with MIL-type electrodes being tested.

5. After completion of the weld and stress relief, it shall be allowed to cool, the weld reinforcement and backing strip shall be removed flush with the base plate. The backing strip may be removed by the air carbon arc gouging process. 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.



1/ See table XIII.

FIGURE 2. Welded test assembly for MIL-100S tests and for MIL-120S low cooling rate tests. 1/

Table XIII. Welded test assembly.

MIL-type	100S	
Purpose	Qualification	Quality conformance
Welding process	All	All
Stress relief	(See note 1.)	(See note 1.)
Base material	Table X	Table X
Welding parameters	(See note 2.)	(See note 2.)
Shielding gas	(See note 3.)	(See note 3.)
Cooling rate	High and low	High and low
Joint configuration	Figure 2	Figure 2
Thickness (T) (inches)	1	1
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	24 minimum	24 minimum
Root opening (R) (inches)	1/2	1/2
Root face (F) (inches)	0 to 3/16	0 to 3/16
Included angle (θ) (degrees)	45	45
Backing strap dimensions (inches)	1/2 by 1	1/2 by 1
Test specimens (number/type)	2 Tensile 2 Bend 10 Charpy AND 4 DT (See note 4.)	2 Tensile 2 Bend 10 Charpy OR 4 DT (See note 4.)

Table XIII. Welded test assembly. (continued)

MIL-type	120S	
Purpose	Qualification	Quality conformance
Welding process	All	All
Stress Relief	(See note 1.)	(See note 1.)
Base material	Table X	Table X
Welding parameters	(See note 2.)	(See note 2.)
Shielding gas	(See note 3.)	(See note 3.)
Cooling rate	Low	Low
Joint Configuration	Figure 2	Figure 2
Thickness (T) (inches)	3/4	3/4
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	30 minimum	24 minimum
Root opening (R) (inches)	1/2	1/2
Root face (F) (inches)	0 to 3/16	0 to 3/16
Included angle (θ) (degrees)	45	45
Backing strap dimensions (inches)	1/2 by 1	1/2 by 1
Test specimens (number/type)	2 Tensile 2 Bend 10 Charpy AND 4 DT (See note 4.)	2 Tensile 2 Bend 10 Charpy OR 4 DT (See note 4.)

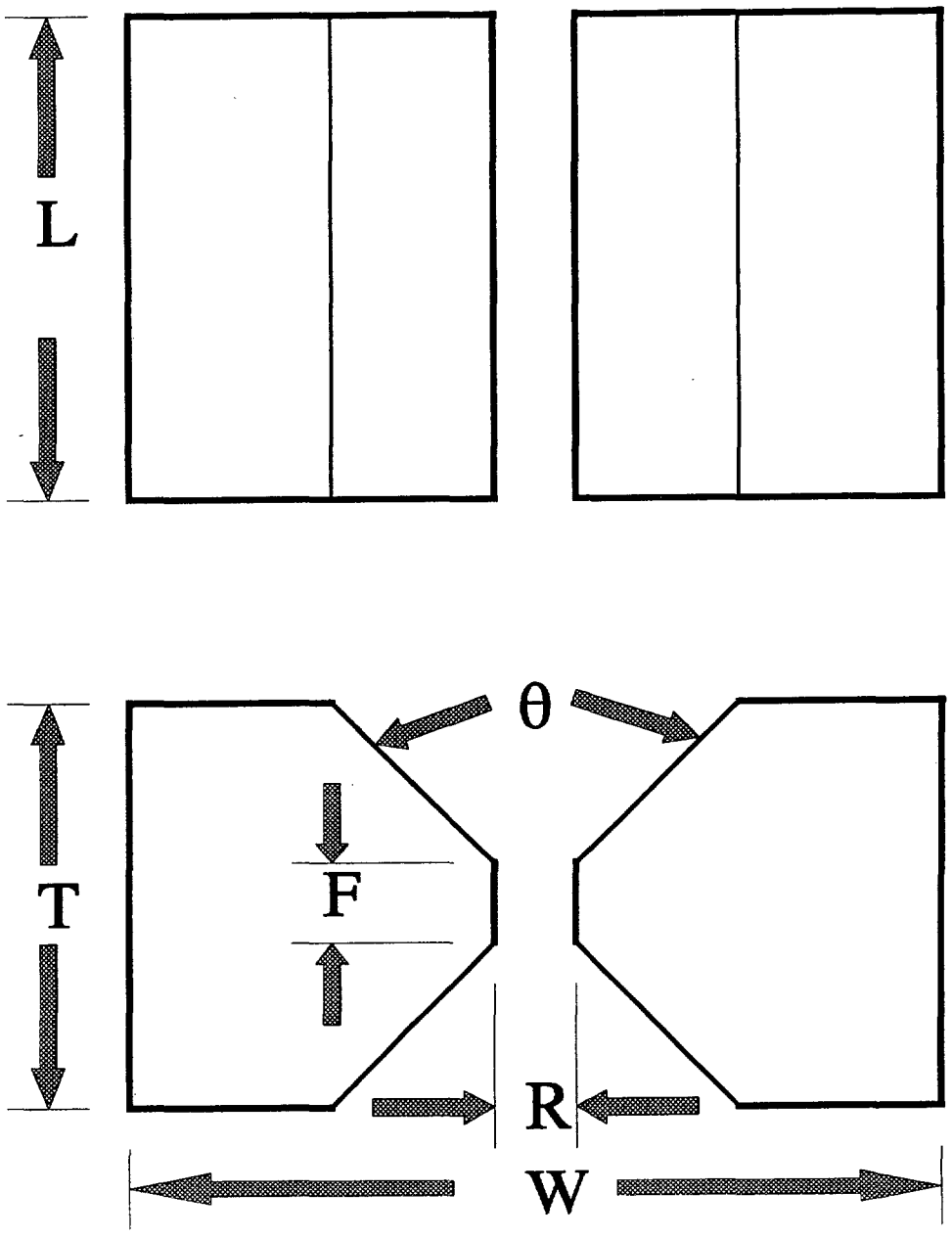
Notes to table XIII:

1. Welded test assemblies shall not be stress relieved. Heat soaking for hydrogen removal is prohibited.

2. The welding-heat input shall be as specified in table VIII. Welding may be continuous except for interpass cooling. Time delay per pass beyond that necessary for interpass cooling shall be reported. The preheat and interpass temperature shall be in accordance with table VIII. When MIL-100S tests are conducted with MIL-S-24645 or ASTM A 710 steel, the preheat for the high cooling rate test shall be 60 to 125°F.

3. Shielding gas shall be argon for GTAW, and argon plus 2 percent oxygen for GMAW welded electrodes. Argon plus 5 percent CO_2 may also be used for GMAW welded electrodes. For MIL-120S, shielding gas for GMAW shall be either argon plus 2 percent oxygen or argon plus 5 percent CO_2, as specified (see 6.2). The argon, oxygen and carbon dioxide used for this test shall be in accordance with MIL-A-18455, BB-O-925 and BB-C-101, respectively, or equal. The neutral granular flux for the SAW process shall be in accordance with 4.2.1 or 4.2.3 herein which is consistent with MIL-type electrodes being tested.

4. 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. The backing strip may be removed by the air carbon arc gouging process. 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.



1/ See table XIV.

FIGURE 3. Welded test assembly for MIL-120S high cooling rate tests. 1/

Table XIV. Welded test assembly.

MIL-type	120S	
Purpose	Qualification	Quality conformance
Welding process	All	All
Stress Relief	(See note 1.)	(See note 1.)
Base material	Table X	Table X
Welding parameters	(See note 2.)	(See note 2.)
Shielding gas	(See note 3.)	(See note 3.)
Cooling rate	High	High
Joint Configuration	Figure 3	Figure 3
Thickness (T) (inches)	2	2
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	30 minimum	24 minimum
Root opening (R) (inches)	0 to 3/16	0 to 3/16
Root face (F) (inches)	0 to 3/16	0 to 3/16
Included angle (θ) (degrees)	45	45
Backing strap dimensions (inches)	N.A.	N.A.
Test specimens (number/type)	From EACH side: 2 Tensile 2 Bend 10 Charpy AND 4 DT	From EACH side: 2 Tensile 2 Bend 10 Charpy OR 4 DT

Notes to table XIV:

1. Welded test assemblies shall not be stress relieved. Heat soaking for hydrogen removal is prohibited.

2. The welding-heat input shall be as specified in table VIII. Welding may be continuous except for interpass cooling. Time delay per pass beyond that necessary for interpass cooling shall be reported. The preheat and interpass temperature shall be in accordance with table VIII.

3. Shielding gas shall be argon for GTAW, and argon plus 2 percent oxygen

for GMAW welded electrodes. Argon plus 5 percent CO_2 may also be used for GMAW welded electrodes. For MIL-120S, shielding gas for GMAW shall be either argon plus 2 percent oxygen or argon plus 5 percent CO_2, as specified (see 6.2). The argon, oxygen and carbon dioxide used for this test shall be in accordance with MIL-A-18455, BB-O-925 and BB-C-101, respectively, or equal. The neutral granular flux for the SAW process shall be in accordance with 4.2.1 or 4.2.3 herein which is consistent with MIL-type electrodes being tested.

4. After completion of the weld, it shall be allowed to cool, the weld reinforcement shall be removed flush with the base plate. 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.

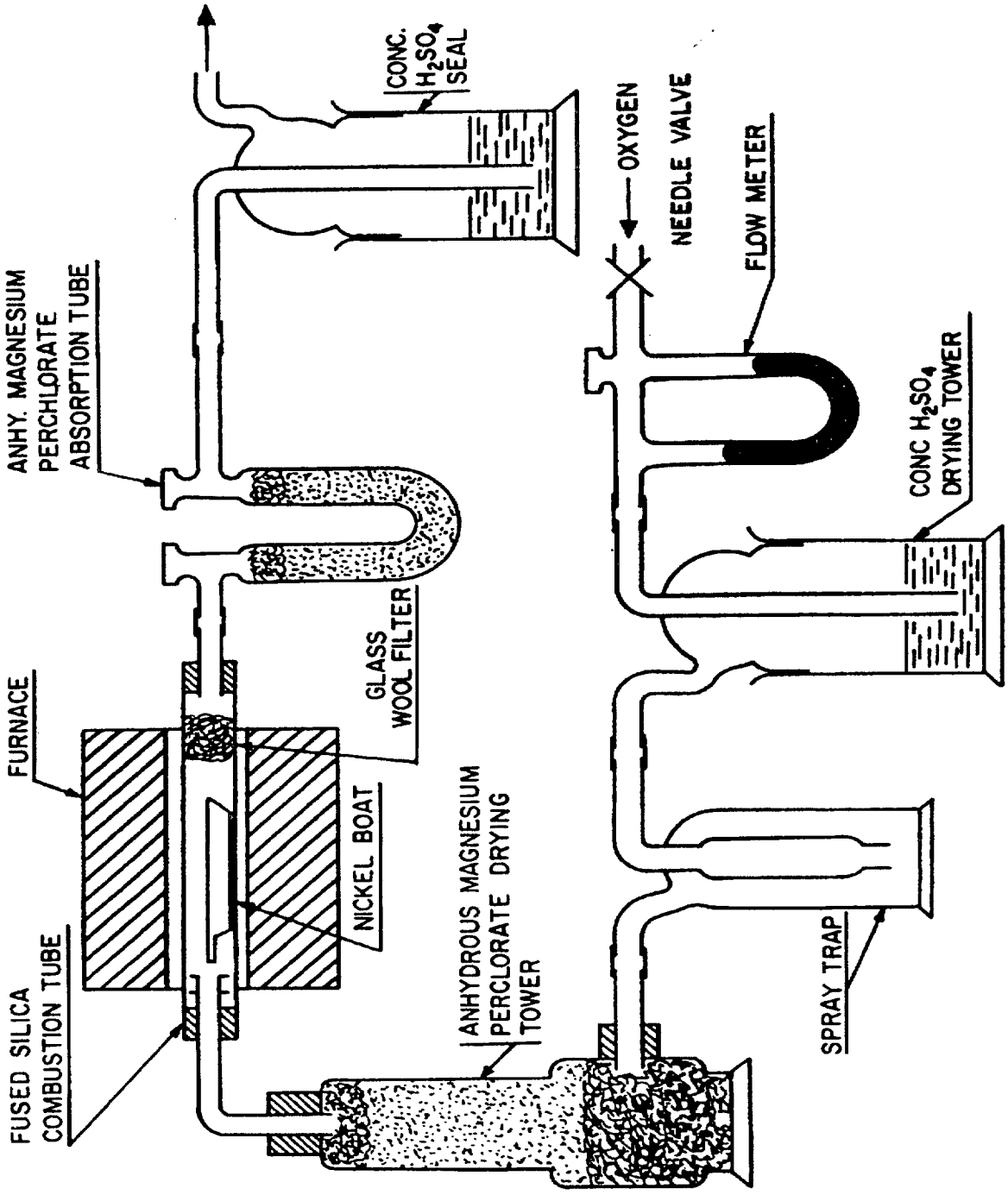


FIGURE 4. Schematic drawing of train for moisture determination.

METHOD OF DETERMINING TOTAL WATER CONTENT OF FLUX

Notes to figure 4:

1. Apparatus.

a. Furnace: Tube furnace capable of furnishing temperatures to 2000°F within the combustion tube is satisfactory. The length of the heating element shall be sufficient to heat 8 - 10 inches of the middle portion of the combustion tube to the required temperature. Furnace shall be equipped with a temperature controller and pyrometer.

b. Oxygen supply: The oxygen supply should be free of organic matter. If organic matter is present, oxygen should be purified by passing it through a small combustion tube lightly packed with asbestos or copper oxide, heated to a temperature of 1100 to 1200°F.

c. Oxygen drying train: This consists of a pressure reducing valve on the oxygen supply, a needle valve and oxygen flow meter to regulate the flow of oxygen, a wash bottle containing concentrated sulfuric acid (96 percent), a spray trap and a drying tower filled with anhydrous magnesium perchlorate.

d. Combustion tube: A fused silica combustion tube, open at both ends, with a devitrification point above 2000°F shall be used. About 6 inches of the tube shall project from either side of the furnace. A plug of fine glass wool is inserted into the outlet end of the combustion tube to filter the gases. It shall be inserted far enough into the tube so that it is heated to 400 to 500°F.

e. Water absorption train: The water driven from the sample is collected in a U-tube absorber (Schwartz) filled with anhydrous magnesium perchlorate. A gas-sealing bottle containing concentrated sulfuric acid (96 percent) is attached to the outlet end of the moisture U-tube absorber.

2. Temperature.

A temperature of 1800 ± 50°F shall be maintained within the combustion tube for the determination.

3. Preparation and handling of sample.

The sample shall be immediately transferred to a dried, stoppered vial or sample bottle. The sample size used in each determination shall be approximately four grams; it shall be weighed directly on the balance dish and transferred to the boat weighing the sample to the nearest 0.001 gram.

4. Handling of combustion boat and absorption tube.

The ignited nickel boat after removal from the combustion tube shall be transferred to a Pyrex desiccator containing anhydrous magnesium perchlorate as a desiccant. The absorption tube shall be handled with lint-free gauze at all times and shall be stored in the balance case during the cooling period so that it assumes the temperature of the atmosphere in which it is to be weighed.

5. Desiccants.

The anhydrous magnesium perchlorate and sulfuric acid shall be removed often enough to ensure the best performance. In the case of the absorption tube this can be estimated roughly since it is known that anhydrous magnesium perchlorate will absorb at least 16 percent of its weight in water without any noticeable loss in drying efficiency.

6. Oxygen flow.

The flow of oxygen to the train shall be maintained at 200 to 250 mL/minute. Once the flow of oxygen is established it shall not be changed throughout the determination.

7. Combustion boats.

A nickel combustion boat which will hold a four-gram sample shall be used. (The ignited sample can be removed after the determination and the boat reused. A small amount of alumina in the heated zone of the combustion tube will prevent nickel boat from fusing with combustion tube).

8. Step by step procedure.

a. Blank determination.

(1) With the furnace operating at a temperature of 1800°F, the oxygen flow shall be adjusted to 200 to 250 mL/minute. The nickel boat shall be placed in the middle of the heated zone of the combustion tube and the absorption U-tube attached to the train. A period of 30 minutes shall be employed to ignite the boat and "condition" the absorption U-tube.

(2) The moisture absorption U-tube shall be removed from the system and placed in the balance case and the nickel boat shall be removed from the combustion tube and placed in the desiccator. The combustion tube of the furnace shall be closed after removing the boat.

(3) After cooling for a period of 20 minutes, the absorption U-tube shall be weighed. The boat shall be removed from the

desiccator and exposed for a period of time approximating the time required to transfer a sample from the balance pan to the boat in an actual determination.

(4) The combustion tube shall be opened, the moisture absorption U-tube placed in the system, the boat placed in the center of the combustion tube and the cover replaced.

(5) After a period of 30 minutes, the absorption U-tube shall be removed from the system and placed in the balance case and the boat shall be removed from the combustion tube and placed in a desiccator.

(6) The moisture absorption U-tube shall be weighed after a period of 20 minutes. The gain in weight is the blank.

(b) Standardization.

(1) Proper operation of the moisture test apparatus shall be demonstrated prior to conducting moisture determinations of flux samples.

(2) Prepare water standards using fused quartz capillary tubes which have been rinsed in alcohol, dried at 200°F and stored in a desiccator. For each water standard, weigh a clean, dry capillary tube to the nearest 0.1 mg. Inject 5 microliters of distilled water into the capillary tube. Weigh the water filled capillary tube to the nearest 0.1 mg. The amount of water in the standard (S1) is determined by difference in these weights.

(3) Analyze the water standard according to the instructions for moisture determination in (2) through (5) below. The amount of water recovered from the standard is weight gain of the absorption U-tube (S2) minus the blank determination (b).

(4) Determine the recovery of water from the standard.

Percent recovery = $100(S2 - B)/S1$

The percent recovery must be between 95 percent and 105 percent to establish proper operation of the moisture test samples.

(c) Moisture determination.

(1) Immediately after weighing the absorption U-tube in item 6 of the blank determination procedure, the sample shall be weighed out on the balance pan.

(2) The boat shall be removed from the desiccator and the sample quickly transferred from the balance pan to the boat.

(3) The combustion tube shall be opened, the moisture absorption U-tube placed in the line, the boat transferred to the center of the combustion tube and the cover replaced.

(4) After a period of 30 minutes, the absorption U-tube shall be removed from the system and placed in the balance case.

(5) The absorption U-tube shall be weighed after the 20-minute cooling period.

(6) If additional samples are to be run, the nickel boat may be removed from the combustion tube at step 4; the ignited sample is removed and the boat placed in the desiccator to cool. Since the same boat can be used for the following determination, it is not necessary to run a blank determination for each sample. Therefore, after item 5 another determination may be started immediately.

9. Calculation.

$$\text{Percent moisture} = \frac{A-B}{\text{Wt. of sample}} \times 100$$

A = gain in weight of absorption U-tube in moisture determination.
B = gain in weight of absorption U-tube in blank determination.

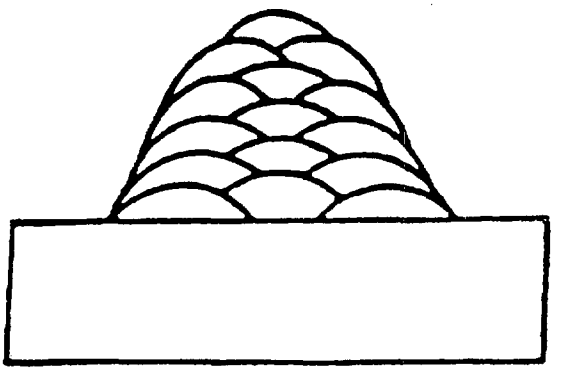


FIGURE 5. Chemical analysis weld pad schematic.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the comment number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of this form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-E-23765/2E	2. DOCUMENT DATE (YYMMDD) 1994 APRIL 22

3. DOCUMENT TITLE
ELECTRODES AND RODS - WELDING, BARE, SOLID, OR ALLOY CORED; AND FLUXES, LOW ALLOY STEEL

4. NATURE OF CHANGE (identity paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) DSN (if applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME Technical Point of Contact (TPOC) JOHN DORN, SEA 03M21 ADDRESS ALL CORRESPONDENCE AS FOLLOWS:	b. TELEPHONE (Include Area Code) (1) Commercial: TPOC: 703-602-0205 DSN: 8-332-0205
c. ADDRESS (Include Zip Code) COMMANDER, NAVAL SEA SYSTEMS COMMAND ATTN: SEA 03R42 2531 JEFFERSON DAVIS HIGHWAY ARLINGTON, VA 22242-5160	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403 Falls Church, VA 22041-3466 Telephone 703-756-2340 DSN 289-2340