T9074-BC-GIB-010/0200

NAVSEA Technical Publication

FILLER MATERIALS FOR CRITICAL APPLICATIONS: REQUIREMENTS FOR FLUX-CORED WELDING ELECTRODES, BARE WELDING ELECTRODES AND FLUXES, AND COVERED WELDING ELECTRODES FOR LOW-ALLOY STEEL APPLICATIONS

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Title: Filler Materials for Critical Applications: Requirements for Flux-Cored Welding Electrodes, Bare Welding Electrodes and Fluxes, and Covered Welding Electrodes for Low-Alloy Steel Applications

Purpose: This document is intended to replace military specifications for welding filler materials for low-alloy steels used for structural applications in combatant surface ships and submarines. It combines in one publication all requirements for manufacturing, testing, and quality assurance of flux-cored electrodes, bare electrodes and fluxes and covered electrodes used for welding HY-80/100/130 steels and HSLA-80/100 steels. It includes updated requirements based on recent experience in surface ship and submarine construction, operation, and maintenance. This document is intended to update and replace MIL-E-24403/2C, MIL-E-23765/2E and MIL-E-22200/10C for the electrode types included in this publication.

TMDER/ACN Numbers Incorporated: N/A

Continue on reverse side or add pages as needed.

CERTIFICATION STATEMENT

This is to certify that responsible NAVSEA activities have reviewed the above-identified document for technical adequacy and suitability for the intended use. This form is for internal NAVSEA management use only, and does not imply contractual approval or acceptance of the technical publication by the Government.

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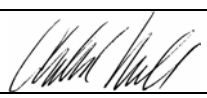
C. L. Null		NAVSEA	05M2	12/11/02

RECORD OF REVISIONS

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SUMMARY OF SOURCE DOCUMENTS INCORPORATED IN
TECHNICAL PUBLICATION T9074-BC-GIB-010/0200

SOURCE DOCUMENT	REV	AMEND	DATE	SUBJECT	APPENDIX IN TECH PUB
MIL-E-24403	2C	--	07/07/89	Flux-Cored Electrodes for Welding Low-Alloy Steel	A
MIL-E-23765	2E	--	04/22/94	Solid or Alloy Cored Bare Electrodes and Rods and Fluxes for Welding Low-Alloy Steel	B
MIL-E-22200	10C	--	06/27/94	Iron powder, Low Hydrogen Covered Electrodes for Welding Medium, High Tensile and Higher Strength Low-Alloy Steel	C

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This specification is approved for use by the Naval Sea Systems Command (NAVSEA), 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 the general requirements, quality assurance provisions, test procedures, and instructions for packaging for bare welding electrodes and fluxes, covered welding electrodes, and flux-cored welding electrodes for low-alloy steel applications.

1.2 Classification. Welding electrodes shall be furnished in the types, classes, and sizes specified in the appendices (see 3.1).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification, and in sections 3 and 4 of the various appendices. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification and the applicable appendix, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

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 05M2, 1333 Isaac Hull Ave SE Stop 5160, Washington Navy Yard, DC 20376 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of the Main Body of this document or by letter.

AMSC N/A FSC 3439

SPECIFICATIONS

FEDERAL

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

MILITARY

MIL-A-18455	-	Argon, Technical.
MIL-S-16216	-	Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100). 1/
MIL-S-24645	-	Steel Plate, Sheet, or Coil, Age-Hardening Alloy, Structural, High Yield Strength (HSLA-80 and HSLA-100). 1/

STANDARDS

MILITARY

MIL-STD-2035	-	Nondestructive Testing Acceptance Criteria.
MIL-STD-2149	-	Explosion Testing Ferrous and Non-Ferrous Metallic Materials and Weldments, Standard Procedure For. 1/

NOTICE: Some of the above MIL- documents are scheduled to be canceled and replaced by other documents. Until the new documents are issued, current references will be retained.
1/ This specification has been revised and consolidated into NAVSEA Technical Publication T9074-BD-GIB-010/0300.

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

NAVSEA Technical Publications

T9074-AS-GIB-010/271	-	Requirements for Nondestructive Testing Methods.
T9074-BD-GIB-010/0300	-	Base Materials for Critical Applications: Requirements for Low-Alloy Steel, Plate, Forgings, Castings Shapes, Bars and Heads of HY-80/100/130 & HSLA-80/100

(Unless otherwise indicated, copies of the above documents, drawings and publications are available from the Naval Inventory Control Point, 700 Robbins Avenue, Building 1, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents, which are DoD adopted, are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A 710	-	Standard Specification for Precipitation-Strengthened Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Structural Steel Plates (DoD Adopted)

D 635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
E 29 - Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959)

AMERICAN WELDING SOCIETY (AWS)

A3.0 - Standard Welding Terms and Definitions. (DoD-adopted)
A4.3 - Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding (DoD-adopted)
A4.4 Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings.
A5.01 - Filler Metal Procurement Guidelines. (DoD-adopted)
A5.5 - Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding. (DoD-adopted.)
A5.23 - Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding. (DoD-adopted)
A5.28 - Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding. (DoD-adopted)
A5.29 - Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding. (DoD-adopted)
B4.0 - Standard Methods for Mechanical Testing of Welds. (DoD-adopted.)

(Application for copies should be addressed to Global Engineering Documents, An Information Handling Services Group Company, at 15 Inverness Way East, Englewood, Colorado 80112-5776. Telephone (800) 854-7179, (303) 397-7956; Fax (303) 397-2740; Internet www.global.ihs.com .)

AMERICAN NATIONAL STANDARDS INSTITUTE

ANSI/NCSL Z540-1 - Calibration Laboratories and Measuring and Test Equipment - General Requirements

(Application for copies should be addressed to American National Standards Institute, 1819 L Street NW, 6th Fl., Washington, DC 20036. Telephone (212)642-4980; Fax (212)398-9287; Internet www.ansi.org)

INTERNATIONAL ENGINEERING CONSORTIUM

IEC 60974 - Arc Welding Equipment

(Application for copies of IEC specifications should also be addressed to American National Standards Institute.)

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION

NEMA EW 1 - Electric Arc Welding Power Sources

(Application for copies should be addressed to National Electrical Manufacturer's Association, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209. Telephone (703)841-3200, Fax (703)841-5900, Internet http://www.nema.org/)

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

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related appendices), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Appendices. The individual item requirements shall be as specified herein and in the applicable appendices. In the event of any conflict between the provisions of this specification and the appendices, the latter shall govern.

3.2 Qualification. Electrodes furnished under this specification shall be products that are approved by the NAVSEA Materials Engineering Division and are identified in the qualified products list for electrode and flux products for this Technical Publication before contract award (see 6.3). Manufacturers shall successfully complete qualification inspection (see 4.3) prior to being included in the list of qualified electrode and flux manufacturers. A qualification inspection report shall be prepared in accordance with the requirements of this specification (see 6.3). Qualification based upon previous specification revisions or amendments are not valid for this specification, unless specifically approved by NAVSEA Materials Engineering Division.

3.3 Materials. All elements of the electrodes covered by this specifications (including base material, fluxes, and/or coatings) shall be produced from materials which ensure the deposited weld metal or the bare wire, as applicable, will conform to the requirements of the applicable appendix. When coatings are used, the composition of the deposited weld metal and procedure for moisture control between baking and packaging shall form a part of the qualification, and any subsequent major change that may modify the design or performance of the product may require requalification or additional tests, and shall be subject to the approval of the NAVSEA Materials Engineering Division. The electrodes shall be asbestos free, and a certificate of compliance shall be submitted to the contracting activity when required (see 6.2). When specified (see 6.2), manufacturers shall demonstrate that plastic spools, if used, do not burn or stop burning when tested in accordance with procedures of ASTM D 635.

3.3.1 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.4 Chemical composition. The bare electrode or the deposited weld metal, as applicable, shall meet the alloy identity requirements for coils in AWS A5.01 and the limits on chemical composition specified in the applicable appendix.

3.5 Mechanical properties. The deposited weld metal shall exhibit the mechanical properties specified in the applicable appendix. Tensile specimens should be kept cool (i.e., shall not be warm to the touch) during machining using appropriate methods and shall not be heated above room temperature at any time prior to testing.

3.6 Diffusible hydrogen. The deposited weld metal shall meet the requirements for limits on diffusible hydrogen specified in the applicable appendix.

3.7 Nondestructive evaluation. The length of test weld that shall meet the nondestructive testing requirements specified herein shall be the length of weld that contains all required chemical and mechanical property test specimens. The minimum lengths of weld that shall be subjected to required nondestructive testing shall be 25 inches for qualification inspection and 17 inches for quality conformance inspection.

3.7.1 Radiography. Radiographs of welds deposited with all types of electrodes or rods shall meet the class 1 acceptance criteria as specified in MIL-STD-2035, except that high cooling rate welds shall meet the class 2 acceptance criteria as specified in MIL-STD-2035. Any linear indication transverse to the weld length in the high cooling rate welds or the low cooling rate submerged arc welds shall be cause for rejection of the weld.

3.7.2 Magnetic particle inspection. Magnetic particle inspection of welds, when required, shall meet the class 1 acceptance criteria for non-linear indications and the acceptance criteria for linear indications specified in MIL-STD-2035.

3.7.3 Ultrasonic and visual inspection of MIL-10718-M welds. Ultrasonic inspection (UT) is required for qualification inspection only of high cooling rate MIL-10718-M welds. Results of UT inspection performed in accordance with the transverse discontinuities (special case) requirements of NAVSEA Technical Publication T9074-AS-GIB-010/271, section 6.6.4.3.5 shall not exhibit suspected transverse cracks. Visual inspection (VT) is required for both qualification and conformance testing of all MIL-10718-M welds. VT inspection results shall conform to Class 2 acceptance criteria as specified in MIL-STD-2035.

3.8 Alloy identity. The alloy identity requirements of AWS A5.01 are considered mandatory.

3.9 Alloy testing. When specified (see 6.2), each spool, coil and container of electrode or rod shall be tested for alloy identity after final marking. Identification of each spool, coil, or container of electrodes tested after final marking and meeting the acceptance criteria shall include the words “Alloy tested”.

3.10 In-Process Excavation. Grinding, burring, machining, or other excavation during welding of a test plate shall be limited to weld starts and stops, correction of operator errors including use of the incorrect heat input and, as necessary, contouring in way of the bead to be subsequently deposited to avoid a welding defect or allow deposition without adjusting the target heat input. Excavation to avoid a defect or allow deposition at the target heat input shall only be performed against a previously deposited bead and not against the base metal. The amount, location, and method of excavation employed shall be recorded by the welder on the test plate work sheet. Under no circumstances shall grinding or other excavation be performed for the purpose of altering the bead position in an attempt to alter weld metal mechanical properties.

3.11 Stability. The stability of the electrodes and of the packaging shall be such that electrodes after receipt from the manufacturer will comply with this specification after storage in original unopened containers under roof and on dry platforms for a warranty period of one year. Warranty periods longer than one year are also acceptable.

3.12 Rounding procedure. For purposes of determining conformance with this specification, an observed or calculated value shall be rounded to the nearest 1000 pounds per square inch for tensile and yield strength and to the “nearest unit” in the last right-hand place of figures used in expressing the limiting value for other values in accordance with the rounding method specified in ASTM E 29.

3.13 Welding machine requirements. For both qualification and conformance testing of electrodes and fluxes in this specification, welding machines used to supply power shall be a variable voltage direct current (dc) motor-generator type, a variable voltage or constant voltage dc rectifier welder, a variable voltage or constant voltage dc inverter, an alternating current (ac) welding transformer, or an ac inverter, all of which must conform to NEMA EW 1 or IEC 60974. Multiple process machines are acceptable provided that they are properly set up. The power source must be appropriate for the process to be tested and shall be of sufficient rating to supply current demanded by the electrode type and size under test. Open circuit voltage shall not exceed 80 volts. For welding using the pulsed gas metal arc process, the exact model power supply shall be recorded. If applicable, the mode or program used for welding shall be recorded.

3.14 Lot identification requirements. For both qualification and quality conformance testing of electrodes and fluxes in this specification, lot identification shall be accomplished by marking each unit and shipping container with a unique manufacturer's control number. If these control numbers are encoded, the manufacturer shall furnish the interpretive key to the consignee. The control number shall be in a position that can be easily located by the purchaser.

3.15 Welding. (Also see 4.12)

3.15.1 Preheat and interpass temperature. Preheat and interpass temperatures shall be controlled within the ranges specified using temperature indicating crayons or other suitable means. Preheat shall be applied evenly along the length of the test assemblies. For SMAW electrodes preheat shall be applied using electric resistance contact strip heaters or other suitable devices (e.g. electric resistance ceramic pad heaters). The preheat and interpass temperatures for each test assembly shall be monitored at a distance of 1- to 1.5-inch from the bevel edge on both plates being joined at a minimum of three locations along the length (at each end and the middle on the side opposite from the heater strips). The heat shall be applied in a way to ensure that it is through thickness with heater strips (for SMAW) on the bottom of each assembly (opposite from the side being welded).

3.15.2 Thermal cycling. Welding should be continuous except for interpass cooling. Any heating devices used for controlling preheat and interpass temperatures shall be removed (or, if the device is part of the fixture, turned off) immediately on completion of the last weld pass. If welding of any test assembly is to be stopped for more than two hours, the test assembly shall be allowed to cool in still air, then re-heated to preheat temperature when required. Time delays per pass beyond that necessary for interpass cooling shall be reported on the certification of quality conformance test record. Under no circumstances shall a plate be heated to a temperature greater than 25F in excess of the maximum interpass temperature specified for that plate. Immediately after the final bead is deposited, the test assembly shall be allowed to cool in still air. No post-weld soaking or other heat treatment is allowed.

3.15.3 Instrumentation. For shielded metal arc or gas tungsten arc welding, voltage shall be measured between the test plate and a point as near as possible to the electrode holder/torch or the electrode holder/torch cable. For submerged arc, gas metal arc, and flux cored arc welding, voltage shall be measured between the wire feeder drive rolls and the work piece. Welding current and arc voltage measurements shall be made using digital or analog meters. Digital meters may be RMS-type devices provided the digital RMS meters are only used for DC and non-pulsed arc welding; RMS meters shall not be used where AC or pulsed arc welding is performed. Tong meters shall not be used. Only calibrated instruments shall be used.

3.15.4 Root passes. If required for ease of welding, the root layers may be deposited with a heat input other than that specified. For single-V joints, this is restricted to a single layer (i.e., one bead in thickness). For double-V joints, an alternate heat input may be used for no more than two layers on each side welded. The root layers for the first side welded of double-V joints may be deposited in the flat position. Otherwise, root layers will be deposited in the same welding position required for the fill passes. Additionally, for gas metal arc or submerged arc tests in 2 inch thick double-V joints, up to two layers of shielded metal arc weld metal (MIL-11018-M or MIL-10718-M for MIL-100S welds or MIL-11018-M or MIL-12018-M for MIL-120S welds) may be used for the root passes. These layers do not require removal prior to second side welding with the gas metal arc or submerged arc processes.

3.15.5 Weld sequencing. Weld beads shall be located within the joint such that the target heat input may be used while maintaining acceptable weld quality. The direction of welding shall be the same for all beads in a weldment, including both sides of a two-sided weldment. In addition, bead placement in a layer shall be from one side wall to the other, with the "start" side wall being the same for all layers in a weldment. The use of a "split bead" or "temper bead" placement technique is not allowed. Minor adjustments to individual bead locations may be made to ensure adequate fusion and weld quality when properly documented, but in no case to intentionally influence weld metal mechanical properties. Each weld pass shall be completed prior to commencing any other weld pass. For double-V joints, each side of the joint shall be independently welded from start to finish. This means that side 1 welding shall be complete before side 2 is started.

3.15.6 Restraint. Welded test assemblies for evaluation of SMAW electrodes shall be thermally insulated or separated from the workbench. To minimize the angular and longitudinal distortion of the completed test weld, test assemblies shall be fully restrained during heating, welding, and cooling by appropriate fixturing or strongbacks unless otherwise specified by the purchaser (see 6.2). Restraining fixtures and strongbacks shall not interfere with the placement of strip heaters or heating pads on the backside of the assembly. Contact points between the fixture and the test plates shall be minimized to minimize the heat sink effect of the fixturing and strongbacks. Base plates on either side of the weld joint shall not be back set (reverse distorted) before welding to compensate for weld shrinkage, as an alternative to the required fixturing (or strongbacks).

3.15.7 Additional welding requirements.

a. All test variables such as amps, volts, bead placement and travel speed shall be recorded and reported.
b. The edge preparation if flame cut shall be ground to remove slag and surface irregularities.
c. The as-welded weld reinforcement shall not be greater than 3/16 inch.
d. Carbon arc or other thermal gouging operations shall not be performed on completed welds. This does not apply to plate preparations for the original joint. Thermal cutting may be performed on completed welds provided cutting is not within 1/2 inch of the weld face.
e. After completion of the weld (and, for MIL-10718-M, completion of VT inspection), the weld reinforcement and backing strap shall be removed flush with the base plate on both surfaces before performing required nondestructive testing. Grinding shall be performed to the extent necessary to provide for nondestructive inspection of welds and to repair defects in accordance with MIL-STD-2035.
f. Weld pick-up (i.e., welding performed prior to formal nondestructive inspection to correct minor visual surface irregularities, such as low areas in the weld reinforcement, weld bead roll and a start-stop area) and minor repair may be accomplished on the weld face (before or after flush grinding) and on the backside after backing bar removal provided that the same electrode being tested is used in conjunction with the same welding conditions, welding position, and other controls used in the original welding of the test assembly.
g. 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 for removal of test specimen coupons.
h. For each test plate, a record of actual weld bead placement, actual root opening and weld bead sequence shall be kept. The total number of weld passes, the actual root opening, and the actual bead placement shall be recorded and reported with a schematic sketch or the use of written format for bead placement, such as 1 full, 2 split, 3 triple and 5 quad layers.

3.16 Instrumentation records. Instrument calibration records shall be traceable to calibration performed in accordance with ANSI/NCSL Z540-1 or equivalent standard.

4. VERIFICATION

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

4.1.1 Product quality requirements. Every test prescribed by this specification, including, but not limited to qualification tests, production lot acceptance tests, and final inspection tests whether

performed by the manufacturer or the Government, is a quality assurance tool intended to ensure a consistent manufacturing process and total compliance with all requirements of this specification.

The Government reserves the right to inspect and perform any test, including through the use of independent laboratory tests, on any part of any product produced to this specification at any time through the end of the useful life of the product (i.e., through the manufacturer's warranty period; see 3.11) to ensure compliance with this requirement.

4.1.2 Responsibility for compliance. All items must meet all requirements of sections 3 and 5 in the base document and in the applicable appendix. The inspection(s) set forth in this specification shall become a part of the manufacturer's overall inspection system or quality program for product(s) supplied to military specifications. Sampling for quality conformance neither authorizes submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.3 Certification of quality conformance. A certificate of quality conformance shall be prepared for each lot of material offered for acceptance, in accordance with the lot definition of the applicable appendix. The certificate shall include all actual data of specified chemical and mechanical tests, including all test results that failed to meet specified requirements, and a record of any stress relief heat-treatment (if applicable). Qualitative results of nondestructive tests and other inspections or tests shall be recorded on the certificate. In addition to the requirements of 4.10, the certificate shall state that each lot has been sampled, tested, and inspected in accordance with the specification requirements to produce an electrode or flux that meets the requirements throughout the product within the tolerances allowed. The certificate shall state that each lot meets all specification requirements and shall be signed by a responsible representative of the manufacturer. Where test certificates issued by the manufacturer contain the above data requirements, a separate certificate of conformance will not be required.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.3).
b. Quality conformance inspection (see 4.4).

4.3 Qualification inspection. Qualification will be authorized only to the manufacturer (see 6.3) of welding electrodes, rods and fluxes. Qualification shall be conducted at a laboratory satisfactory to the NAVSEA Materials Engineering Division. Qualification shall consist of the examinations and tests specified in the applicable appendix (see 3.1).

4.3.1 Samples for qualification inspection. Samples shall be selected at one time in the presence of the Government representative and so indicated. The manufacturer shall indicate on the sample whether the electrodes and packages were produced on a laboratory or experimental scale, or on a production scale.

4.4 Quality conformance inspection.

4.4.1 General. Each lot of welding electrodes, rods and fluxes shall be inspected in accordance with requirements of the applicable appendix. Lots shall be as defined in the applicable appendix.

4.4.2 Sampling for visual examination of bare wire, rods and flux-cored electrodes. Sample rods and electrodes shall be selected either from the production line immediately prior to packaging or from filled unit packages. If selected from the production line, the total sample shall be in accordance with table I and the electrodes or rods shall be selected throughout the run so that all parts of the run are represented. If selection is made after the packaging operation, the total sample shall be in accordance with table I and approximately the same number of electrodes or rods shall be selected from each of the sample unit packages (five cut-lengths (rods) of each package) and sufficient electrode to form one complete circle shall be taken from each sample spool, coil and drum.

Table I. Sampling for visual/dimensional examination (bare wire, rods, and flux-cored electrodes).

Lot size, number of spools, coils or drums of electrodes or boxes of rods in lot	Sample size, number of spools, coils, drums or boxes selected at random for examination	Acceptance number, maximum number spools, coils, drums or boxes containing defective electrodes or rods for acceptance of the lot
2 to 8	2	0
9 to 15	2	0
16 to 25	3	0
26 to 50	3	0
51 to 90	5	0
91 to 150	5	0
151 to 280	8	1
281 to 500	8	1
501 to 1,200	13	2
1,201 to 3,200	13	2
3,201 to 10,000	20	3
10,001 to 35,000	20	3

Any sample coil, spool, drum, box or other container that contains any nonconforming material shall be counted as defective. If in any sample the number of coils, spools, drums or boxes that do not conform to this specification exceeds the acceptance number specified in table I, then this shall be cause for rejection of the lot.

4.4.3 Sampling for Visual Examination of Covered Electrodes. Sample electrodes shall be selected either from filled unit packages or from the production line after the baking operation. If sample electrodes are selected from filled unit packages or cans, the total sample shall be in accordance with Schedule A of table II for electrode sizes 1/8-inch and larger and Schedule B for electrode sizes 3/32-inch and smaller for single sampling, and approximately the same number of electrodes shall be selected from each of the unit packages or groups of cans (6 cans per group). Lot size shall be expressed in pounds. Sample size shall be the number of electrodes to be examined. A minimum number of unit packages shall be selected to permit sampling of ten electrodes maximum from each 50-pound package or from each 10-pound package. If the sample electrodes are selected from the production line, the total sample shall be equivalent to the above and the electrodes shall be selected through the production period so that all parts of the lot are represented. The electrodes selected shall be identified as to type, wet batch, lot, size, and other available information such as contract or order number being filled. When a lot is found to be acceptable, any electrodes in the lot found to be defective shall be replaced with non-defective electrodes prior to shipment. In no case shall known defective material be shipped.

Table II. Sampling for visual/dimensional examination (covered electrodes).

Lot Size (pounds of electrodes)	Sample Size (number of electrodes to be examined)		Acceptance number, maximum number of defective electrodes for acceptance of the lot	
	Schedule A	Schedule B	Schedule A	Schedule B
2 to 8	2	2	0	0
9 to 15	2	2	0	0
16 to 25	3	3	0	0
26 to 50	5	5	0	0
51 to 90	5	5	0	0
91 to 150	8	8	0	1
151 to 280	13	13	1	2
281 to 500	13	13	1	2
501 to 1,200	20	20	2	3
1,201 to 3,200	32	32	3	5
3,201 to 10,000	32	32	3	5
10,001 to 35,000	50	50	5	7

4.5 Nondestructive testing.

4.5.1 Radiography. Radiography shall be performed in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271, using the standard 2-2T quality level.

4.5.2 Magnetic particle inspection. Magnetic particle inspection shall be performed in accordance with NAVSEA Technical Publication T9074-AS-GIB-010/271.

4.5.3 Ultrasonic and visual inspection of MIL-10718-M welds. Ultrasonic inspection (UT) of high cooling rate MIL-10718-M qualification inspection welds shall be performed in accordance with the transverse discontinuities (special case) requirements of NAVSEA Technical Publication T9074-AS-GIB-010/271. Visual inspection (VT) of both qualification and conformance inspection of MIL-10718-M welds shall be performed in accordance with the requirements of NAVSEA Technical Publication T9074-AS-GIB-010/271.

4.6 Alloy identity. Alloy identity tests shall be conducted using any of the methods specified in AWS A5.01. In the event a specific test method is required, it shall be so specified (see 6.2).

4.7 Retests. When any original required conformance test (chemical, mechanical property, nondestructive inspection, visual/dimensional, etc.) representing a lot of material fails to meet specification requirements, the lot may be retested at the manufacturer's discretion. If the manufacturer chooses to retest the lot, the retests shall be as follows:

a. If the test failed due to one (or more) of the conditions listed in 4.7,1, then the lot shall be retested according to the requirements in 4.7.2.
b. If the test failed due to conditions other than those listed in 4.7.1, then the lot shall be retested according to the requirements in 4.7.3.

Note that all the specimens in a single test, whether the test involves a single specimen (such as for RT) or multiple specimens (such as for CVN impact tests), shall be considered a "set."

4.7.1 Testing/specimen preparation error retests. Retests to correct errors in testing and/or test specimen preparation are permitted under the following conditions:

a. Improperly fabricated test welds. This applies to test welds that have not been fabricated in accordance with the applicable specification or the published welding operating ranges for the product under test.
b. Improperly prepared specimens. This applies to test specimens that are not in compliance with applicable standards.
c. Test equipment malfunction in the process of conducting a test.
d. Flaws in test specimens that are not indicative of inferior or defective product. Flaws at weld starts and stops at the ends of the test assembly, lack of fusion and slag due to operator technique are normal weld artifacts and do not count as flaws indicative of inferior or defective products. Cracks, clustered porosity, flakes, and ruptures are flaws that may be indicative of inferior or defective products and shall not qualify a lot for a testing/specimen preparation error retest.

4.7.2 Testing/specimen preparation error retest requirements. Retests for conditions listed in 4.7.1 shall be as follows:

a. For each original test that failed due to one (or more) of the conditions in 4.7.1, only one testing/preparation error retest is permitted.
b. A testing/preparation error retest shall consist of one replacement specimen for each specimen that failed due to the conditions in 4.7.1. Note for VT, MT and RT, the specimen is the entire weld. If the testing error is due to a malfunction of MT and/or RT equipment or to a flaw not indicative of inferior or defective products (see 4.7.1.d) removed by grinding or other suitable methods within 1/16 inch of the top surface, the original test assembly may be retested.
c. Results of all retests and reasons for all retests shall be reported on the certification of quality conformance.
d. Retests of weld metal (e.g., mechanical properties) shall be from the same weld used for the original test, if feasible. If replacement test welds are needed, they shall be fabricated using consumables from the original sampling, if feasible. If sufficient material is not available from the original sampling or storage of an opened package is expected to influence results, another sample may be taken from the same lot and/or production run.
e. Retests of product (e.g., diffusible hydrogen, moisture, and chem. pads) shall be from the same sampling as the original test, if feasible. If sufficient material is not available from the original sampling or storage of an opened package is expected to influence results, another sample may be taken from the same lot and/or production run.
f. If the results of the testing/preparation error retest do not satisfy the applicable requirements, then a conformance retest shall be performed per 4.7.3.

4.7.3 Conformance retest requirements. Retests for failure to meet test requirements shall be as follows:

a. For each original test that failed due to conditions other than those listed in 4.7.1, only one conformance retest is permitted.
b. A conformance retest shall consist of repeating the test that failed two times (i.e., two-for-one). Note that a mechanical property test such as tensile or impact toughness involves a set of test specimens and therefore two full sets of specimens for each test that failed are required under this two-for-one rule.
c. Results of all retests and reasons for all retests shall be reported on the certification of quality conformance.
d. Retests of weld metal shall be from the same weld used for the original test, if feasible. If replacement test welds are needed, they shall be fabricated using consumables from the original sampling, if feasible. If sufficient material is not available from the original sampling or storage of an opened package is expected to influence results, another sample may be taken from the same lot and/or production run.
e. Retests of product shall be from the same sampling as the original test, if feasible. If sufficient material is not available from the original sampling or storage of an opened package is expected to influence results, another sample may be taken from the same lot and/or production run.

f. Unless the welding procedure was determined to be the root cause of the original test failure, any replacement test weld shall employ the same welding procedure as the original test weld. If a new procedure is used to correct the root cause of the original test failure, the retest shall include all tests conducted for the original weld. Two-for-one is only required for the test that failed. All future lots of the material must use the new procedure. The reason for changing procedure shall be justified to the purchaser and included on the certification.

g. If the results of any conformance retest do not satisfy the applicable requirements, then the lot shall be rejected.

4.7.4 Check Mechanical Testing Tolerances. Repeating the mechanical property conformance tests as part of receipt inspection by the purchaser may employ the following check mechanical testing tolerances to determine acceptability of the product to the requirements in the applicable appendix. The use of these values by the purchaser is at the purchaser's option and, if any or all of these tolerances are to be used, their use shall be indicated in section 6.2.

4.7.4.1 Mechanical Property Tolerances. Mechanical property tolerances shall be as follows:

a. Yield strength test results may be higher or lower than the specified requirement by 3% (rounded off to nearest 1000 psi).
b. Ultimate tensile strength (when required) test results may be lower than the specified requirement by 3% (rounded off to nearest 1000 psi).
c. Elongation test results shall not be lower than 93% of the minimum requirement.
d. Charpy V-notch or Dynamic Tear test results may be lower than the minimum requirements by 10%. This applies to both minimum individual values and to minimum average values.

Note product-specific check tolerance requirements in appendices (see Mechanical Property table footnotes in appropriate appendix).

4.7.5 Chemical Composition Tolerance. Repeating chemical composition conformance tests as part of receipt inspection by the purchaser may employ the following check chemical composition tolerances to determine the acceptability of MIL-100S-1, MIL-100S-2 and MIL-101TM electrodes to the requirements in the applicable appendix. The use of these values by the purchaser is at the purchaser's option and, if any or all of these tolerances are to be used, their use shall be indicated in section 6.2.

100S-1 / 100S-2 / 101TM

ELEMENT	TOLERANCE 1/
Manganese	0.07
Silicon	0.03
Phosphorus	0.003
Sulfur	0.003
Nickel	0.06
Molybdenum	0.03
Chromium	0.03
Vanadium	0.02
Aluminum	0.003
Titanium	0.02
Zirconium	0.003

1/ Weight percent Applies to values higher than maximum and lower than minimum requirement , as applicable

4.8 Chemical analysis.

4.8.1 Chemical range limits. The chemical compositions specified in the appendices are minimum and maximum limits. However, these specifications do 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 be verified not to alter the design criteria and be supported by test data. This information shall be reported to NAVSEA Materials Engineering Division, who will determine if requalification is required in cases where the changes are found to adversely affect design criteria or performance.

At the time of qualification, or for products qualified to previous revisions of this specification (i.e., MIL-E-24403/2, MIL-E-23765/2 and MIL-E-22200/10), the aim values and maximum and minimum limits for each major alloying element (C, Si, Mn, Cr, Cu, Ni, Mo, V) and boron and related maximum and minimum carbon equivalent values shall be established or developed when data is available for acceptance of this product. These values (maximum and minimum limits for each major alloying element and boron, and the maximum and minimum carbon equivalent values) shall be reported to the NAVSEA Materials Engineering Division when available. The values for both major alloying elements and carbon equivalent limits shall represent statistically determined variations due to manufacturing tolerances. The carbon equivalent shall be determined using the formula specified in 4.8.3. 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 Uniformity of composition plan. The manufacturer must have a NAVSEA Materials Engineering Division 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 and shall for solid wire include testing of each individual coil of rod stock received from the mill or supplier. The test plan must exhibit 95 percent confidence level, based on statistical analysis of actual test data that not less than 95 percent of the unwelded electrode and rods for gas metal arc and gas tungsten arc welding and the deposited weld metal for all other electrode forms and processes from each lot will be within the chemistry range specified for each element in accordance with the chemistry limits of the formulation. In the case of a new product or a product where sufficient data has not been developed, the 95/95 tolerance limits shall be provided as soon as possible after data is developed. 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.

4.8.3 Carbon equivalent control. The manufacturer shall verify the chemical uniformity of each lot using the plan in paragraph 4.8.2, when developed, and shall verify that the high and low carbon equivalent (C.E.) limits established in 4.8.1 are met, based on actual chemical analyses 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

When specified, the maximum C.E. shall not exceed limits in the appendix for the specific product.

4.9 Diffusible hydrogen control plan. The manufacturer shall have a NAVSEA Materials Engineering Division approved test plan to verify uniformity of diffusible hydrogen in each lot. The diffusible hydrogen tests shall be conducted according with applicable appendix. The 95/95 confidence limit shall be determined using the average values from the diffusible hydrogen tests performed in accordance with AWS A4.3. The test plan shall exhibit a 95 percent confidence level, based on statistical analysis of actual test data (i.e., average values), that not less than 95 percent of the electrodes from each lot will meet the diffusible hydrogen limits of the applicable appendices. Any lot that is rejected because of high hydrogen content may be reprocessed or may be retested as specified in 4.7. If the supplier chooses reprocessing, the rejected lot shall not be reprocessed more than two times. Failure to meet the requirements for diffusible hydrogen after the second reprocessing shall cause final permanent rejection of the lot. In addition to diffusible hydrogen, all other tests (i.e., chemical and mechanical property) shall be performed using electrodes sampled after the last reprocessing operation.

4.10 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 4.10.1. The cause for any retest shall be reported for information and the results of all tests, including failures, shall be reported. For submerged arc welding (SAW) electrodes, the certification shall report the brand name of the flux used in conformance testing.

4.10.1 Quality conformance test data. The minimum quality conformance test data shall include results of all tests required by this specification. Operational parameters for any welded test assemblies shall also be reported. The manufacturer, purchaser, 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.

4.11 Mix-up. If, subsequent to shipment, a heat or lot is found to contain material of a type or class different from that specified, the contractor shall notify all purchasers who procured to the requirements herein and in the applicable appendix, and received material from that heat or lot, of the condition. The contractor shall be responsible for re-inspection to ensure that any unused material from the same heat or lot is correct.

4.12 Welding heat input. Heat input (kJ/in) shall be calculated using the following formula:

$$\text{Heat Input (kJ/in)} = \frac{\text{Volts x Amperes x 0.06}}{\text{Travel Speed (inches per minute)}}$$

The root pass(es) shall be excluded from all heat input calculations. Specified heat inputs reflect minimum acceptable ranges and qualification or quality conformance testing at values beyond the specified range shall be accepted.

4.12.1 Operational heat input calculation. Operational heat input shall be the actual heat input recorded or calculated for individual passes during welding of the test assemblies. For shielded metal arc welding, calculate the operational heat input of each pass in the test assembly using the following procedure:

a. To determine the travel speed for each complete weld pass, divide the total length of the complete weld pass by the total arc time for the pass. Total length of the complete weld pass and total arc time for the pass shall be calculated as in b. and c., below, respectively.

b. To determine the total length of the complete weld pass, measure each weld bead individually and add the bead lengths. Measure each bead from the apparent trailing edge of the bead to the apparent trailing edge of the stop crater. Do not use the length of the test assembly as the pass length.

c. To determine the total arc time of the complete weld pass, measure the arc time for each weld bead in the pass and add the individual bead arc times together. An electronic arc timer or equivalent automated system that measures the total arc time for the pass may also be used.

d. Measure the arc voltage and welding amperage for each weld bead in the pass. Average the voltage and amperage to derive the average voltage and amperage values for the weld pass.

e. Insert the average travel speed, arc voltage and amperage for each complete pass into the heat input equation of 4.12 to calculate the heat input for the weld pass.

4.12.2. Average heat input. The average heat input shall be the average of the operational heat input of all passes in the test assembly and shall fall within the range (and tolerances) specified in the applicable appendix.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2 and 6.5) and the applicable appendices.

6. NOTES

6.1 Intended use. This specification is intended to provide the general requirements for acquisition of low-alloy steel welding electrodes, rods and fluxes.

6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number, and date of this specification.
(b) Title, number, and date of the applicable appendix.
(c) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).
(d) Whether a certificate of compliance indicating electrodes are asbestos free (see 3.3).
(e) Whether plastic spools must not burn or must stop burning in accordance with procedures of ASTM D 635 (see 3.3).
(f) Whether alloy testing after marking is required (see 3.9).
(g) If alternate restraint methods other than fixturing and strongbacks are acceptable to minimize angular distortion of test welds (see 3.15.6).
(h) Specific alloy identity test requirements, if required (see 4.6).
(i) If any or all of the check mechanical property and chemical composition tolerances are to be used on receipt inspection by the purchaser (see 4.7.4 and 4.7.5).
(j) Level of preservation and packing required and special packaging requirements other than those specified in the applicable appendix (see 5.1).

6.2.1 Ordering unit. Electrodes should be ordered by the pound.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products, which are, at the time of award of contract, qualified for inclusion in the qualified products list for the electrodes and fluxes covered by this Technical Publication, whether or not such products have actually been so listed by that date. The qualified products list is maintained by and is available from the NAVSEA Materials Engineering Division. It should be noted that qualification based upon previous specification revisions or amendments are not valid for this specification, unless specifically approved by NAVSEA Materials Engineering Division. The attention of the contractors is called to these requirements,

and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the Naval Sea Systems Command, SEA 05M2, 1333 Isaac Hull Ave SE Stop 5160, Washington Navy Yard, DC 20376. Application for qualification tests must be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).

6.3.1 Qualification application. Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 9801 Tabor Avenue, Philadelphia, PA 19120.

6.4 Definitions. For the purpose of this specification, the welding terms and definitions contained in AWS A3.0 shall apply. Additional definitions are as follows:

6.4.1 Contractor. The contractor is the seller under the contract or purchase order, which incorporates this specification.

6.4.2 Manufacturer. The manufacturer is the actual processor of the welding electrode, rod, or flux engaged in the final cleaning, spooling, cutting to length, affixing rod identification, marking and packaging operations.

6.4.3 Command or Agency concerned. The Command or Agency concerned is the Government or prime contractor or authorized representative who has design or acquisition responsibility acting under contract to the Government.

6.4.4 Purchaser. The purchaser is the activity that placed the contract or purchase order with the contractor.

6.5 Packaging.

6.5.1 Standard packaging. Standard packaging in the appendices is described as the standard AWS packaging for the particular type electrode.

6.5.2 Loose-fill packaging. The use of all types of loose-fill materials for packaging and packing applications such as cushioning, filler, or dunnage is prohibited for materials destined for shipboard installation or storage. If cushioning is required, specify the use of cellulosic material, bound fiber, fiberboard, or transparent flexible cellular material.

6.6 Inspection after delivery. Post-delivery inspection of electrodes to determine conformance to this specification and the applicable appendix, and for acceptance thereof, is the responsibility of the Command or Agency concerned. Post-delivery inspection testing of electrodes intended for critical applications, such as submarine structures, shall be in accordance with the applicable fabrication document.

6.7 Subject term (key word) listing.

Core wire
Shielded metal arc welding
Gas tungsten arc welding
Gas metal arc welding
Flux-cored arc welding
Submerged arc welding
Welding flux
Welding electrode
Chemical composition
Mechanical properties
Nondestructive testing
Diffusible hydrogen

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 of 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 T9074-BC-GIB-010/0200	2. DOCUMENT DATE (YYMMDD)

3. DOCUMENT TITLE

FILLER MATERIALS FOR CRITICAL APPLICATIONS: REQUIREMENTS FOR FLUX-CORED WELDING ELECTRODES, BARE WELDING ELECTRODES AND FLUXES, AND COVERED WELDING ELECTRODES FOR LOW-ALLOY STEEL APPLICATIONS

4. NATURE OF CHANGE (Identify 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) Charles Null, NAVSEA 05M2 ADDRESS ALL CORRESPONDENCE AS FOLLOWS:	B. TELEPHONE (Include Area Code) (1) Commercial TPOC: (202)781-3669
C. ADDRESS (Including Zip Code) COMMANDER, NAVAL SEA SYSTEMS COMMAND ATTN: SEA 05M2 1333 ISAAC HULL AVE SE, STOP 5160 WASHINGTON NAVY YARD, DC 20376	IF YOU DO NOT RECEIVE A REPLY WITH 45 DAYS, CONTACT: Commander, NAVAL SEA SYSTEMS COMMAND ATTN: SEA 05M 1333 ISAAC HULL AVE SE, STOP 5132 WASHINGTON NAVY YARD, DC 20376 TELEPHONE (202) 781-3666

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APPENDIX A

ELECTRODES - WELDING, FLUX-CORED, LOW-ALLOY STEEL

A.1. SCOPE

A.1.1 Scope. This appendix covers the requirements for low-alloy steel flux cored welding electrodes designed for use with the flux cored arc welding process with or without gas shielding, specifically for the fabrication of HSLA-80, HSLA-100, HY-80 and HY-100 steel weldments for as-welded applications. This appendix is based on AWS A5.29, although it contains numerous additional requirements. This appendix is a mandatory part of the specification.

A.1.2 Classification. Electrodes shall be of the types specified (see A.3.1.1) and shall be of the forms and sizes in accordance with AWS A5.29.

A.2. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

A.3. REQUIREMENTS

A.3.1 General requirements. Electrodes provided under this specification shall be in accordance with AWS A5.29, and as specified herein.

A.3.1.1 Chemical composition. The types and chemical composition of the deposited weld metal shall be in accordance with the approved formulation, which is bracketed by the maximum and minimum values in table I. The carbon equivalent calculated as indicated in paragraph 4.8.3 shall not exceed 0.20.

A.3.1.2 Mechanical properties. The mechanical properties of deposited weld metal shall be as specified in table II.

A.3.1.3 Hydrogen content. The diffusible hydrogen levels in milliliters (mL) per 100 grams of deposited weld metal shall not exceed 4.0 mL per 100 grams maximum average value nor 4.8 mL per 100 grams maximum single value. Electrodes with an LH suffix added to the designation shall not exceed 2.6 mL per 100 grams maximum average value nor 3.2mL per 100 grams maximum single value. A diffusible hydrogen control plan in accordance with 4.9 of the Main Body is required.

A.3.1.4 Hydrogen content after moisture exposure. At qualification the manufacturer shall provide data to benchmark the hydrogen content after moisture exposure of the product being qualified. Diffusible hydrogen measurements in accordance with AWS A4.3 shall be made on electrode from the same spool using electrode from the outer layer or layers of the spool, both before and after exposure in a suitably controlled environmental chamber for 9 hours minimum at 80F, minus 0, plus 5F and 80% relative humidity, minus 0, plus 5%. Results of these tests shall be provided to NAVSEA Materials Engineering Division as part of the qualification report. These benchmark test results shall be used to assess changes to manufacturing procedures that may affect hydrogen content after moisture exposure. The results of these tests shall be made available upon request to all purchasers of this product referencing this document.

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

MIL-type 1/	Chemical composition (wt. percent) 2/ 3/									
	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Nickel	Chromium	Molybdenum	Vanadium	Copper
MIL-101TC MIL-101TM	0.07	0.50 to 1.50	0.60	0.015	0.015	1.30 to 3.75	0.20	0.50	0.05	0.06

1/ MIL-XXXTY The first two numbers in the MIL-type designation classify tensile strength in ksi ÷ 10 (i.e., 10 = 100 ksi, 12 = 120 ksi).
MIL-XXXTY The third number indicates what positions the electrodes should be used in.
0 is for electrodes used in the flat and horizontal welding position and tested in the flat position.
1 is for electrodes designed primarily for all welding positions. Sizes 5/64" and smaller electrodes are used in all positions and are tested in the vertical position (3G) position (including explosion crack starter tests; see MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300). Sizes greater than 5/64 " are used primarily for flat position welding and for horizontal fillet welds and are tested in the flat position (including explosion crack starter tests; see MIL STD 2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300)
MIL-XXXTY The first letter (T) indicates that these are flux-cored electrodes.
MIL-XXXTY The last letter describes the shielding gas (C for carbon dioxide, M for 75% argon, 25% carbon dioxide shielding mixture). Carbon dioxide shall be in accordance with Grade B of BB-C-101 and argon shall be in accordance with MIL-A-18455.
For example, MIL-101TC is a 100,000psi tensile strength (10) electrode that can be welded in all positions (1) with a flux core (T) and carbon dioxide shielding gas (C). MIL-101TM is the same, except that it is to be used with 75% argon, 25% carbon dioxide shielding gas mixture (M).

2/ Single values are maximum percentages.

3/ Boron shall be analyzed to the parts per million (ppm) level and reported for information and for use in calculating the carbon equivalent.

Table II. As-welded mechanical properties. 1/

MIL-type	101TC 101TM
Yield strength (1000 pounds per square inch) (ksi) 2/	82 to 110
Elongation in 2 inches min. (percent)	18
Transverse side bend	3/
Charpy V-notch. Energy ft-lb minimum average @ Temperature (degrees Fahrenheit) (F) 4/	35@(-60F) 60@(0F)
Dynamic tear. Energy ft-lb minimum average @ Temperature (degrees Fahrenheit) (F)	300@(-20F) 5/ 450 @(+30F) 6/
Explosion crack starter test	7/

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 yield. When specified by the purchaser (see A.6.2), an 88ksi minimum yield strength shall be required, e.g., for joining HY-100 or HSLA-100.

3/ The bend radius shall be 2t and 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 1/8 inch.

4/ For each testing temperature, the average value shall be determined based on five tests. Only one test specimen may have a value below the minimum average specified; such a test specimen may have a value no more than 10 foot-pounds below the minimum average specified.

5/ The average value shall be determined based on two tests. One test specimen may have a value no more than 50 ft-lbs below the minimum average specified.

6/ The average value shall be determined based on two tests. One test specimen may have a value no more than 25 ft-lbs below the minimum average specified.

7/ Acceptance criteria shall be in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.

A.3.1.5 Visual/dimensional inspections. Sampling for visual and dimensional inspection shall be as specified in Main Body 4.4.2. Electrode size and tolerances, electrode finish and uniformity, electrode winding and electrode identification shall be in accordance with AWS A 5.29.

A.3.1.6 Magnetic particle and radiographic inspection. Welds shall be inspected in accordance with requirements in Main Body 3.7, 3.7.1 and 3.7.2.

A.4. VERIFICATION

A.4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see A.4.2).
b. Quality conformance inspection (see A.4.3).

A.4.2 Qualification inspection. Electrodes selected for qualification 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 testing will be conducted at a Government test facility (see 6.3 of Main Body). The manufacturer or contractor will be responsible for funding schedule B testing unless other funding provisions are arranged with the Government or prime contractor.

Table III. Summary of weld metal tests required for qualification. 1/

Test	Schedule		Test procedures	Requirements
	A	B 2/, 6/		
Chemical analysis	X	---	AWS A5.29 and Main Body 4.8	Table I herein
Alloy identity	X	---	AWS A5.01	Main Body 3.8
Diffusible hydrogen 5/	X	---	AWS A4.3	A.3.1.3 and A.3.1.4 herein
Welded test assembly	X	X	AWS A5.29 and A.4.4.1 herein	AWS A5.29
Nondestructive testing	X	X	Main Body 4.5.1 and 4.5.2	Main Body 3.7.1 and 3.7.2
Visual and Dimensional Examination	X	X	Main Body 4.4.2	A.3.1.5
Tension	X	X	AWS B4.0	Table II herein
Transverse side bend	X	X	AWS B4.0	Table II herein
Charpy V-notch 3/	X	X	AWS B4.0	Table II herein
Dynamic tear 3/	X	X	AWS B4.0	Table II herein
Explosion test series 4/	---	X	A.4.4.2 herein	Table II herein

1/ 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/ When a single electrode formulation is being qualification tested for use with both shielding gases (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 average impact test results.
3/ Both the Charpy V-notch and the dynamic tear tests shall be conducted to determine conformance to the impact requirements of table II.
4/ If the results of the mechanical tests of MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300 indicate that the weld metal properties on an electrode from the same welding position are equivalent to those of a larger size electrode of the same classification and formulation previously qualified, the crack starter test may be eliminated.
5/ Samples of MIL-101TM and MIL-101TC electrodes shall be evaluated for diffusible hydrogen measurements by welding in the flat position and the following welding parameters.

0.045” dia. electrode:
Amperage = 220 – 230
Electrode stick out = 5/8” (plus or minus 1/16")

0.062” dia. electrode:
Amperage = 255 – 265
Electrode stick out = 5/8” (plus or minus 1/16")

Voltage shall be as specified by the manufacturer. Similar parameters, appropriately adjusted by the manufacturer, shall be used with other sizes.
6/ Feedability will be evaluated based on standard shipyard practices during schedule B testing.

A.4.2.1 Special instructions. When applying for qualification test authorization, or after tests have been conducted and reports submitted, the manufacturer shall furnish the information specified in A.4.2.1.1 or A.4.2.1.2. (Note: This information, together with qualification test results will be held in confidence by the Government as proprietary information.)

A.4.2.1.1 Single heat lot. For lots conforming to AWS A5.01 classification T3, the manufacturer shall furnish the following information:

a. Type and size range (each size manufactured shall be specified) for which qualification is desired (see A.4.2.2).

b. Composition of tube, or strip, and flux ingredients in terms of nominal percentages for each constituent. 1/
c. Composition of deposited weld metal.
d. Recommended amperage for each weld test and size of electrode to be qualification tested.
e. Residual drawing lubricant and / or feeding lubricant left on the wire and its effect on diffusible hydrogen and moisture pickup on exposure. 1/
f. Brand name.

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

A.4.2.1.2 Chemical control lot. For lots conforming to AWS A5.01 classification T4, the manufacturer shall furnish the following information:

a. The type and size range (each size manufactured shall be specified) for which qualification is desired (see A.4.2.2).
b. Chemical composition-control limits for mill coil. 1/
c. Method of determining chemical-composition of the mill coil.
d. Production line quality control methods used in producing electrodes from chemically controlled mill coil. 1/
e. Percent allowable variation (disclosed) from standard (not disclosed) for each formulated chemical element in the mix of chemically controlled flux material for each MIL-type electrode. 1/
f. Method of determining chemical composition of the mix of chemically controlled flux material. 1/
g. Production line quality control methods used in producing electrodes from chemically controlled flux material. 1/
h. Recommended amperage for each weld test, and size of electrode to be qualification tested.
i. Residual drawing lubricant and / or feeding lubricant left on the wire and its effect on diffusible hydrogen and moisture pickup on exposure. 1/
j. Brand name.

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

A.4.2.1.3 Change Control Procedure. The manufacturer shall document the criteria and procedure for verifying the acceptability of any changes, which may be made in key processes after qualification of the product that may affect the design or performance of the product. The change control procedure shall be maintained at the manufacturer's plant for Government audit purposes and need not be submitted. Any changes, which are determined necessary to a process that negatively affect the acceptable performance of the product shall be submitted to NAVSEA Materials Engineering Division for concurrence with the supporting data to show acceptability.

A.4.2.2 Sample for qualification tests. The electrode selected for testing shall be one spool, one drum, or one coil of each size of each type for which the manufacturer desires to qualify. However, for electrode sizes less than or equal to 5/64” diameter if the manufacturer’s formulation is the same for the range of sizes of that type, only the largest size of that range of sizes shall be tested to qualify all sizes represented.

A.4.3 Quality conformance tests. For quality conformance inspection, electrodes shall be selected in accordance with the lot definition in A.4.3.1. Electrodes selected shall be used for tests specified in table IV.

A.4.3.1 Lot. A lot of electrodes is defined as either of the following:

a. One AWS A5.01 Class T3 lot, not to exceed 25,000 pounds of electrodes, or
b. One AWS A5.01 Class T4 lot.

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

Test	Test procedures	Requirements
Chemical analysis 3/	AWS A5.29 and Main Body 4.8	Table I herein
Alloy identity	AWS A5.01	Main Body 3.8
Diffusible hydrogen 2/	AWS A4.3	A.3.1.3 herein
Nondestructive testing	Main Body 4.5	Main Body 3.7
Visual and Dimensional Examination	Main Body 4.4.2	A.3.1.5
Tension	AWS B4.0	Table II herein
Charpy V-notch 1/	AWS B4.0	Table II herein
Dynamic tear 1/	AWS B4.0	Table II herein

1/ Either the Charpy V-notch test or the dynamic tear test shall be performed.

2/ See Table III for welding parameters

3/ Carbon equivalent 95/95 tolerance limits shall be reported (see Main Body 4.8.3).

A.4.4 Weld metal test procedures.

A.4.4.1 Qualification and quality conformance samples. Two test welds shall be prepared, one at a high cooling rate and one at a low cooling rate. Qualification testing shall require two (2) 0.500 inch diameter tension specimens, ten (10) Charpy V-notch specimens (five (5) at each test temperature) AND four (4) dynamic tear specimens (two (2) at each test temperature) from both the high and low cooling rate test welds. Quality conformance testing shall require two (2) 0.500 inch diameter tension specimens and either ten (10) Charpy V-notch specimens (five (5) at each test temperature) OR four (4) dynamic tear specimens (two (2) at each test temperature) from both the high and low cooling rate test welds. The dimensions of the test welds and the location of the tensile and impact specimens shall be as shown in figure 1. Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered at T/2 (3/8 inch below the surface) of the test plate. No specimens shall be removed from within 3/4 inch of the ends of the welded test assembly. The test welds shall be welded, machined, and tested as outlined below. Tests conducted shall be in accordance with table III, schedule A for qualification or with table IV for quality conformance testing.

(a) The base-plate material shall be HY-80 steel. The base plates shall be in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300, except for quality conformance testing when the Charpy V-notch is the only impact test being conducted, in which case the base plates may be in the as-rolled condition and need only conform to the chemical requirements of MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300. When specified (see A.6.2), the same lot of electrodes shall also be tested for quality conformance using a MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 HSLA-80 base plate weldment.
(b) The 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 value as specified in table V.
(d) Testing shall be of the as-welded condition.
(e) The high cooling rate sample shall be prepared in the flat position using a heat input of 30 plus or minus 5 kJ/in with minimum preheat and maximum interpass temperatures of 125 and 150F, respectively, for steel conforming to MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300 (HY-80/100). The minimum preheat temperature shall be 60F and the maximum interpass temperature shall be 125F for steel conforming to MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 (HSLA-80/100). See Table V for welding current.
(f) The low cooling rate sample for electrode 5/64" and smaller in diameter shall be prepared in the vertical up position using a heat input of 55 plus or minus 5kJ/in and minimum preheat and maximum interpass temperatures of 225 F and 275 F, respectively. See Table V for welding current. The low cooling rate sample for electrode larger than 5/64" diameter shall be welded in the flat position, using minimum preheat and maximum interpass temperatures of 225 and 275 F, respectively, a heat input of 55 plus or minus 5kJ/in and welding electrical parameters that produce a sound weld.
(g) Peening of weld beads shall not be permitted.
(h) The test weld shall be prepared by using welding sequence and techniques recommended by the electrode manufacturer.
(i) When 48 hours have elapsed after completion of the welding, the weldment shall have the reinforcement and backing strap removed flush with the base plate on both surfaces.
(j) See Table II for mechanical property testing requirements.
(k) See Main Body 3.15 for additional welding requirements.

Table V. Electrode size and welding current for 30kJ/in and 55 kJ/in test assemblies.

Electrode diameter (inch)	Welding current (amperes) 1/	
	MIL-101TC MIL-101TM	
	30kJ/in	55kJ/in
0.035	200	180
0.045	250	190
0.052	275	200
0.120	----	----
1/16	300	220
5/64	330	230
3/32	----	----
7/64	----	----
1/8	----	----
5/32	----	----

1/ Welding current shall be within plus of minus 10 percent of the value specified. If no value is specified, values appropriate for producing a sound weldment at the required heat input and welding position shall be used.

A.4.4.2 Explosion crack starter.

A.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/NAVSEA Technical Publication T9074-BD-GIB-010/0300.
(b) Dimensions of the test assemblies shall be in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.
(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 V.
(e) The preheat and interpass temperature shall be 250 plus or minus 25F.
(f) The welding-heat input shall be 55 plus or minus 5 kJ/in. (See Table V for welding current).
(g) Peening of weld beads shall not be permitted.
(h) The test assembly shall be prepared by using the welding sequence and techniques recommended by the electrode manufacturer, which shall be reported.
(i) The joint surfaces shall not be clad or buttered.
(j) The tests shall be conducted at zero F in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300. Two crack starter tests shall be conducted.

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

A.5. PACKAGING

A.5.1 Packaging. See note on special packaging in Main Body 5.1. For standard acquisition, electrodes shall be packaged in accordance with AWS A5.29.

A.6. NOTES

A.6.1 Intended use.

A.6.1.1 General. This specification covers low-alloy steel flux cored welding electrodes that are able to deposit radiographic quality weld metal which, when in the as-welded condition, meets the mechanical properties specified herein when welded on HY-80, HY-100, HSLA-80, and HSLA-100 steels.

A.6.1.1.1 MIL-types 101TC and 101TM. These classifications cover electrodes primarily designed for welding in all positions using gas shielding.

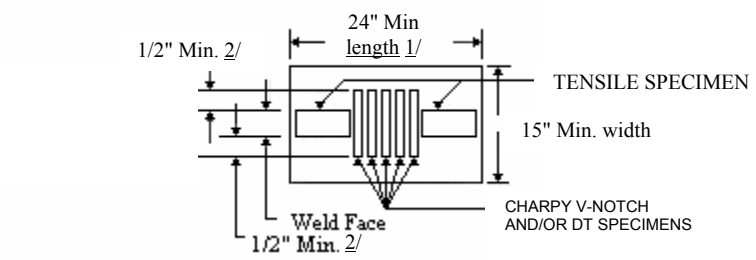
A.6.1.1.2 LH suffix. The above electrodes with an LH suffix can be used with substantially reduced preheat when approved by NAVSEA Materials Engineering Division.

A.6.2 Acquisition requirements. Acquisition documents must specify the following:

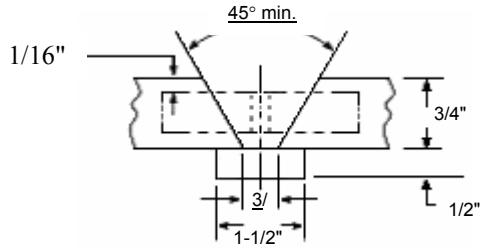
(a) Title, number, and date of this appendix.
(b) Type, size (diameter), packaging (coil form) and weight required (see A.1.2 and AWS A5.29).
(c) When an 88ksi minimum yield strength is required (see table II, note 2/).
(d) Whether an additional test weldment of steel conforming to MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 HSLA-80 steel base-plate material is required (see A.4.4.1(a)).

A.6.3 Subject term (key word) listing.

Flux cored arc welding
Chemical composition
Mechanical properties
Diffusible hydrogen
Qualification testing
Conformance testing



(A) PLAN VIEW OF TEST SPECIMEN LAYOUT



(B) GROOVE PREPARATION OF TEST PLATE
SHOWING ORIENTATION OF CHARPY V-NOTCH AND DYNAMIC TEAR TEST SPECIMENS

Figure 1. Welded joint for tensile and impact tests 4/

NOTES:
1/ Base plate size shall be increased to provide additional Charpy (or dynamic tear) test specimens as required. Note that no specimens shall be removed from within 3/4 inch of the ends of the welded test assembly.
2/ No base metal shall be removed within 1/2 inch of the edges of the face of the weld by flame cutting.
3/ Root opening shall be 1/4 inch minimum.
4/ See A.4.4.1 for additional specimen number, location and orientation details.

APPENDIX B

ELECTRODES AND RODS - WELDING, BARE, SOLID, OR ALLOY CORED; AND FLUXES, LOW-ALLOY STEEL

B.1. SCOPE

B.1.1 Scope. This appendix 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. This appendix is based on AWS A5.23 and A5.28, although it contains numerous additional requirements. This appendix is a mandatory part of the specification.

B.1.2 Classification.

B.1.2.1 Electrode and rod types, forms and sizes, 100S and 120S material. Electrodes and rods shall be of the types specified (see B.3.2) and shall be of the forms and sizes in accordance with AWS A5.28 (see B.6.2). For coils and spools, in addition to the standard sizes listed in AWS A5.28, electrode diameters of 5/32, 3/16, 7/32, and 1/4 inch are acceptable and shall be in accordance with the sizes and tolerances in AWS A5.23. For welding rods, in addition to the standard sizes listed in AWS A5.28, electrode diameters of 0.030, 0.035, 0.052, 7/32, and 1/4 inch are acceptable.

B.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 B.3.2.1.3).

B.2. APPLICABLE DOCUMENTS

This section is not applicable to this appendix

B.3. REQUIREMENTS

B.3.1 General. Electrodes and rods provided under this specification shall be in accordance with AWS A5.23 or A5.28, as appropriate, and as specified herein. Neutral granular flux provided under this specification shall be in accordance with AWS A5.23 and as specified herein.

B.3.2 Types.

B.3.2.1 100S and 120S types.

B.3.2.1.1 Finish. 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 or arc enhancers or feeding aids provided such coatings do not impair usability of the electrodes and rods or the quality or soundness of weld metal deposits. When alternative rust preventative, arc enhancer or feeding aid coatings are used for electrode diameters 3/32 inch and smaller, the manufacturer shall provide data and other evidence to verify that the coating prevents rust, enhances arc stability or aids in feeding and does not impair usability of the electrode or the quality and soundness of the weld deposit.

B.3.2.1.2 Special type with suffix RC. Special electrodes and rods designated by the suffix RC shall not be copper coated but may have either a bright finish or a rust preventative or arc enhancer or feeding aid coating provided the coating does not impair usability of the electrodes or rods or the quality and soundness of the weld metal deposits.

B.3.2.1.3 Type with suffix F. For as-welded or stress-relieved applications, the designation of a qualified flux consists of the designation of the electrode it was qualified with, plus the suffix F (for example, MIL-100S-1F).

B.3.2.1.4 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.

B.3.2.1.5 Special 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.

B.3.2.1.6 Types with suffix C. MIL-100 and MIL-120 alloy-cored electrodes shall be designated by suffix C.

B.3.2.1.7 Types with suffix SA. MIL-100S and MIL-120S electrodes with higher carbon content intended only for SAW shall be designated with suffix SA.

B.3.3 Chemical composition. Chemical composition of unwelded electrodes and rods or deposited weld metal, as specified herein, shall be in accordance with the approved formulation which is bracketed by the maximum and minimum values in table I. For solid electrodes and rods, chemical analysis shall be made on the solid electrode or rod in accordance with AWS A5.28. In addition, a chemical analysis shall be performed on each individual coil of rod stock received from the mill or supplier. For alloy-cored electrodes used for GMAW, the chemical analysis shall be made in accordance with AWS A5.28. For alloy-cored electrodes used for SAW (see B.4.4.5), chemical analysis shall be made in accordance with AWS A5.23. The maximum and minimum carbon equivalent for MIL-100S and MIL-120S must be established in accordance with Main Body paragraph 4.8.3. If the product is to be copper-coated, then the maximum carbon equivalent of the rod stock shall be decreased appropriately to account for effect of the copper coating on the carbon equivalent of the deposited weld metal. Data demonstrating that acceptable MIL-100S properties for GMAW and SAW are achieved from fast cooling rate tests at the maximum carbon equivalent value in accordance with Main Body paragraph 4.8.3 shall be submitted to NAVSEA Materials Engineering Division for specific approval. The maximum carbon equivalent for MIL-100S shall not exceed 0.23.

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

B.3.4.1 Stress relief. When specified (see B.6.2), types MIL-100S and MIL-120S weld metal test plates shall be stress relieved at 1125 plus or minus 25F for one of the following periods as specified (see B.4.4.1 and B.6.2): (a) for not less than 50 hours 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 10F per hour from the stress relief temperature to 600F.

B.3.5 Magnetic particle and radiographic inspection. Welds shall be inspected in accordance with requirements in Main Body 3.7, 3.7.1 and 3.7.2.

B.3.6 Cut-length rods (100S and 120S materials only).

B.3.6.1 Length. For 36-inch long rods, the length tolerance is plus 0, minus 1/2 inch. In addition to that length tolerance, for 36-inch long rods up to 10 percent of the rods in any container may be shorter than 35.5 inches, but not shorter than 24 inches. When specified (see B.6.2), rods may be supplied in lengths of 12 or 18 inches, which also have length tolerances of plus 0, minus 1/2 inch.

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

Welding process	ALL	GMAW SAW	ALL	GMAW SAW
Type 2/	100S-1 100S-2	100S-1C 100S-2C	120S-1 120S-2	120S-1C 120S-2C
Chemical composition (weight percent) 1/				
Carbon	0.07 3/	0.07 3/	0.070 3/, 4/	0.070 3/, 4/
Manganese	1.25-1.8	1.25-2.5	0.90-2.35	1.4-3.8
Silicon	0.20-0.55	0.20-0.55	0.60	0.20-0.55
Phosphorus	0.012	0.012	0.012	0.012
Sulfur	0.008	0.010	0.008	0.010
Nickel	1.40-2.10	1.40-2.10	1.00-3.0	1.00-3.5
Molybdenum	0.25-0.55	0.25-0.55	0.30-1.00	0.30-1.10
Chromium	0.30 8/	0.30 8/	0.80	0.60
Vanadium	0.05	0.04	0.03	0.04
Aluminum	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/, 7/	5/, 6/, 7/	5/, 6/, 7/	5/, 6/, 7/
Boron	7/	7/	7/	7/

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

2/ Including applicable suffixes (see B.3.2).

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

5/ When the basic type electrode or rod has a copper coating in accordance with B.3.2.1.1, 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, a sampling plan must be in place to incorporate material from all production lines in the chemical analysis

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

7/ Copper (except for copper coated and suffix RC electrodes) shall be reported for information only. Boron shall be analyzed to the parts per million (ppm) level, reported for information and for use in calculating the carbon equivalent.

8/ When specified by the purchaser, a 0.05% maximum chromium content in the bare electrode or rod (not weld deposit) may be required for control of hexavalent chromium in fumes (see B.6.2.)

Table II. Mechanical properties for as-welded SAW, GMAW and GTAW welds. 1/, 12/

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/, 12/	102 to 123 3/, 4/, 12/
Elongation in 2 inches min. (percent)	16	15
Transverse side bend	5/	5/
Charpy V-notch. Energy ft-lb min. average @ Temperature (degrees Fahrenheit) (F)	35@(-60F) 6/ 60@(0F) 6/	45@(-60F) 6/, 7/ 60@(0F) 6/
Dynamic tear. Energy ft-lb minimum average @ Temperature (degrees Fahrenheit) (F)	300@(-20F) 8/, 9/ 450@(+30F) 9/, 10/	400@(-20F) 8/, 9/ 575@(+30F) 9/, 10/
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 B.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 B.6.2). Single values shall be not less than 100 ksi or greater than 125 ksi, or, when specified (see B.6.2), 130 ksi.
5/ The convex surface of the specimen shall have no cracks or other indications exceeding 1/8 inch. Tears less than 1/8 inch on the corners of the bend specimen are acceptable.
6/ For each testing temperature, the average value shall be determined based on five tests. Only one test specimen may have a value below the minimum average specified; such a test specimen may have a value no more than 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 –60F shall be not less than 40 foot-pounds.
8/ The average value shall be determined based on two tests. One test specimen may have a value no more than 50 ft-lbs below the minimum average specified.
9/ For high cooling rate tests, dynamic tear test results shall be reported for information only.
10/ The average value shall be determined based on two tests. One specimen may have a value ~~of~~ no more than 25 ft-lbs below the minimum average specified.
11/ Acceptance criteria shall be in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.
12/ The check tolerance for receipt inspection (see 4.7.4 and 4.7.5 in Main Body) cannot be used on the maximum yield strength requirement for MIL-100S or MIL-120S type filler materials.

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

Type 2/	100S-1 100S-2	120S-1 120S-2
Ultimate tensile strength (minimum) (ksi)	90	3/
Yield strength (minimum) (ksi)	80	3/
Elongation in 1.4 or 2 inches (minimum) (percent)	18	3/
Transverse side bend	4/	4/
Charpy V-notch. Energy ft-lb minimum average @ at +10F Temperature degrees Fahrenheit (F)	35 5/	3/ 5/

1/ See B.3.4.1.
2/ Including applicable suffixes (see B.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 the Government. The required mechanical properties after stress relief for MIL-120S type weld metal shall be as specified (see B.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/ The average value shall be determined based on five tests. Only one test specimen may have a value below the minimum average specified; such a test specimen may have a value no more than 10 foot- pounds below the minimum average specified.

B.3.6.2 Marking. In addition to the requirements of AWS A5.28, cut-length rods shall be identified by positive and legible methods such as imprinting or indenting the applicable type designation number at one or more locations on the rod surface approximately 1 inch from the rod end, or shall be identified by pressure-sensitive adhesive, plastic-coated tape imprinted with the applicable type number at one or more locations and attached to the rod approximately 1 inch from its end. Imprints on rods or on tape shall be with fade-proof ink and shall be resistant to oils, solvents, all atmospheric conditions, and to normal wear and tear encountered in shipping and handling.

B.3.7 Diffusible hydrogen. 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 IV. A diffusible hydrogen control plan in accordance with 4.9 of Main Body is required.

B.3.7.1 Hydrogen content after moisture exposure. At qualification the manufacturer shall provide data to benchmark the hydrogen content after moisture exposure of the product being qualified. Diffusible hydrogen measurements in accordance with AWS A4.3 shall be made on electrode from the same spool using electrode from the outer layer or layers of the spool, both before and after exposure in a suitably controlled environmental chamber for 9 hours minimum at 80F, minus 0, plus 5F and 80% relative humidity, minus 0, plus 5%. Results of these tests shall be provided to NAVSEA Materials Engineering Division as part of the qualification report. These benchmark test results shall be used to assess changes to manufacturing procedures that may affect hydrogen content after moisture exposure. The results of these tests shall be made available upon request to all purchasers of this product referencing this document.

B.3.8 Moisture content of MIL-100 and MIL-120 type fluxes. The total moisture content of MIL-100S-1F, MIL-100S-2F, MIL-120S-1F or MIL-120S-2F flux shall not be greater than 0.10 percent by weight when the infrared method identified in AWS A4.4 is used. For MIL-100S-1F, MIL-100S-2F, MIL-120S-1F and MIL-120S-2F, flux lots exhibiting moisture contents between 0.10 and 0.14 percent by weight when the infrared method identified in AWS A4.4 is used shall be accepted provided diffusible hydrogen testing confirms that the lot meets the requirements of table IV. When other moisture content testing methods are used the total moisture content shall not exceed 0.05 percent by weight. For MIL-100S-1F,

MIL-100S-2F, MIL-120S-1F and MIL-120S-2F, when other moisture content testing methods are used flux lots exhibiting moisture contents between 0.05 and 0.10 percent by weight shall be accepted provided diffusible hydrogen testing confirms that the lot meets the requirements of table IV.

Table IV. Diffusible hydrogen values. 1/

Type 2/	Welding Process	Maximum Average	Maximum single value 3/
100S-1	GMAW	4.0	4.8
100S-1 100S-1F	SAW	5.5	6.7
100S-2	GMAW	2.6	3.4
100S-2 100S-2F	SAW	3.0	3.8
120S-1	GMAW	4.0	4.8
120S-1 120S-1F	SAW	5.5	6.7
120S-2	GMAW	2.6	3.4
120S-2 120S-2F	SAW	3.0	3.8

1/ See paragraph 4.9 on diffusible hydrogen control plan in Main Body.
2/ Including applicable suffixes (see B.3.2).
3/ Refers to the highest single value determined in a set of 4 tests per AWS A4.3 (see Main Body 4.9).

B.3.9 Visual/dimensional inspections. Sampling for visual and dimensional inspection shall be as specified in Main Body 4.4.2. Electrode size and tolerances, electrode finish and uniformity, electrode winding and electrode identification shall be in accordance with AWS A 5.28 and B.1.2.1.

B.4. VERIFICATION

B.4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see B.4.2).
b. Quality conformance inspection (see B.4.3).

B.4.2 Qualification inspection. Electrodes selected for qualification shall be used for tests specified in table V. For each lot of material, sufficient samples shall be selected to perform the tests listed. Schedule A tests shall be conducted by the manufacturer, and upon successful completion of these tests, schedule B testing will be conducted at a Government test facility (see 6.3 of Main Body). The manufacturer or contractor will be responsible for funding schedule B testing unless other funding provisions are arranged with the Government or prime contractor.

B.4.2.1 Special instructions. When applying for test authorization, or after tests have been authorized and when samples are submitted, the manufacturer shall furnish the following information. (This information, together with test results obtained from the sample, shall form a part of the qualification test. All information will be held in confidence by the Government.)

B.4.2.1.1 Bare solid electrode, single heat lot. For bare solid electrode, conforming to AWS A5.01 classification S3 (without the requirement that the electrodes be from one production cycle), the following information shall apply:

(a) Type and size under which approval is desired.
(b) Composition of wire in terms of nominal percentages for each constituent. 1/
(c) Composition of the deposited weld metal.
(d) Shielding gas composition.
(e) Recommended amperages for each weld test.
(f) Brand name of electrode and, when applicable, brand name of flux.
(g) Residual drawing lubricant and/or arc enhancer or feeding lubricant left on the wire and its effect on diffusible hydrogen and moisture pickup on exposure. 1/
(h) Cleaning method. 1/

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

B.4.2.1.2 Bare solid electrode, chemical control lot. For bare solid electrode, conforming to AWS A5.01 classification S4 in addition to the information in B.4.2.1.1, the following shall be furnished for approval of the command or agency concerned:

(a) Chemical composition control limits in wire of each type electrode. 1/
(b) Production line methods used to produce electrodes from chemically controlled core wire. 1/
(c) Method of determining wire chemistry.

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

B.4.2.1.3 Alloy-cored electrode, batch control lot. For alloy-cored electrode, conforming to AWS A5.01 classification T3, the following information shall be furnished:

(a) The type and size range (each size manufactured shall be specified) for which qualification is desired.
(b) Composition of tube, or strip, and flux ingredients in terms of nominal percentages for each constituent. 1/
(c) Composition of deposited weld metal.
(d) Recommended amperage for each weld test and size of electrode to be qualification tested.
(e) Brand name.
(f) Residual drawing lubricant and/or arc enhancer or feeding lubricant left on the wire and its effect on diffusible hydrogen and moisture pickup on exposure. 1/

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

B.4.2.1.4 Alloy-cored electrode, chemical control lot. For alloy-cored electrode, conforming to AWS A5.01 classification T4, the following information shall be furnished:

(a) The type and size range (each size manufactured shall be specified) for which qualification is desired.
(b) Chemical composition control limits for mill coil. 1/
(c) Method of determining chemical composition of the mill coil.
(d) Production line quality control methods used in producing electrodes from chemically controlled mill coil. 1/
(e) Percent allowable variation (disclosed) from standard (not disclosed) for each formulated chemical element in the mix of chemically controlled filler material for each type electrode.
(f) Method of determining chemical composition of the mix of the chemically controlled filler material.

(g) Production line quality control methods used in producing electrodes from chemically controlled flux material. 1/
(h) Recommended amperage for each weld test, and size of electrode to be qualification tested.
(i) Brand name.
(j) Residual drawing lubricant and/or arc enhancer or feeding lubricant left on the wire and its effect on diffusible hydrogen and moisture pickup on exposure. 1/

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

B.4.2.1.5 SAW flux. For SAW granular neutral flux, conforming to AWS A5.01 classification F2, the following information shall be provided:

(a) The type of flux for which qualification is desired.
(b) Percentage allowable variation (disclosed) from standard (not disclosed) for each formulated chemical element in the chemically controlled flux for each type.
(c) Method of determining chemical composition of the chemically controlled flux. 1/
(d) Production line quality control methods used in producing the chemically controlled flux. 1/
(e) Brand name.

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

B.4.2.1.6 Change Control Procedure. The manufacturer shall document the criteria and procedure for verifying the acceptability of any changes, which may be made in key processes after qualification of the product that may affect the design or performance of the product. The change control procedure shall be maintained at the manufacturer's plant for Government audit purposes and need not be submitted. Any changes, which are determined necessary to a process that negatively affect the acceptable performance of the product shall be submitted to NAVSEA Materials Engineering Division for concurrence with the supporting data to show acceptability.

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

Test	A	B 9/	Test Procedures	Requirements
Cast 4/	X	---	AWS A5.28 7/	AWS A5.28 7/
Helix 4/	X	---	AWS A5.28 7/	AWS A5.28 7/
Chemical analysis	X	---	AWS A5.28, B.3.3 and Main Body 4.8 8/	Table I herein
Alloy identity	X	---	AWS A5.01	Main Body 3.8
Diffusible hydrogen	X	---	AWS A4.3 6/	B.3.7 herein
Moisture Testing	X	X	AWS A4.4 and B.4.2.2.2 herein	B.3.8 herein
Welded test assembly	X	X	B.4.4 herein	Figure 1 or both figures 1 and 2 herein
Nondestructive testing	X	X	Main Body 4.5.1 and 4.5.2	B.3.5 and Main Body 3.7.1 and 3.7.2
Visual and Dimensional Examination	X	X	Main Body 4.4.2	B.3.9
Tension	X	X	AWS B4.0	Tables II & III herein
Transverse side bend	X	X	AWS B4.0	Tables II & III herein
Charpy V-notch 5/	X	X	AWS B4.0	Tables II & III herein
Dynamic tear 5/	X	X	AWS B4.0	Table II herein
Explosion test series	---	X	B.4.4.7 herein	Table II herein

1/ The brand name of flux used in Schedule A and B testing shall be specified in the qualification test reports.
2/ Applicable to all electrode types (see B.3.2)
3/ Use SAW with a qualified electrode to qualify neutral granular fluxes for the as-welded condition.
4/ Not applicable to straight-cut rod electrodes.
5/ See figures 1 and 2 and their associated tables for requirements on Charpy V-notch and Dynamic tear testing.

Table V notes continued on next page

6/ For electrodes to be qualified for use with the GMAW process, diffusible hydrogen specimens shall be prepared in the flat position using the spray transfer mode, C-5 (5% CO_2 / 95% Ar) shielding gas, 1/2-inch gas cup inner diameter, 35cfh gas flow, using mechanized or automatic welding methods. The power supply shall be constant potential with no oscillation. Torch angle shall be perpendicular to the test specimen. Instrumentation shall be an in-line ammeter and a voltmeter sensing voltage between the wire feeder drives rolls and the test assembly fixture (see Main Body 3.15.3).

Wire feed speeds shall be as specified below. The voltage shall be adjusted to produce a short arc length without electrode stubbing or excessive spatter. In general, the proper arc can be obtained by bringing the voltage to the point where stubbing begins, then gradually increasing the voltage to the point where no stubbing occurs and the arc has a "crackling" sound.

The following welding parameters shall be used. If the voltage or current varies significantly (i.e. 1 volt or 10 amps) from the ranges shown, the actual parameters and the justification for the deviation shall be submitted to NAVSEA Materials Engineering Division for approval. Travel speed shall be adjusted to obtain a nominal bead width of 5/8-inch plus or minus 1/16-inch.

0.045” dia. electrode

Voltage at wire feeder	=	~25.5 to ~26.5 V
Current - bare wire	=	~240 to ~260 A
Current - copper plated	=	~260 to ~280 A
Electrode stick out	=	5/8” (plus or minus 1/16")
Wire feed speed	=	296 to 306 inches per minute (ipm)

0.062” dia. electrode

Voltage at wire feeder	=	~25.5 to ~26.5 V
Current - bare wire	=	~315 to ~325 A
Current - copper plated	=	~335 to ~345 A
Electrode stick out	=	5/8” (plus or minus 1/16")
Wire feed speed	=	190 – 200 ipm

Similar parameters, appropriately adjusted by the manufacturer, shall be used with other sizes.

7/ AWS A5.28 applies to electrodes used for all welding processes, except use AWS A5.23 for 3/32” and larger electrodes.
8/ See AWS A5.23 in the case of alloy cored electrodes used with SAW.
9/ Feedability will be evaluated based on standard shipyard practices during schedule B testing.

B.4.2.2 Samples for qualification tests.

B.4.2.2.1 Electrode samples.

B.4.2.2.1.1 100S and 120S materials. For each type electrode to be qualified, one spool (12 inch or larger), multiple spools less than 12 inches, or one coil (65 pounds and under), of the appropriate electrode size(s) specified in Table VIII (“Electrode size tested”) shall be tested. The spool(s) (or coil) and the electrode size(s) tested shall be representative of the cleaning method used for all forms and for the range of sizes to be qualified (see Table VIII “Size range qualified”). If more than one cleaning method is used for the sizes to be qualified, qualification applications shall give complete details. When an electrode is to be qualification tested for the SAW process, the manufacturer shall furnish a sample of the flux. All samples shall be selected in the presence of the Government representative.

B.4.2.2.1.1.1 Bare solid electrode sample. Approval obtained for the electrode size(s) tested qualifies the same type electrode for the size range indicated in Table VIII.

B.4.2.2.1.1.2 Alloy-cored electrode sample. When tested using the GMAW process, approval obtained for the 1/16-inch size electrode qualifies all sizes smaller than 3/32

inch of the same type. Unlike GMAW, 1/16-inch alloy-cored electrode is not normally used for SAW. Therefore, when tested using the SAW process, approval obtained for the 1/8-inch size electrode qualifies all sizes 3/32-inch and larger for the same type that are made to the same formulation.

B.4.2.2.2 SAW flux sample. The flux sample selected for testing (see Tables V and VI) shall be at least 100 pounds supplied in sealed containers. When both schedule A and schedule B tests are to be conducted, at least 200 pounds of flux in at least two sealed containers shall be selected at the same time. Half of the flux shall be used for the schedule A tests while the remainder shall be used for the schedule B tests. The container or containers of flux shall remain unopened until the start of welding. The sample for moisture content testing shall be removed from the top of a previously unopened container.

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

Test	Test Procedures	Requirements
Cast 4/, 7/	AWS A5.28	AWS A5.28
Helix 4/, 7/	AWS A5.28	AWS A5.28
Chemical analysis	AWS A5.28 and Main Body 4.8	Table I herein
Alloy identity	AWS A5.01	Main Body 3.8
Diffusible hydrogen 6/	AWS A4.3	B.3.7 herein
Moisture Content	AWS A4.4 and B.4.2.2.2 herein	B.3.8 herein
Welded test assembly	B.4.4 herein	Figure 1 or both figures 1 and 2 herein
Nondestructive testing	Main Body 4.5	Main Body 3.7
Visual and Dimensional Examination	Main Body 4.4.2	B.3.9
Tension	AWS B4.0	Tables II and III herein
Charpy V-notch 5/	AWS B4.0	Table II and III herein
Dynamic tear 5/	AWS B4.0	Table II herein

1/ When a heat of metal is processed into electrodes and rods, weld metal tests are required only with electrodes.
2/ Applicable to all electrode types (see B.3.2).
3/ Use SAW with a qualified electrode for quality conformance inspection of a lot of qualified neutral granular flux (100S-1F, 100S-2F, 120S-1F, 120S-2F). A lot of electrodes and a lot of qualified granular flux can be quality conformance inspected by the same set of tests.
4/ Not applicable to rods.
5/ Either Charpy V-notch or dynamic tear testing shall be performed.
6/ The diffusible hydrogen test for the GMAW process shall be conducted using the spray transfer mode and the parameters presented in note 6/ to Table V, or using parameters as otherwise indicated in note 6 of Table V for other diameter electrodes.
7/ AWS A5.28 applies to all electrodes, except use AWS A5.23 for 3/32” and larger electrodes.

B.4.3 Quality conformance inspection. Quality conformance inspection tests shall be performed in accordance with table VI. For each lot of material, sufficient samples shall be selected to perform the tests listed. Quality conformance tests shall be conducted by the manufacturer.

B.4.3.1 Lot.

B.4.3.1.1 Bare solid electrodes. For the purposes of quality conformance inspection, a lot of electrodes shall be the quantity of one type alloy produced as specified in B.4.2.1.1 or B.4.2.1.2. In addition, for chemical composition control lots, mill coils conforming to established wire

chemistry control for a specific type of electrode shall be appropriately identified and segregated to avoid mix-ups.

B.4.3.1.2 Alloy-cored electrodes. For the purposes of quality conformance inspection, a lot of electrodes shall be the quantity of one type alloy produced as specified by either Class T3 (core batch control) not to exceed 25,000 lbs. of electrodes or Class T4 (core composition control) of AWS A5.01.

B.4.3.1.3 Submerged arc flux. For the purposes of quality conformance inspection, a lot shall consist of all flux of one type and as specified by Class F2 of AWS A5.01.

B.4.4 Weld metal test procedures.

B.4.4.1 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, table VII and table XI. For qualification, weldments shall be tested in the stress relieved condition in accordance with B.3.4.1 for both the 50-hour total and 1-hour per inch of thickness holding time. For quality conformance, weldments shall be stress relieved in accordance with B.3.4.1(a) or B.3.4.1(b) as specified (see B.6.2).

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

B.4.4.2 As-welded applications. For electrodes and rods for as-welded applications, the welding parameters, welding position, and welding process shall be in accordance with figures 1 and 2 and table VIII.

B.4.4.3 Fluxes. For qualification, MIL-100S-1F, MIL-100S-2F, MIL-120S-1F, and MIL-120S-2F flux types shall be used in combination with a corresponding type electrode to deposit weld metal by the SAW process, and the weldments tested in the as-welded condition. Welding parameters, welding position, and welding process shall be in accordance with figures 1 and 2 and table VIII. For quality conformance, test weldments shall be made in combination with a corresponding type electrode in accordance with B.4.4.1 or B.4.4.2, as applicable.

B.4.4.4 Alloy-cored electrodes. Test weldments shall be made in accordance with B.4.4.1 or B.4.4.2, 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.

B.4.4.5 Electrode/flux combinations. For qualification testing of MIL-120S type 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 B.6.1.2). For conformance testing of MIL-120S type electrodes with the SAW process, the specific brand name electrode and flux combination(s) specified (see B.6.2) shall be used for conformance testing.

B.4.4.6 Base metal. Unless otherwise specified (see B.6.2), the base metal steel used for the tests required herein shall be in accordance with table IX.

B.4.4.7 Explosion crack starter. Fabrication of the weldments shall be as follows:

B.4.4.7.1 MIL-100S and MIL-120S material.

(a) The base plate shall be as specified in table IX.
(b) Dimensions of the test assemblies shall be as specified in MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.
(c) The preheat and interpass temperature shall be 250 plus or minus 25F.
(d) The welding heat input shall be 110 kJ/in minimum for MIL-100S and 50 to 60 kJ/in for MIL-120S.
(e) Peening of weld beads shall not be permitted.
(f) The test assembly shall be prepared by using welding sequence and techniques recommended by the manufacturer which shall be reported.
(g) The joint surface shall not be clad or buttered.
(h) 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.
(i) The weldments shall be fabricated using the welding position and electrode diameter specified in table X.
(j) The tests shall be conducted at zero F in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300. Two crack starter tests shall be conducted.

B.4.4.7.2 Prolongation assembly. The prolongation assembly shall be tested in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.

Table VIII. Welding parameters for as-welded applications. 1/, 2/, 3/. 10/, 11/, 13/, 14/

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

Type 4/	120S-1, 120S-2						120S-1, 120S-1F, 120S-2, 120S-2F			
Electrode size tested (inches) 5/	0.045				1/16		1/16		3/32	
Size range qualified (inches)	0.02 to 0.045				0.052 to 5/64		0.052 to 5/64		3/32 to 1/4	
Welding process	Pulsed arc GMAW		Spray GMAW		Spray GMAW		SAW		SAW	
Position	Vertical up	Flat	Flat		Flat		Flat		Flat	
Cooling rate 6/	High	Low	High	Low	High	Low	High	Low	High	Low
Heat input (kJ/in) 7/	34	45	31	48	31	48	40	50	40	50
Preheat and interpass temperature (F)	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325

See Notes for table VIII at top of the page following end of Table VIII continuations.

Table VIII. Welding parameters for as-welded applications. (continued) 1/, 2/, 3/, 10/, 11/, 13/, 14/

Welding Parameters for quality conformance tests.												
Type	100S-1 100S-2				100S-1 100S-1F 100S-2 100S-2F		120S-1 4/ 120S-2 4/				120S-1 4/ 120S-1F 120S-2 4/ 120S-2F	
Electrode size tested (inches) 5/	Each size 0.045 and smaller 12/		Each size 0.052 and larger		Each size		Each size 0.045 and smaller		Each size 0.052 and larger		Each size	
Size range certified (inches)	Size tested		Size tested		Size tested		Size tested		Size tested		Size tested	
Welding process	Spray GMAW	Pulsed arc GMAW	Spray GMAW		SAW		Spray GMAW	Pulsed arc GMAW	Spray GMAW		SAW	
Position	Flat	Vertical up	Flat		Flat		Flat	Vertical up	Flat		Flat	
Cooling rate 6/	High	Low	High	Low	High	Low	High 9/	Low	High	Low	High	Low
Heat input (kJ/in) 7/	30	110	30	110	40	110	28	45	31	48	40	50
Preheat and interpass temperature (degrees Fahrenheit) (°F)	125 to 150	225 to 275	125 to 150	225 to 275	125 to 150	225 to 275	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325

See notes for table VIII at top of the next page.

Notes for table VIII.

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

2/ Alternate welding parameters may be used for qualification or quality conformance testing when approved by the Government.

3/ Including applicable suffixes (see B.3.2).

4/ For qualification testing and heat quality conformance testing of MIL-120S types, electrodes or rods representing the highest carbon equivalent (see Main Body 4.8) 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.

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 1 for both low cooling rate tests and high cooling rate tests. For MIL-120S types, test plates shall be in accordance with figure 1 for the low cooling rate test and in accordance with figure 2 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 with figure 1 when approved by NAVSEA Materials Engineering Division, provided these conditions are observed:

(a) Test data from both figure 1 and figure 2 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 1 test plates.

(c) When both test plates are tested, results from the figure 2 test plates shall be the authoritative results.

7/ See Main Body 4.12. Average heat input shall fall within 2 kJ/in of the heat input specified. Further, the operational heat input of at least 80% of all individual passes shall be within 2kJ/in of the specified heat input. No pass shall have an operational heat input more than 7kJ/in from the specified heat input. A weld pass shall be defined as one bead extending from the beginning to the end of the test assembly.

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 1 on one-inch thick plate at the high cooling rate.

10/ The weld sample shall be allowed to sit undisturbed for 48 hours before any cutting or testing of any kind is performed.

11/ When steel conforming to MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 (HSLA-80 or HSLA-100) is specified or permitted (see B.6.2) the high cooling rate weld shall be prepared using a +60 F minimum preheat temperature and a +125 F maximum interpass temperature.

12/ Electrode sizes 0.035 inches and smaller shall be tested at a minimum heat input of 55 kJ/in for the low cooling rate condition, unless otherwise specified by the purchaser (see B.6.2).

13/ Purchasers of products for the GTAW process shall define required testing parameters in the purchase order (see B.6.2).

14/ See Main Body 3.15 for additional welding requirements.

Table IX. Base metal requirements.

Types 1/, 2/	Base metal
100S-1 3/ 100S-1F 100S-2 3/ 100S-2F	4/ HY-80 or HY-100 steel in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300 or HSLA-80 or HSLA-100 in accordance with MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 when specified (see B.6.2).
120S-1 120S-1F 120S-2 120S-2F	4/ HY-100 steel in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300 and an optional additional test with HSLA-100 in accordance with MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 when specified (see B.6.2)

1/ For quality conformance testing in the stress relieved condition to the requirements as specified in table III, other base metal steels may be specified (see B.6.2).
2/ Including applicable suffixes (see B.3.2).
3/ For quality conformance testing, if specified (see B.6.2), MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 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 B.6.2).
4/ These grades of steel are required (see figures 1 and 2) when dynamic tear tests are to be conducted. When dynamic tear tests are not to be conducted, the base plate material shall be in accordance with the chemical composition requirements of MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300. The plate material can be in the as-rolled condition without being quenched and tempered nor tested for mechanical properties.

Table X. Welding parameters for explosion crack starter tests.

Qualification electrode size (inches)	Welding process	Position	Size range qualified
			100S-120S
0.045	Pulsed-arc GMAW	Vertical up	0.02 to 0.045
1/16 (0.062)	Spray-arc GMAW	Flat	0.052 to 5/64
1/8	SAW	Flat	3/32 to 1/4

B.4.4.8 MIL-120S retest utilizing post weld soak. When approved by NAVSEA Materials Engineering Division, MIL-120S filler metals may be 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.

B.5. PACKAGING

B.5.1 Packaging. See B.6.2 and notes on special packaging in Main Body 5.1.

B.5.1.1 Electrodes and rods. For standard acquisition, electrodes and rods shall be packaged in accordance with AWS A5.28.

B.5.1.2 Flux. For standard acquisition, fluxes shall be packaged in accordance with AWS A5.23.

B.6. NOTES

B.6.1 Intended use.

B.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 IX using either SAW welding processes employing a suitable neutral granular flux or GMAW and GTAW processes with a suitable shielding gas. 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 IX 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. Qualified electrodes bearing the SR suffix may be used for stress-relieved applications as well.

B.6.1.1.1 Type MIL-100S-1. Type MIL-100S-1 electrode is suitable for welding HY-80 and HSLA-80 steel and HY-100 and HSLA-100, when approved.

B.6.1.1.2 Type MIL-100S-2. Type MIL-100S-2 electrode is suitable for welding HSLA 80 and HY-80 steel and, when approved, HSLA-100 and HY-100. In addition, this type electrode is suitable for welding HSLA-80 and HSLA-100 in approved reduced preheat applications.

B.6.1.1.3 Type MIL-120S-1. Type MIL-120S-1 electrode is suitable for welding HY-100 steel.

B.6.1.1.4 Type MIL-120S-2. Type MIL-120S-2 electrode is suitable for welding HSLA-100 and HY-100 steel. In addition, this type of electrode is suitable for welding specially approved reduced preheat or soak applications.

B.6.1.1.5 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.

B.6.1.1.6 Special type with suffix RC. Restricted copper electrodes and rods will be used when specified (see B.6.2 and table I).

B.6.1.1.7 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.

B.6.1.1.8 Types with suffix C. Alloy-cored electrodes are intended for use with the GMAW and SAW processes only.

B.6.1.1.9 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.

B.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.

B.6.2 Acquisition requirements. Electrodes, rods or flux intended for stress-relieved applications shall be so specified in the acquisition documents. Acquisition documents should specify the following:

(a) Title, number, and date of this appendix.
(b) Types, forms, and sizes required (see B.1.2.1).
(c) Whether type MIL-100S or MIL-120S weld metal test plates should be tested for conformance with stress-relieved requirements (see B.3.4.1).
(d) Time at the stress relief temperature (see B.3.4.1 and B.4.4.1).
(e) If 12 or 18 inch rods are required (see B.3.6.1).
(f) Whether the copper content should be restricted (see footnote 7/ to table I and B.6.1.1.6).
(g) Whether a maximum chromium content of 0.05% is required to control hexavalent chromium in welding fumes (see note 8/ of Table I).

(h) Whether higher maximum average yield strength of 125 ksi is allowed and whether maximum single values greater than 125 but not greater than 130 ksi are allowed (see footnote 4/ of table II).
(i) The required mechanical properties for type MIL-120S test welds that have been stress-relieved (see footnote 3/ to table III).
(j) Which specific brand name electrode and flux combination(s) shall be used for conformance testing (see B.4.4.5). See current QPL for qualified combinations.
(k) When HSLA-80 or HSLA-100 steel conforming to MIL-S-24646/NAVSEA Technical Publication T9074-BD-GIB-010/0300 is specified or permitted for as-welded test applications (see footnote 11/ to table VIII).
(l) Whether a minimum heat input greater than 55kJ/in is required for electrode sizes 0.035 inches and smaller in diameter (see footnote 12/ of table VIII).
(m) Testing parameters of products for the GTAW process (see footnote 13/ of table VIII).
(n) Other base metal steel for use in testing in the stress relieved condition, if required (see B.4.4.6, table IX and footnote 1/ thereof).
(o) Packaging requirements, including any special packaging or shipping requirements, such as hermetically sealed containers for MIL-100S-2F, MIL-120S-1F, or MIL-120S-2F fluxes, palletization of material for shipment, or prohibitions against polystyrene (loose-fill) materials for cushioning, filler or dunnage (see B.5.1).
(p) Whether a second test weldment is required for quality conformance testing in the as-welded condition (see footnote 3/ of table IX).
(r) Shielding gas required for GMAW (see note 3/ to table XI, note 3/ to table XII, and note 3/ to table XIII).
(s) Whether a second test weldment is required using ASTM A710 or MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 grade HSLA-80 steel base plate material (see footnote 2/ to table XII).

B.6.3 Definitions. For the purpose of this specification, the welding terms and definitions contained in AWS A3.0 and AWS A5.01 shall apply, with the following additions and/or modifications. In this specification, the terms electrode and rod are used interchangeably with the term wire and denotes a filler-metal wire with no coating other than that incidental to its manufacture or preservation, as specified.

B.6.3.1 Alloy-cored electrode. An alloy-cored electrode is a composite filler metal electrode consisting of a metal tube or other hollow configuration containing alloying ingredients, which could be used for GMAW or SAW. Some brands have been designed especially for the submerged arc welding process using a neutral granular flux.

B.6.4 Subject term (key word) listing.

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

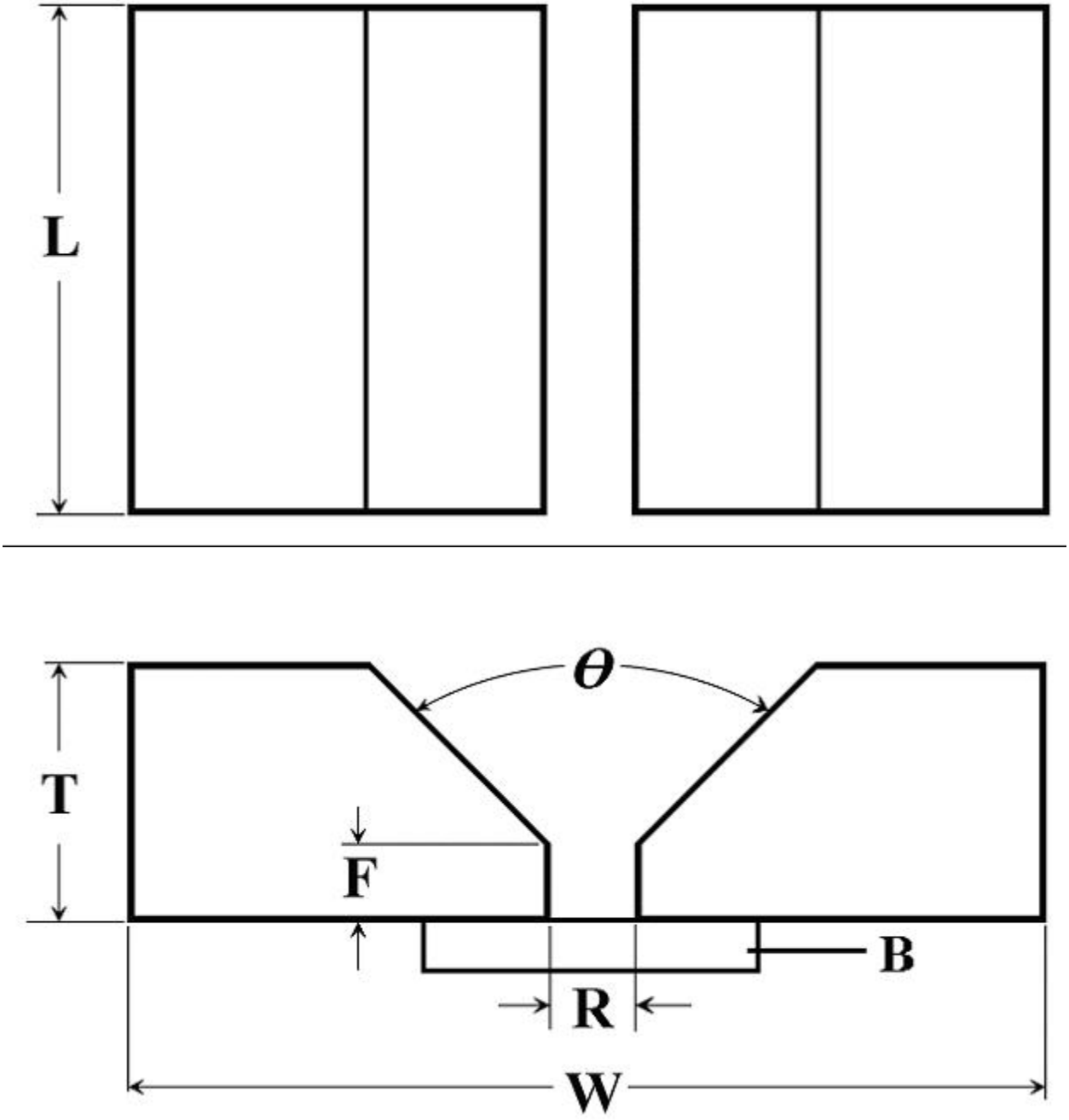


Figure 1. Single-V style weld sample. 1/

NOTES:
1/ See tables XI and XII.

Table XI. Welded test assembly for stress relieved applications. 6/

	Qualification		Quality Conformance	
Welding process	SAW	GMAW	SAW	GMAW
Stress Relief	(See note 1/)	(See note 1/)	(See note 1/)	(See note 1/)
Position	Flat	Table VII	Flat	Table VII
Base Material	Table IX	Table IX	Table IX	Table IX
Electrode size	1/8	1/16	1/8	1/16
Welding parameters	(See note 2/)	(See note 2/)	(See note 2/)	(See note 2/)
Shielding gas	N.A.	(See note 3/)	N.A.	(See note 3/)
Joint configuration	Figure 1	Figure 1	Figure 1	Figure 1
Thickness (T) (inches)	3/4	3/4	3/4	3/4
Width (W) (inches)	10 minimum	10 minimum	10 minimum	10 minimum
Length (L) (inches)	18 minimum 5/	18 minimum 5/	12 minimum	12 minimum
Root opening (R) (inches)	1/2 minimum	1/2 minimum	1/2 minimum	1/2 minimum
Root Face (F) (inches)	0 to 1/16	0 to 1/16	0 to 1/16	0 to 1/16
Included angle (θ)	45	45	45	45
Backing strap size (B) (inches)	1/4 to 3/8 by 1-1/2	1/4 to 3/8 by 1-1/2	1/4 to 3/8 by 1-1/2	1/4 to 3/8 by 1-1/2
Test specimens (number/type)	From each weld: 2 tensile, 2 bend 5 Charpy (See note 4/)	From each weld: 2 tensile, 2 bend 5 Charpy (See note 4/)	From each weld: 1 Tensile, 5 Charpy (See note 4/)	From each weld: 1 Tensile, 5 Charpy (see note 4/)

1/ Prior to machining specimens or removing backing strip, weldments shall be stress relieved in accordance with B.3.4.1 and B.4.4.1.

2/ 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 500F respectively.

3/ Shielding gas shall be argon for GTAW and argon plus 2 percent oxygen for GMAW welding electrodes. Argon plus 5 percent CO2 may also be used for GMAW welding electrodes. For MIL-120S, shielding gas for GMAW shall be either argon plus 2 percent oxygen or argon plus 5 percent CO2, as specified (see B.6.2). The neutral granular flux for the SAW process shall be in accordance with B.4.4.1 or B.4.4.3 herein, whichever is consistent with the type electrodes being tested.

4/ Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered in the weld metal at 3/8 inch below the surface of the test plate. CVN specimens shall have the notch perpendicular to the welded assembly top surface, shall be centered in weld metal, and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. No specimens shall be removed from within 3/4-inch of the ends of the welded test assembly. See figure 3 for more specimen location information.

5/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate may be decreased below the minimum length, but shall not be less than 12 inches.

6/ See Main Body 3.15 for additional welding requirements.

Table XII. Welded test assembly for MIL-100S (low and high cooling rate test) and for MIL-120S (low cooling rate test). 6/

Type	100S		120S	
Purpose	Qualification	Quality conformance	Qualification	Quality conformance
Welding process	All	All	All	All
Stress Relief	(See note 1/)	(See note 1/)	(See note 1/)	(See note 1/)
Base Material	Table IX	Table IX	Table IX	Table IX
Welding parameters	(See note 2/)	(See note 2/)	(See note 2/)	(See note 2/)
Shielding gas	(See note 3/)	(See note 3/)	(See note 3/)	(See note 3/)
Cooling rate	High and low	High and low	Low	Low
Joint configuration	Figure 1	Figure 1	Figure 1	Figure 1
Thickness (T) (inches)	1	1	3/4	3/4
Width (W) (inches)	15 minimum	15 minimum	15 minimum	15 minimum
Length (L) (inches) 5/	30 minimum	24 minimum	30 minimum	24 minimum
Root opening (R) (inches)	1/2 minimum	1/2 minimum	1/2 minimum	1/2 minimum
Root Face (F) (inches)	0 to 1/16	0 to 1/16	0 to 1/16	0 to 1/16
Included angle (θ)	45	45	45	45
Backing strap size (B) (inches)	1/2 by 1-1/2	1/2 by 1-1/2	1/2 by 1-1/2	1/2 by 1-1/2
Test specimens (number/type)	From each weld: 2 tensile, 2 bend, 10 Charpy AND 4 DT (See note 4/)	From each weld: 2 tensile, 10 Charpy OR 4 DT (See note 4/)	From each weld: 2 Tensile, 2 Bend, 10 Charpy AND 4 DT (See note 4/)	From each weld: 2 Tensile, 10 Charpy OR 4 DT (see note 4/)

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. The preheat and interpass temperature shall be in accordance with table VIII. When MIL-100S tests are conducted with MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 or ASTM A 710 steel (see B.6.2) the minimum preheat and maximum interpass temperatures for the high cooling rate test shall be 60 and 125F, respectively.

3/ Shielding gas shall be argon for GTAW and argon plus 2 percent oxygen for GMAW welding electrodes. Argon plus 5 percent CO2 may also be used for GMAW welding electrodes. For MIL-120S, shielding gas for GMAW shall be either argon plus 2 percent oxygen or argon plus 5 percent CO2, as specified (see B.6.2). The neutral granular flux for the SAW process shall be in accordance with B.4.4.1 or B.4.4.3 herein, whichever is consistent with the type electrodes being tested.

4/ Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered in the weld metal at 3/8-inch below the surface of the test plate. CVN and DT specimens shall have the notch perpendicular to the welded assembly top surface, shall be centered in weld metal, and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. No specimens shall be removed from within 3/4-inch of the ends of the welded test assembly. See figure 3 for more specimen location information.

5/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate may be decreased below the minimum length, but shall not be less than 24 inches.

6/ See Main Body 3.15 for additional welding requirements.

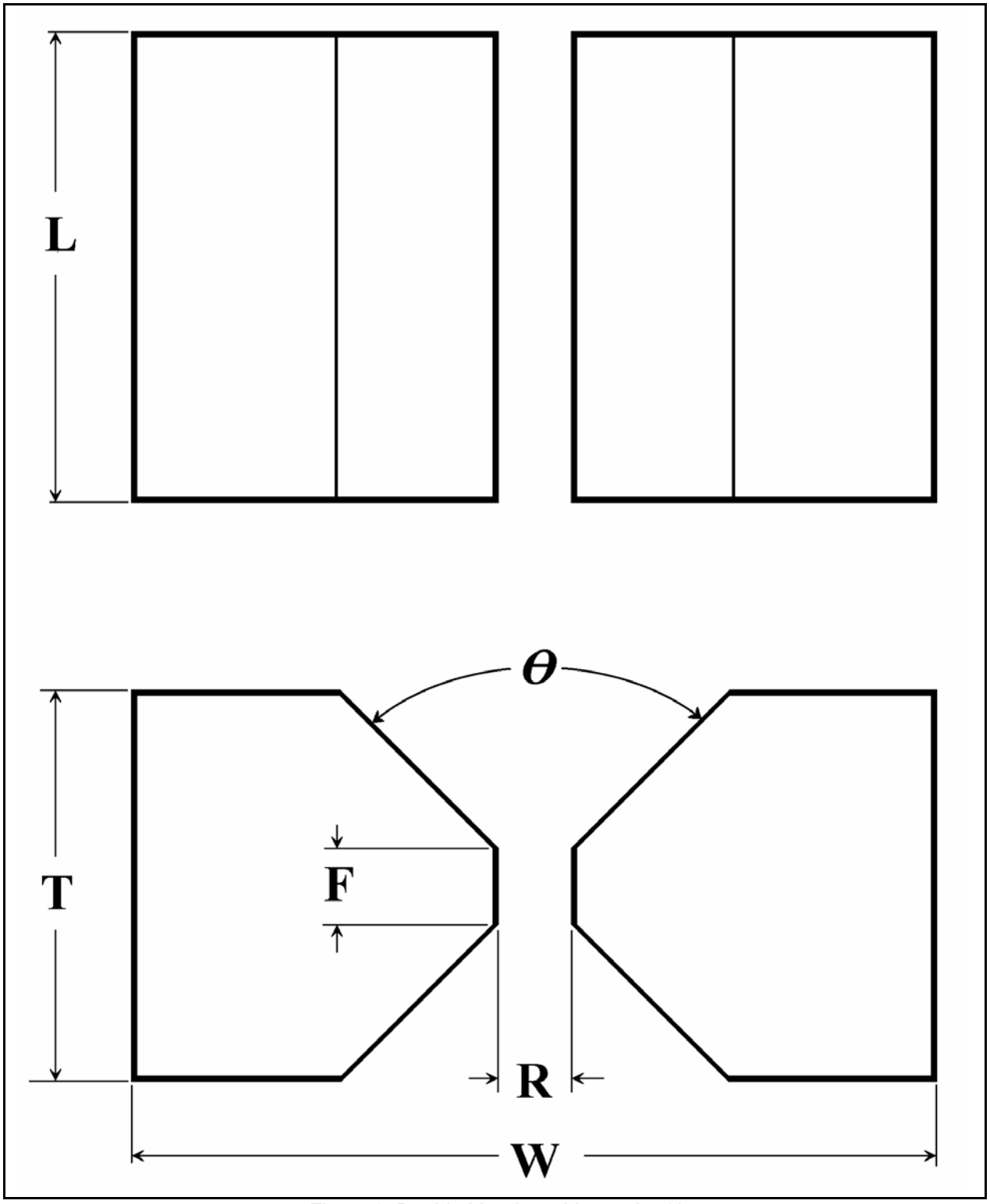


Figure 2. Double-V style weld sample. 1/

NOTES:
1/ See table XIII.

Table XIII. Welded test assembly for MIL-120S high cooling rate tests. 6/

Type	120S	
Purpose	Qualification	Quality conformance
Welding process	All	All
Stress relief	(See note 1/)	(See note 1/)
Base material	Table IX	Table IX
Welding parameters	(See note 2/)	(See note 2/)
Shielding gas	(See note 3/)	(See note 3)
Cooling rate	High	High
Joint configuration	Figure 2	Figure 2
Thickness (T) (inches)	2	2
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	30 minimum 5/	24 minimum 5/
Root opening (R) (inches)	0 to 3/16	0 to 3/16
Root Face (F) (Inches)	0 to 1/16	0 to 1/16
Included angle (θ) (degrees)	45	45
Backing strap dimensions	N.A.	N.A.
Test specimens (number/type)	From EACH side: 2 Tensile, 2 Bend, 10 Charpy AND 4 DT (See note 4/)	From EACH side: 2 Tensile, 10 Charpy OR 4 DT (See note 4/)

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

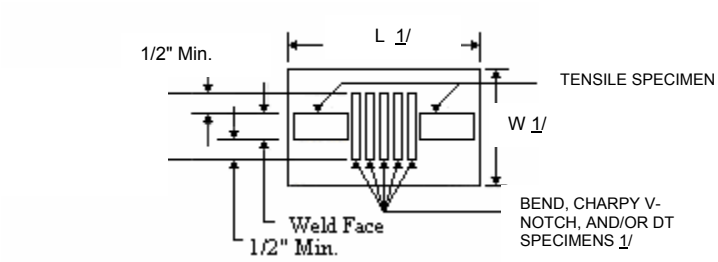
2/ The welding heat input shall be as specified in table VIII.

3/ Shielding gas shall be argon for GTAW, and argon plus 2 percent oxygen for GMAW welding electrodes. Argon plus 5 percent CO2 may also be used for GMAW welding electrodes. For MIL-120S, shielding gas for GMAW shall be either argon plus 2 percent oxygen or argon plus 5 percent CO2, as specified (see B.6.2). The neutral granular flux for the SAW process shall be in accordance with B.4.4.1 or B.4.4.3 herein, whichever is consistent with type electrodes being tested.

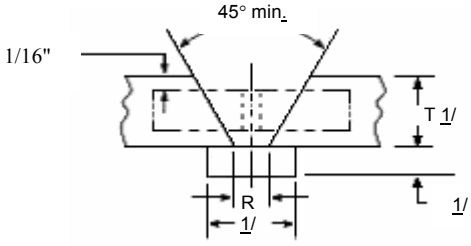
4/ Tensile specimens from each side shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered in the weld metal at 3/8 inch below the surface of side represented by the specimen. CVN and DT specimens from each side shall have the notch perpendicular to the welded assembly top surface, shall be centered in weld metal, and the top surface of each specimen shall be 1/16 inch below the surface of the side of the welded test assembly represented by the specimen. No specimens shall be removed from within 3/4 inch of the ends of the welded test assembly. Specimen location from each side shall be as illustrated in figure 3(A).

5/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate may be decreased below the minimum length, but shall not be less than 24 inches.

6/ See Main Body 3.15 for additional welding requirements.



(A) PLAN VIEW OF TEST SPECIMEN LAYOUT FOR SINGLE-V AND EACH SIDE OF DOUBLE-V TEST PLATES



(B) GROOVE PREPARATION OF SINGLE-V TEST PLATE
SHOWING ORIENTATION OF CHARPY V-NOTCH AND DYNAMIC TEAR TEST SPECIMENS

Figure 3. Welded joint for tensile and impact tests

NOTES:
1/ See tables XI, XII, and XIII as appropriate. Note that no specimens shall be removed from within 3/4-inch of the ends of the welded test assembly.

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APPENDIX C

ELECTRODES, WELDING, MINERAL COVERED, IRON-POWDER, LOW-HYDROGEN MEDIUM, HIGH TENSILE AND HIGHER-STRENGTH LOW ALLOY STEELS

C.1. SCOPE

C.1.1 Scope This appendix covers iron-powder, low-hydrogen types of covered electrodes for the fabrication and repair welding of high tensile, and higher-strength low-alloy (HY/HSLA) steels for as-welded and stress-relieved applications. This appendix is based on AWS A5.5, although it contains numerous additional requirements. This appendix is a mandatory part of the specification.

C.1.2 Classification. Electrodes shall be of the types specified (see C.3.2), and shall be of the sizes and lengths specified in AWS A5.5 (see C.6.2).

C.2. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

C.3. REQUIREMENTS

C.3.1 General. Electrodes provided under this specification shall be in accordance with AWS A5.5 and as specified herein.

C.3.2 Chemical composition. Chemical composition of deposited weld metal shall be in accordance with table I and the approved formulation, which is bracketed by the maximum and minimum values in table I.

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

C.3.3.1 Stress relieved material. For qualification inspection and when specified for quality conformance inspection (see C.6.2), the MIL-10018-M1 and MIL-10718-M welded test assembly shall be stress relieved as follows: 1125 plus or minus 25F, held at this temperature for 1 hour minimum and furnace cooled at 200F per hour or slower to 500F.

C.3.4 Coverings of electrodes.

C.3.4.1 Composition. The chemical composition of the electrode covering, except as specified in C.3.4.2 and C.3.4.3, is optional with the manufacturer.

C.3.4.2 Total iron content. The total iron content of the covering, including any combined iron in addition to metallic iron powder, shall be not less than 15 percent.

C.3.4.3 Moisture content. The absorbed moisture of the covering shall be not greater than 0.10 weight percent when removed from the manufacturer's sealed container. After exposure to elevated temperature and humidity conditions as specified in AWS A5.5, the absorbed moisture of the covering shall be not greater than 0.20 weight percent. If the infrared detection method identified in AWS A4.4 is used for determining moisture content, the maximum absorbed moisture when removed from the manufacturer’s sealed container shall be 0.15 weight percent and after exposure to elevated temperature and humidity as specified in AWS A5.5, the maximum absorbed moisture shall be 0.2 weight percent.

Table I. Chemical composition (wt. percent) of deposited weld metal. 1/

Element	MIL-10018-M1	MIL-10718-M	MIL-12018-M2
Carbon	0.06	0.07	0.07
Manganese	0.80 - 1.85	0.80 - 1.85	0.80 - 1.85
Silicon	0.65	0.60	0.65
Phosphorus	0.025	0.025	0.025
Sulfur	0.017	0.017	0.012
Chromium	0.40 4/	0.40 4/	0.65
Nickel	1.25 - 3.00	1.25 - 2.50	1.50 - 4.00
Molybdenum	0.50	0.25 - 0.50	0.90
Vanadium	0.05	0.05	0.05
Copper	2/	2/, 3/	2/, 3/
Boron	---	3/	3/

1/ Single values are maximums.

2/ When specified (see C.6.2), use of the suffix RC with MIL-10018-M1, MIL-10718-M, or MIL-12018-M2, for example MIL-10018-M1-RC, indicates that the maximum copper content of the deposited weld metal shall be 0.15 percent. The remaining basic compositional requirements remain unchanged for the specific type.

3/ Copper (except for suffix RC electrodes) shall be reported for information only. Boron shall be analyzed to the parts per million (ppm) level, reported for information and for use in calculating the carbon equivalent.

4/ When specified by the purchaser, a 0.20% maximum chromium content may be required for control of hexavalent chromium in fumes (see C.6.2)

Table II. Mechanical properties. 1/, 13/

Property	Condition	MIL-10018-M1	MIL-10718-M	MIL-12018-M2
Yield strength (ksi)	As-welded	82 - 110 2/	88 - 122 2/, 12/	102 - 123 2/, 3/
	Stress relieved	80	86	----
Ultimate tensile strength (ksi)		4/	4/	4/
Elongation in 2 inches (percent)	As-welded	20 5/	20 5/	18 5/
	Stress relieved	20	20	----
Transverse side bend		6/	6/	6/
Charpy V-notch 8/ Energy ft-lb average @ Temperature (F)	As-welded	35@(-60F) 60@(0F)	35@(-60F) 60@(0F)	45@(-60F) 8/ 60@(0F)
	Stress relieved	20@(-60F) 50@(0F)	20@(-60F) 50@(0F)	----
Dynamic tear, Energy ft-lb average @ Temperature (F) 9/, 10/	As-welded	300@(-20F) 450@(30F)	300@(-20F) 450@(30F)	400@(-20F) 575@(30F)
Explosion test series		11/	11/	11/

1/ Single values are minimum unless otherwise noted.
2/ Yield strength shall be the average of two test specimens with no individual value more than 2 ksi below the minimum specified value. For MIL-10718-M and MIL-12018-M2, no value shall be more than 2 ksi above the maximum specified value.
3/ When specified (see C.6.2), the maximum yield strength may be 125 ksi and the maximum individual value may be 130ksi.
4/ The ultimate tensile strength and reduction of area shall be recorded for information only (both as-welded and stress-relieved when applicable).
5/ For high cooling rate tests, the minimum elongation for MIL-10018-M1 and MIL-10718-M is 18 percent; for MIL-12018-M2 it is 15 percent.
6/ 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.
7/ The average of the five values (Three values for MIL-10718-M after discarding the high and low) shall equal or exceed the minimum average specified; one of the five (three) values may be up to 10 ft-lbs (5 ft-lbs for MIL-10718-M) lower than the minimum average value. The remaining values must meet or exceed the minimum average specified.
8/ For high cooling rate tests of type MIL-12018-M2, the minimum average Charpy V-notch toughness shall be 40 ft-lbs @ minus 60F.
9/ For each testing temperature, the average value of two test specimens shall be equal to or greater than the minimum average specified. For the minus 20F test temperature, one specimen may have a value up to 50 ft-lbs below the minimum average specified. For the 30F test temperature, one specimen may have a value up to 25 ft-lbs below the minimum average specified.
10/ For high cooling rate tests, dynamic tear test results shall be reported for information only.
11/ Acceptance criteria shall be in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.
12/ A higher maximum yield strength may be qualified for specific sizes of MIL-10718-M electrodes provided all other mechanical properties are as specified in table II and when approved by NAVSEA Materials Engineering Division.
13/ Only yield strength check mechanical tolerance (see Main Body 4.7.4) is allowed on MIL-10718-M electrode.

C.3.4.4 Diffusible hydrogen. The diffusible hydrogen levels in milliliters per one hundred grams (mL/100 g) of deposited weld metal shall be not greater than the following values for welds deposited with electrodes removed from sealed manufacturer's containers:

(a) Electrodes 1/8 inch size and smaller, maximum average value of 3.2 mL/100 g and maximum single value of 4.0 mL/100g.
(b) Electrodes 5/32 inch size and larger, maximum average value of 3.5 mL/100 g and maximum single value of 4.3 mL/100 g.

A diffusible hydrogen control plan in accordance with 4.9 of Main Body is required.

C.3.4.5 Flaking and cracking of covering. The sum of the surface area of the core wire exposed by flaking and cracking of the covering shall not exceed that permitted for arc ends in accordance with AWS A5.5.

C.3.4.6 Slag characteristics. The slags deposited by the coverings shall be removable by hand tools (i.e., slag removal shall not require power tools, though power tools may be used) from the weld deposits. Slag characteristics shall be such that grinding during test plate preparation shall not be required for slag removal.

C.3.4.7 Dielectric strength. The coverings of electrodes at room temperature and in the dry condition, that is, as removed from freshly opened containers, shall have a dielectric strength that shall insulate against a difference potential of 110 volts (v), 60 hertz (Hz), alternating current (ac), unless otherwise specified by the purchaser (see C.6.2).

C.3.5 Electrode identification. The MIL grade shall be indicated on each electrode. When specified (see C.6.2), each electrode shall also be marked (in addition to the requirements of AWS A5.5) with the heat, lot, or other controlled marking code.

C.3.6 Visual/dimensional inspections. Sampling for visual and dimensional inspection shall be as specified in Main Body 4.4.3. Identification shall be in accordance with C.3.5. Electrode sizes, lengths and tolerances, electrode core wire and covering quality and concentricity, electrode grip end and arc end requirements shall be in accordance with AWS A 5.5.

C.4. VERIFICATION

C.4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.2)
b. Quality conformance inspection (see 4.3).

C.4.2 Qualification inspection. Electrodes selected for qualification shall be used for tests specified in table III. Type MIL-10018-M1 shall be tested in both the as-welded and stress-relieved conditions. Schedule A tests shall be conducted by the manufacturer, and upon successful completion of these tests, schedule B testing will be conducted at a Government test facility (see 6.3 of Main Body). The manufacturer or contractor will be responsible for funding schedule B testing unless other funding provisions are arranged with the Government or prime contractor.

C.4.2.1 Special instructions. When applying for test authorization, or after tests have been authorized and when samples are submitted, the manufacturer shall furnish the following information, as appropriate. (NOTE: This information, together with test results obtained with the

electrode sample, shall form a part of the qualification test; all information will be held in confidence by the Government.)

C.4.2.1.1 For covered electrode lots conforming to AWS A5.01 classification C4.

(a) The lengths of the electrodes and diameters of coating and core wire.
(b) Type under which approval is desired.
(c) Composition of core wire and covering(s) in terms of nominal percentages for each constituent. 1/
(d) Composition of the deposited weld metal.
(e) Recommended amperages for each weld test. 1/
(f) Brand name.

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

C.4.2.1.2 For covered electrode lots conforming to AWS A5.01 classification C3, in addition to the information in C.4.2.1.1, the following shall be furnished for approval by the Government.

(a) Chemical composition control limits in core wire of each type electrode. 1/
(b) Method of determining core wire chemistry.
(c) Production line methods used to produce electrodes from chemically controlled core wire. 1/
(d) Procedure for control of moisture content between baking and packaging.
(e) Percent allowable variation from standard for each chemical element in the covering mixture of each type electrode. 1/
(f) Method of determining covering mixture chemistry.
(g) Production line methods used to produce electrodes from chemically controlled covering mixture. 1/

1/ Information shall be maintained at the manufacturer's plant for Government audit purposes; need not be submitted.

C.4.2.1.3 Change Control Procedure. The manufacturer shall document the criteria and procedure for verifying the acceptability of any changes, which may be made in key processes after qualification of the product, that may affect the design or performance of the product. The change control procedure shall be maintained at the manufacturer's plant for Government audit purposes and need not be submitted. Any changes, which are determined necessary to a process that negatively affect the acceptable performance of the product shall be submitted to NAVSEA Materials Engineering Division for concurrence with the supporting data to show acceptability.

C.4.2.2 Qualification samples. Each manufacturer shall furnish sample packages and electrodes of the type to be qualified. Quantities shall be as requested by the qualifying activity or laboratory.

Table III. Summary of tests required for qualification.

Test	Schedule		Test Procedures	Requirements
	A	B		
Chemical analysis	X	---	AWS A5.5, Main Body 4.8, and C.4.5 herein	Table I herein
Total iron in covering	X	---	C.4.6 herein	C.3.4.2 herein
Covering flaking and cracking	X	---	C.4.7 herein	C.3.4.5 herein
Dielectric strength	X	---	C.4.8 herein	C.3.4.7 herein
Alloy identity	X	X	AWS 5.01	Main Body 3.8
Covering moisture	X	X	AWS A4.4	C.3.4.3 herein
Diffusible hydrogen	X	X	AWS A4.3	C.3.4.4 herein
Welded test assembly	X	X	C.4.4 herein	Figures 1 and 2 herein
Nondestructive testing of MIL-10718-M	X	X	Main Body 4.5	Main Body 3.7
Nondestructive testing of MIL-10018-M1 and MIL-12018-M2	X	X	Main Body 4.5.1 and C.4.9 herein	Main Body 3.7.1
Visual and Dimensional Examination	X	X	Main Body 4.4.3	C.3.6
Tension 1/	X	X	AWS B4.0	Table II herein
Transverse side bend	X	X	AWS B4.0	Table II herein
Charpy V-notch 1/ 2/	X	X	AWS B4.0	Table II herein
Dynamic tear 2/	X	X	AWS B4.0	Table II herein
Explosion test series 3/	---	X	C.4.4.2 herein	Table II herein

1/ Tests shall be conducted for the as-welded condition for all electrodes, and for the stress relieved condition for MIL-10018-M1 and MIL-10718-M electrodes.

2/ See figures 1 and 2 and their associated tables for requirements on Charpy V-notch and Dynamic tear testing. Tables IX, X, XI, XII and XIII specify when CVN or DT testing is required.

3/ When explosion testing is required, all sizes shall be qualification tested in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300 for conformance. However, when qualifying a smaller size electrode of a type previously qualified, if NAVSEA Materials Engineering Division determines the results of the mechanical property tests indicate that the weld metal properties are equivalent to the larger size electrode previously qualified, the explosion crack starter test shall be omitted.

C.4.3 Conformance inspection. Quality conformance inspection tests shall be performed in accordance with table IV. For each lot of material, sufficient samples shall be selected to perform the tests listed. Quality conformance tests shall be conducted by the manufacturer.

C.4.3.1 Lot.

C.4.3.1.1 MIL-10018-M1 and MIL-10718-M electrodes. For MIL-10018-M1 and MIL-10718-M electrodes, a lot shall be defined as a Class C3 lot as described in AWS A5.01.

Table IV. Summary of tests required for quality conformance inspection. 1/

Test	Test Procedures	Requirements
Chemical analysis	Main Body 4.8, AWS A5.5, and C.4.5 herein	Table I herein
Alloy identity	AWS A5.01	Main Body 3.8
Covering moisture	AWS A4.4	C.3.4.3 herein
Diffusible hydrogen	AWS A4.3	C.3.4.4 herein
Welded test assembly	C.4.4 herein	Figures 1 and 2 herein
Nondestructive testing of MIL-10718-M	Main Body 4.5	Main Body 3.7
Nondestructive testing of MIL-10018-M1 and MIL-12018-M2	Main Body 4.5.1 and C.4.9 herein	Main Body 3.7.1
Visual and Dimensional Examination	Main Body 4.4.3	C.3.6
Tension	AWS B4.0	Table II herein
Charpy V-notch 2/	AWS B4.0	Table II herein
Dynamic tear 2/	AWS B4.0	Table II herein

1/ For type MIL-10018-M1 and MIL-10718-M, stress relieved mechanical and impact properties shall be determined only when specified (see C.6.2).
2/ See figures 1 and 2 and their associated tables for the requirements on Charpy V-notch and Dynamic tear tests.

C.4.3.1.2 MIL-12018-M2 electrodes. For MIL-12018-M2 electrodes, a lot shall be defined as a Class C4 lot as described in AWS A5.01. Subject to Government approval, a lot may be defined as the amount produced in a continuous 8 hour period of a Class C3 lot as described in AWS A5.01. Under this definition, should any lot fail due to unacceptable toughness or yield strength, the lot definition shall revert back to Class C4 until five consecutive lots are successfully tested, and the Government approves the data.

When the modified 8 hour Class C3 lot definition is in use, and a series of 50 consecutive lots have been successfully tested, the lot definition may be changed to a Class C3 lot, subject to Government approval. The failure of any lot due to unacceptable toughness or yield strength shall result in the lot definition reverting back to Class C4.

C.4.4 Weld metal test procedures.

C.4.4.1 Qualification and quality conformance samples.

C.4.4.1.1 MIL-10018-M1 electrode. The test assembly shall be welded, machined, and tested as specified in table V. Heat input requirements are as follows:

(a) As specified in Main Body 4.12 and Tables V, IX, and X.
(b) The operational heat input of at least 80% of all individual passes shall be within the specified heat input range. No pass shall have an operational heat input more than 5kJ/in outside the specified range.
(c) Average heat input shall fall within the heat input range specified.

C.4.4.1.2 MIL-10718-M electrode. The test assembly shall be welded, machined, and tested as specified in table VI. Heat input requirements are as follows:

(a) As specified in Main Body 4.12 and tables VI, IX and XI.
(b) The operational heat input of at least 90% of all individual passes shall be within the specified heat input range.
(c) No pass shall have an operational heat input more than 5kJ/in outside the specified range.
(d) Average heat input shall fall within the heat input range specified.

C.4.4.1.3 MIL-12018-M2 electrode. The test assembly shall be welded, machined, and tested as specified in table VII. Heat input requirements are as specified in Main Body 4.12, C.4.4.1.1, and tables VII, XII and XIII.

C.4.4.2 Explosion crack starter tests.

C.4.4.2.1 Welding parameters. Fabrication of the explosion test assemblies and mechanical property prolongation assemblies shall be in accordance with table VIII.

C.4.4.2.2 Test requirements. Two crack starter tests shall be conducted in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300. These tests shall be conducted at zero degrees Fahrenheit, unless otherwise specified by the NAVSEA Materials Engineering Division. The mechanical property prolongations shall be tested in accordance with MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300.

C.4.5 Chemical analysis. Welding of chemical analysis test pads for the electrodes in C.4.5.1 and C.4.5.2 shall be as specified in AWS A5.5. In event of variances with composition requirements or conflicting results by testing activities, analysis shall be verified by procedures specified in AWS A5.5.

C.4.5.1 Chemical analysis of MIL-10018-M1. For MIL-10018-M1 electrodes, if chemical analysis is not determined using chemical analysis test pads welded as specified in AWS A5.5, chemical analysis shall be determined from a milling sample taken from the centerline of the broken tensile specimens or drillings, or by optical emission spectroscopy on any sample that is taken and analyzed at the depth of the tensile specimen centerline.

C.4.5.2 Chemical analysis of MIL-10718-M and MIL-12018-M2. For each diameter of MIL-10718-M and MIL-12018-M2 electrodes, two chemistry pads per lot shall be prepared. One pad shall use electrode from the beginning of the lot and one pad shall use electrode from the end of the lot. Test results for both chemistry pads shall be reported, the values averaged, and the average shall be reported. Averaged chemical analysis values from the chemistry pads shall meet the requirements for MIL-10718-M or MIL-12018-M2, as appropriate, specified in table I and shall determine acceptability of the lot.

In addition for each diameter of MIL-10718-M and MIL-12018-M2 electrode, electrodes from the beginning and end of each lot shall be used to prepare test welds (see figures 1 and 2 as appropriate). Electrodes from the beginning of the lot shall be used for the low cooling rate weld and electrodes from the end of the lot shall be used for the high cooling rate weld. The chemical analyses shall be performed on a milling sample taken from the centerline of the broken tensile specimen(s) or by optical emission spectroscopy on any weld metal sample that is taken and analyzed at the depth of the tensile specimen(s) centerline. Results of chemical analysis from the high and low cooling rate test welds (see Tables VI and VII) shall be averaged and used to determine the carbon equivalent for the lot (see Main Body 4.8.3). When specified (see C.6.2), MIL-10718-M and MIL-12018-M2 electrodes representing the highest and lowest carbon equivalent lots in the order shall be identified for receipt inspection by the user.

Table V. Welding parameters for MIL-10018-M1 weld metal test sample. 1/, 3/

Type	10018-M1													
Base metal	HY-80 steel in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300 2/													
Electrode size tested (inches)	3/32		1/8		5/32		3/16		7/32		1/4		5/16	
Welding process	SMAW		SMAW		SMAW		SMAW		SMAW		SMAW		SMAW	
Position	Vertical up	Flat	Vertical up	Flat	Vertical up	Flat	Flat		Flat		Flat		Flat	
Welding current plus or minus 5 percent (amperes) 4/	95	95	5/	140	5/	170	5/	225	5/	300	5/	350	5/	430
Plate thickness (T) (inches)	1	3/4	1	3/4	1	3/4	1	3/4	1	3/4	1	3/4	1	3/4
Cooling rate	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Joint configuration 7/	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1	Fig. 1
Heat input (kJ/in) 6/	25 to 35	35 to 40	30 to 40	44 to 50	30 to 40	50 to 60	30 to 40	50 to 60	30 to 40	50 to 60	30 to 40	50 to 60	30 to 40	50 to 60
Preheat and interpass temperature (F) 8/	125 to 150	275 to 300	125 to 150	275 to 300	125 to 150	275 to 300	125 to 150	275 to 300	125 to 150	275 to 300	125 to 150	275 to 300	125 to 150	275 to 300

1/ Peening of weld beads shall not be permitted.

2/ When only Charpy V-notch tests are to be conducted, the base plate material shall be HY-80 steel in accordance with the chemical composition requirements of MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300, but the plate material can be in the as-rolled condition without being quenched and tempered, or tested for mechanical properties. If it is necessary to splice two plates together to form the base plates, they shall be welded with full penetration welds.

3/ See Main Body 3.15 for additional welding requirements.

4/ Welding current shall be direct current, electrode positive (DCEP) (d.c. reverse polarity).

5/ Welding current shall be selected by the manufacturer consistent with the other specified parameters.

6/ The difference in average heat input between the high and low cooling rate tests shall be not less than 20 kJ/in (except for the 3/32 and 1/8 inch diameter electrodes, where it shall not be less than 5 kJ/in and 10 kJ/in, respectively). An alternate heat input range may be specified by the purchasing activity to reflect the minimum and maximum cooling rate the purchasing activity will use with agreement from the manufacturer (see C.6.2).

7/ The split-weave technique (the practice of depositing only two wide-weave beads per layer) shall be limited to the first 1/2T of weld joint thickness. Each weld layer beyond the first 1/2T of weld joint thickness shall contain three or more beads which are deposited in sequence across the weld joint.

8/ When tests are conducted using MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 or ASTM A710 steel (see C.6.2), the minimum preheat and maximum interpass temperatures for the high cooling rate test shall be 60 F and 125 F, respectively.

Table VI. Welding parameters for MIL-10718-M weld metal test sample. 1/, 3/, 6/, 9/

Type	10718-M 8/											
Base Metal	HY-100 steel in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300. 2/											
Electrode size (inches)	3/32		1/8		5/32		3/16		7/32		1/4	
Welding process	SMAW		SMAW		SMAW		SMAW		SMAW		SMAW	
Position	Vertical up	Flat	Vertical up	Flat	Vertical up	Flat	Flat		Flat		Flat	
Welding current plus or minus 5 percent (amps) 4/	95	5/	125	140	5/	180	5/	235	5/	300	5/	350
Plate thickness	1	3/4	1	3/4	1	3/4	1	3/4	1	3/4	1	3/4
Cooling rate	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Joint configuration	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1	Figure 1
Heat input (kJ/in)	28 to 32	37 to 42	28 to 34	51 to 57	37 to 43	52 to 58	40 to 46	52 to 58	40 to 46	52 to 58	40 to 46	52 to 58
Preheat and interpass temperature (F) 7/	100 to 125	275 to 300	100 to 125	275 to 300	100 to 125	275 to 300	100 to 125	275 to 300	100 to 125	275 to 300	100 to 125	275 to 300

1/ Peening of weld beads shall not be permitted.

2/ Unless otherwise specified (see C.6.2), the base material shall be HY-100 steel in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300. When only Charpy V-notch tests are to be conducted, the base plate material shall be HY-100 steel in accordance with the chemical composition requirements of MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300, but the plate material can be in the as-rolled condition without being quenched and tempered, nor tested for mechanical properties. If it is necessary to splice two plates together to form the base plates, they can be welded with full penetration welds.

3/ See Main Body 3.15 for additional welding information.

4/ Welding current shall be direct current, electrode positive (DCEP) (d.c. reverse polarity).

5/ Welding current shall be selected by the manufacturer consistent with other specified parameters.

6/ The split-weave technique (the practice of depositing only two wide-weave beads per layer) shall be limited to the first 1/2T of weld joint thickness. Each weld layer beyond the first 1/2T of weld joint thickness shall contain three or more beads which are deposited in sequence across the weld joint.

7/ When tests are conducted using MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 or ASTM A710 steel (see C.6.2), the minimum preheat and maximum interpass temperatures for the high cooling rate test shall be 60 F and 125 F, respectively.

8/ Electrodes from the beginning of the lot shall be used for the low cooling rate weld and electrodes from the end of the lot shall be used for the high cooling rate weld.

9/ Alternate NAVSEA Materials Engineer Division approved weld parameters may be specified by the purchaser (see C.6.2)

Table VII. Welding parameters for MIL-12018-M2 weld metal test sample. 1/, 3/

Type	12018-M2 9/							
Base metal	HY-100 steel in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300 2/							
Electrode size tested (inches)	3/32		1/8		5/32		3/16	
Welding process	SMAW		SMAW		SMAW		SMAW	
Position	Vertical up	Flat	Vertical up	Flat	Horizontal	Flat	Flat	
Welding current plus or minus 5 percent (amperes) 4/	8/	8/	8/	8/	8/	8/	8/	8/
Plate thickness (inches)	2 6/	3/4	2 6/	3/4	2 6/	3/4	2 6/	3/4
Cooling rate	High	Low	High	Low	High	Low	High	Low
Joint configuration 7/	Figure 2	Figure 1	Figure 2	Figure 1	Figure 2	Figure 1	Figure 2	Figure 1
Heat input (kJ/in) 8/	5/	5/	37 to 43 5/	47 to 53 5/	27 to 33 5/	42 to 48 5/	5/	5/
Preheat and interpass temperature (F) 8/	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325	200 to 225	300 to 325

1/ Peening of weld beads shall not be permitted.

2/ When only Charpy V-notch tests are to be conducted, the base plate material shall be HY-100 steel in accordance with the chemical composition requirements of MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300, but the plate material can be in the as-rolled condition without being quenched and tempered, or tested for mechanical properties. If it is necessary to splice two plates together to form the base plates, they shall be welded with full penetration welds.

3/ See Main Body 3.15 for additional welding information.

4/ Welding current shall be direct current, electrode positive (DCEP) (d.c. reverse polarity).

5/ For 3/32- and 3/16-inch electrodes, a heat input range shall be specified by the purchasing activity (with the agreement of the manufacturer) to reflect the minimum and maximum cooling rate the purchasing activity will use (see C.6.2). Heat input ranges for 1/8- and 5/32-inch electrodes shall be as specified unless otherwise specified by the purchasing activity (with the agreement of the manufacturer) to reflect the minimum and maximum cooling rate the purchasing activity will use (see C.6.2).

6/ For these test plates, 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.

7/ The direction of welding shall be the same for all beads in a weldment. The split-weave technique shall be limited to the first 1/2T of weld joint thickness. Each weld layer beyond the first 1/2T of weld joint thickness shall contain three or more beads, which are deposited in sequence across the weld joint.

8/ Welding parameters shall be selected by the manufacturer consistent with the specified heat input (see note 5, above).

9/ Electrodes from the beginning of the lot shall be used for the low cooling rate weld and electrodes from the end of the lot shall be used for the high cooling rate weld.

Table VIII. Explosion test sample welding parameters. 1/, 5/, 6/

Type	MIL-10018-M1		MIL-10718-M		MIL-12018-M2	
Base metal	HY-80 in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300		HY-100 in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300		HY-100 in accordance with MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300	
Welding polarity	DCEP		DCEP		DCEP	
Test assembly requirements 2/	MIL-STD-2149/NAVSEA Technical Publication T9074-BD-GIB-010/0300					
Electrode size 6/	5/32 and smaller	3/16 and larger	5/32 and smaller	3/16 and larger	5/32 and smaller	3/16 and larger
Welding position	Vertical up	Flat	Vertical up	Flat	Vertical up	Flat
Preheat and interpass temperatures	250 +25F/-0F					
Heat input 3/	4/					

1/ Peening of weld beads shall not be permitted.

2/ The joint surfaces shall not be clad or buttered.

3/ Welding amperage shall be in accordance with the manufacturer's recommendations and the actual values used shall be recorded and reported.

4/ The heat input shall be 50 to 60 kJ/in for the 1/8- or 5/32-inch size and larger electrodes and 30 to 40 kJ/in for 3/32 inch size electrodes (see note 6 and Main Body 4.12).

5/ See Main Body 3.15 for additional welding requirements.

6/ Explosion testing shall be conducted on 1/8 or 5/32-inch electrode sizes. Explosion testing of other electrode sizes (from the same manufacturer) are not required provided the same basic formulation and design as used in the qualified electrode size (1/8- or 5/32-inch) is used in the other sizes of electrode, modified as required for the differences in core size, coating thickness and position requirements of these different size electrodes.

C.4.6 Total iron in covering. The total iron content of the covering shall be determined by wet chemical or spectrographic methods. In the case of dispute, the referee method shall be ASTM E 316.

C.4.7 Flaking and cracking of covering. Six electrodes shall be tested for flaking and cracking tendency in accordance with C.4.7.1 and C.4.7.2. Welding current shall be as specified in table V, VI and VII as appropriate. The welding shall consist of depositing a weld bead on a plate surface.

C.4.7.1 Flaking and cracking during welding. Three electrodes shall be tested. The electrode shall be consumed to a stub not exceeding 2 inches in length. If flaking or cracking is observed during welding, the welding shall be stopped immediately and the arc end of the electrode examined for conformance to the requirements of C.3.4.5. If no flaking or cracking is observed during welding, the 2-inch stub length of electrode, which is normally discarded, shall not be examined.

C.4.7.2 Flaking and cracking during restart. Three electrodes shall be tested. The covering shall be grooved to the core wire completely around the electrode at the midpoint of the length. The groove shall be prepared by grinding with the edge of a grindstone (intersection of the flat side of the grindstone with its periphery). The core wire shall be uncovered at the root of the groove to form a land 1/16 inch minimum in width measured along the length of the electrode. The core wire shall not be undercut. The electrode shall be consumed to the root of the groove in the covering, at which time welding shall be stopped without fusing the coating beyond the groove. The half-length electrode shall be removed immediately from the electrode holder and placed on a flat steel plate to cool until it can be held comfortably in the bare hand. After cooling, the electrode shall be inserted in the electrode holder and welding resumed. After the restart, the half-length electrode shall be consumed for 1 inch of its length. Welding shall then be stopped, and the arc end of the electrode examined for conformance to the requirements of C.3.4.5.

C.4.8 Dielectric strength. Dielectric strength of coverings shall be determined by the method shown on figure 4. Methods other than the one shown in figure 4, yielding the required results, may be used as alternates if such methods are acceptable to NAVSEA Materials Engineering Division.

C.4.9 Nondestructive testing. Radiographic inspection is not required for MIL-12018-M2 weldments made at high cooling rates.

C.5. PACKAGING

C.5.1 Packaging. See note on special packaging in Main Body 5.1. For standard acquisition, packaging shall be in hermetically sealed containers as specified in AWS A5.5.

C.6. NOTES

C.6.1 Intended use. This specification is intended to cover several arc-welding electrodes of various alloys and strength levels that deposit weld metal that meets the mechanical property requirements given herein. These electrodes have an extremely low covering moisture content and should reduce the likelihood of underbead cracking in welding of such high yield strength steels as HY-80 and HY-100 of MIL-S-16216/NAVSEA Technical Publication T9074-BD-GIB-010/0300, HY-130 of MIL-S-24371/NAVSEA Technical Publication T9074-BD-GIB-010/0300, and HSLA-80 and HSLA-100 of MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300.

C.6.1.1 MIL-10018-M1. This type is intended for general use in the welding of HY-80 and HSLA-80 steels for as-welded applications and stress-relieved. This electrode is intended for use with dc, electrode positive (DCEP) (dc, reverse polarity) electrical characteristics only.

C.6.1.2 MIL-10718-M. This type is intended to cover low-alloy electrodes for welding joints in HSLA-80, HY-80, HSLA-100 and HY-100 steels where approved; and other applications where improved toughness and usability are required. This electrode is intended for use with dc, electrode positive (DCEP) (dc, reverse polarity) electrical characteristics only.

C.6.1.3 MIL-12018-M2. This type is intended for general use in the welding of HY-100 and HSLA-100 steel for as-welded applications. This electrode is intended for use with dc, electrode positive (DCEP) (dc, reverse polarity) electrical characteristics only.

C.6.1.4 MIL-10018-M1, MIL-10718-M, and MIL-12018-M2 types with suffix RC. Restricted copper electrodes will be used when specified (see C.6.2 and Table I). These types are intended to cover electrodes for welding pressure and strength welds that will be subject to irradiation.

C.6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number and date of this appendix.
(b) Type, size, and length required (see C.1.2).
(c) If stress relief of welded test assembly for MIL-10018-M1 or MIL-10718-M is required for quality conformance inspection (see C.3.3.1 and footnote 1/ to table IV).
(d) Whether the copper content is restricted as designated by the suffix RC to the appropriate type (see footnote 2/ to table I).
(e) Whether a maximum chromium content of 0.20% is required to control hexavalent chromium in welding fumes (see footnote 4/ of table I)
(f) Whether higher maximum yield strength is allowed for type MIL-12018-M2 (see footnote 3/ to table II).
(g) Whether electrodes shall have a dielectric strength other than a dielectric strength able to insulate against 110 volts, 60-Hertz alternating current (see C.3.4.7).
(h) Whether heat, lot, or other marking codes are required for individual electrodes (see C.3.5).
(i) Whether the highest and lowest carbon equivalent electrodes shall be identified (see C.4.5.2 and Main Body 4.8.3).
(j) What preheat and interpass temperature, and what heat inputs are required for MIL-10018-M1 (see footnote 6/ to table V)
(k) Whether a second test weldment is required using ASTM A710 or MIL-S-24645/NAVSEA Technical Publication T9074-BD-GIB-010/0300 grade HSLA-80 steel base plate material (see footnote 8/ to table V and footnote 7/ to table VI).
(l) When an alternate base material is to be used with MIL-10718-M (see footnote 2/ to table VI).
(m) When alternate NAVSEA Materials Engineer Division approved weld parameters are to be used with MIL-10718-M (see footnote 9/ to table VI).
(n) The heat input range of MIL-12018-M2 electrodes (see footnote 5/ to table VII).

C.6.3 Subject term (key word) listing.

Core wire
Shielded metal arc welding
Welding electrode
Chemical composition
Mechanical properties
Non-destructive testing
Diffusible hydrogen
Dielectric Strength

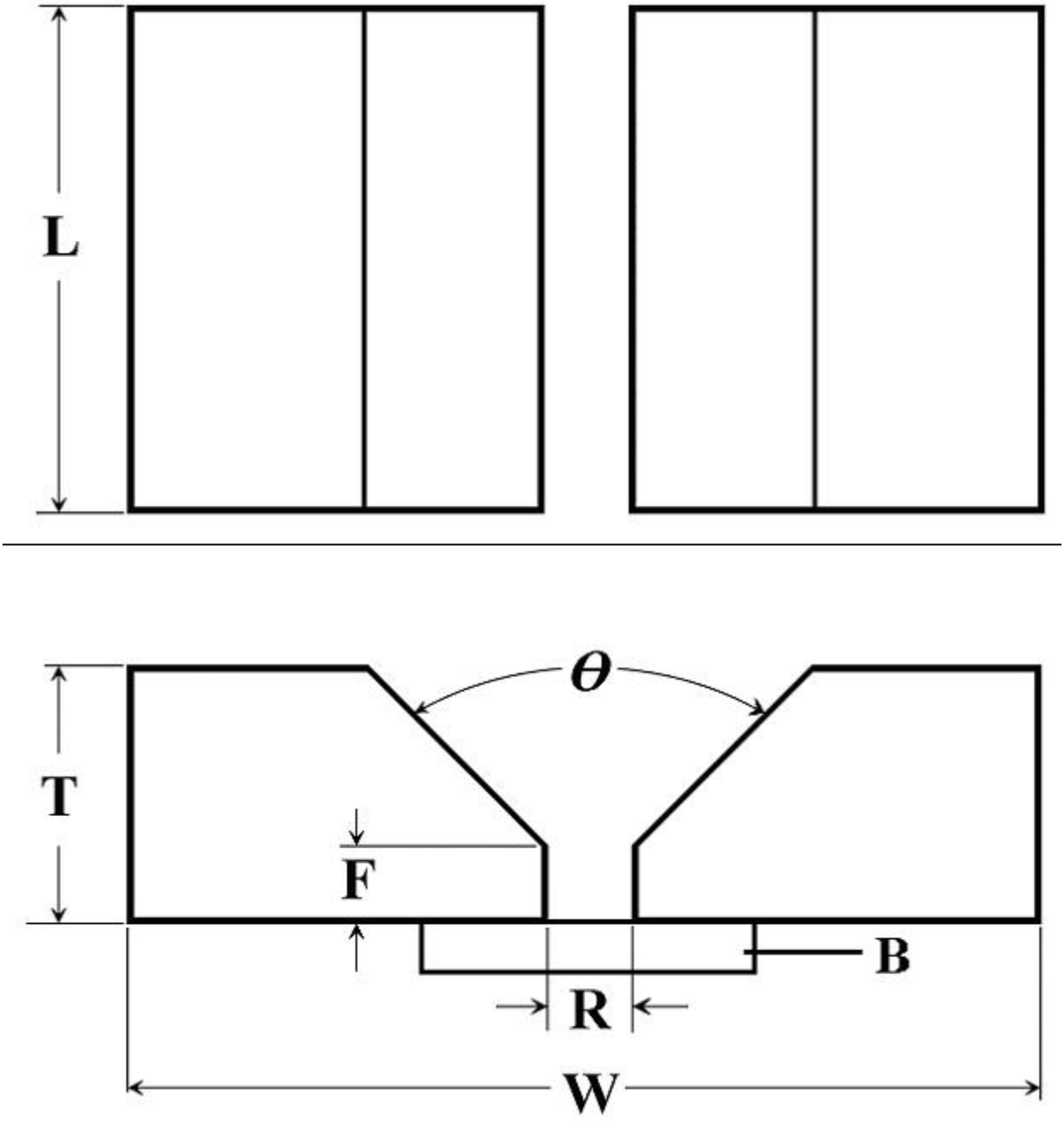


Figure 1. Single-V style weld joint configuration. 1/

NOTES:
1/ See tables IX, X, XI, and XII.

Table IX. Welded test assembly stress relieved applications. 6/

Type	10018-M1 and MIL-10718-M Stress relieved	
Purpose	Qualification	Quality conformance
Stress relief	(See note 1/)	(See note 1/)
Welding parameters	(See note 2/)	(See note 2/)
Joint configuration 3/	Figure 1	Figure 1
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches) 5/	24 minimum	24 minimum
Root opening (R) (inches) 7/	1/4 minimum	1/4 minimum
Root face (F) (inches)	0 to 1/32	0 to 1/32
Included angle (θ) (degrees)	45	45
Backing strip dimensions (B) (thickness x width) (inches) 8/	1/2 x 1-1/2	1/2 x 1-1/2
Test specimens (number/type) 4/	From each weld: 2 Tension 2 Bend 10 Charpy	From each weld: 2 Tension 10 Charpy

1/ Prior to machining specimens or removing backing strip, weldments shall be stress relieved in accordance with C.3.3.1.

2/ Welding parameters shall be in accordance with table V and table VI, as appropriate.

3/ Plate thickness (T) shall be in accordance with table V and table VI, as appropriate.

4/ Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered at 3/8 inch below the surface in the weld metal. CVN specimens shall have the notch perpendicular to the welded assembly top surface, shall be centered in the weld metal and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. No specimens shall be removed from within 3/4-inch of the ends of the welded test assembly. See figure 3 for more specimen location information.

5/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate shall not be less than 18 inches.

6/ See Main Body 3.15 for additional welding requirements.

7/ Root opening shall be 1/2" plus or minus 1/16" for MIL-10718-M

8/ Backing strip shall be 1/4" x 1-1/2" for the MIL-10718-M low cooling rate weld

Table X. Welded test assembly MIL-10018-M1 as-welded. 6/

Type	10018-M1	
Purpose	Qualification	Quality conformance
Stress relief	(See note 1/.)	(See note 1/.)
Welding parameters	(See note 2/.)	(See note 2/.)
Joint configuration 3/	Figure 1	Figure 1
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches) 5/	30 minimum	24 minimum
Root opening (R) (inches)	1/4 minimum	1/4 minimum
Root face (F) (inches)	0 to 1/32	0 to 1/32
Included angle (θ) degrees	45 minimum	45 minimum
Backing strip dimensions (B) (thickness x width) (inches)	1/2 x 1-1/2	1/2 x 1-1/2
Test specimens (number/type) 4/	From each weld: 2 Tension 2 Bend 10 Charpy AND 4 DT	From each weld: 2 Tension 10 Charpy OR 4 DT

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

2/ Welding parameters shall be in accordance with table V.

3/ Plate thickness (T) shall be in accordance with Table V.

4/ Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered at 3/8 inch below the surface in the weld metal. CVN specimens shall have the notch perpendicular to the welded assembly top surface, shall be centered in the weld metal and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. The 5/8 inch DT specimens shall have the notch perpendicular to the welded assembly top surface and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. No specimens shall be removed from within 3/4-inch of the ends of the welded test assembly. See figure 3 for more specimen location information.

5/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate may be decreased below the minimum length, but shall not be less than 18 inches.

6/ See Main Body 3.15 for additional welding requirements.

Table XI. Welded test assembly MIL-10718-M high & low cooling rate. 3/

Type	10718-M	
Purpose	Qualification	Quality conformance
Stress relief	1/	1/
Welding parameters	2/	2/
Joint configuration 4/	Figure 1	Figure 1
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	30 minimum	24 minimum
Root opening (R) (inches)	1/2 plus or minus 1/16	1/2 plus or minus 1/16
Root face (F) (inches)	0 to 1/32	0 to 1/32
Included angle (θ) degrees	45	45
Backing strip dimensions (B) (thickness x width) (inches)	1/2 x 1-1/2 high cooling rate and 1/4 x 1-1/2 for low cooling rate	1/2 x 1-1/2 high cooling rate and 1/4 x 1-1/2 for low cooling rate
Test specimens (number/type) 5/	From each weld: 2 Tension 2 Bend 10 Charpy AND 4 DT	From each weld: 2 Tension 10 Charpy OR 4 DT

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

2/ Welding parameters shall be in accordance with table VI.

3/ See Main Body 3.15 for additional welding requirements.

4/ Plate thickness (T) shall be in accordance with Table VI.

5/ Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered at 3/8 inch below the surface in the weld metal. CVN specimens shall have the notch perpendicular to the welded assembly top surface, shall be centered in the weld metal and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. The 5/8 inch DT specimens shall have the notch perpendicular to the welded assembly top surface and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. No specimens shall be removed from within 3/4-inch of the ends of the welded test assembly. See figure 3 for more specimen location information.

Table XII. Welded test assembly MIL-12018-M2 low cooling rate. 6/

Type	12018-M2	
Purpose	Qualification	Quality conformance
Stress relief	1/	1/
Welding parameters	2/	2/
Joint configuration 3/	Figure 1	Figure 1
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	30 minimum 5/	24 minimum
Root opening (R) (inches)	1/2 minimum	1/2 minimum
Root face (F) (inches)	0 to 1/32	0 to 1/32
Included angle (θ) degrees	45	45
Backing strip dimensions (B) (thickness x width) (inches)	1/2 x 1-1/2	1/2 x 1-1/2
Test specimens (number/type) 4/	From each weld: 2 Tension 2 Bend 10 Charpy AND 4 DT	From each weld: 2 Tension 10 Charpy OR 4 DT

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

2/ Welding parameters shall be in accordance with table VII.

3/ Plate thickness (T) shall be in accordance with Table VII.

4/ Tensile specimens shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered at 3/8 inch below the surface of the weld metal. CVN specimens shall have the notch perpendicular to the welded assembly top surface, shall be centered in the weld metal and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. The 5/8 inch DT specimens shall have the notch perpendicular to the welded assembly top surface and the top surface of each specimen shall be 1/16 inch below the top surface of the welded test assembly. No specimens shall be removed from within 3/4 inch of the ends of the welded test assembly. See figure 3 for more specimen location information.

5/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate may be decreased below the minimum length, but shall not be less than 24 inches.

6/ See Main Body 3.15 for additional welding requirements.

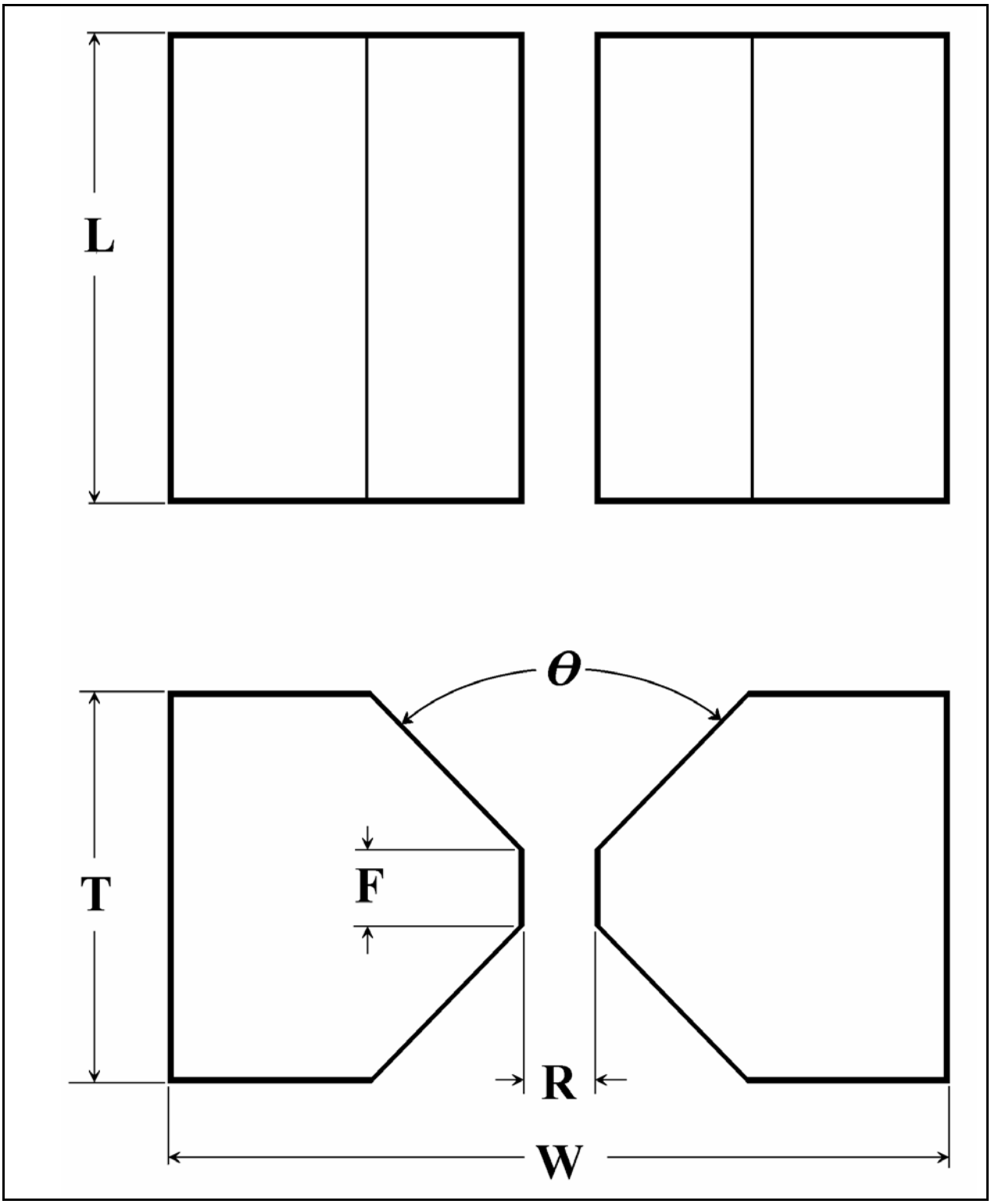


Figure 2 Double-V style weld joint configuration. 1/

NOTES:
1/ See table XIII.

Table XIII. Welded test assembly MIL-12018-M2 high cooling rate. 7/

Type	12018-M2	
Purpose	Qualification	Quality conformance
Stress relief	1/	1/
Welding parameters	2/	2/
Joint configuration 4/	Figure 2	Figure 2 3/
Width (W) (inches)	15 minimum	15 minimum
Length (L) (inches)	30 minimum 6/	24 minimum
Root opening (R) (inches)	0 to 3/16	0 to 3/16
Root face (F) (inches)	0 to 1/16	0 to 1/16
Included angle (θ) degrees	45	45
Test specimens (number/type) 5/	From EACH side: 2 Tension 2 Bend 10 Charpy AND 4 DT	From EACH side: 2 Tension 10 Charpy OR 4 DT

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

2/ Welding parameters shall be in accordance with table VII.

3/ Alternatively, high cooling rate quality conformance testing may be performed in accordance with figure 1 when approved by the Government provided:

(a) Test data from both figure 1 and figure 2 test plates demonstrate comparability with respect to cooling rate and performance.

(b) Written quality conformance test procedures submitted for approval establish welding parameter controls and comparative differences in acceptance criteria for figure 1 test plates.

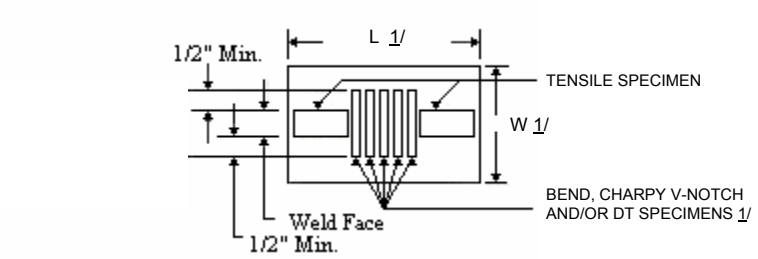
(c) When both test plates are tested, results from the figure 2 test plate shall be the authoritative test.

4/ Plate thickness (T) shall be in accordance with Table VII.

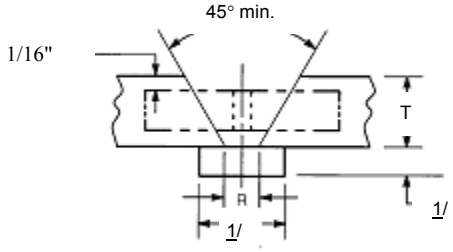
5/ Tensile specimens from each side shall be all weld metal (longitudinal axis of the specimen shall be parallel to the welding direction) and shall be centered at 3/8 inch below the surface of the side represented by the specimen. CVN specimens from each side shall have the notch perpendicular to the welded assembly top surface, shall be centered in the weld metal and the top surface of each specimen shall be 1/16 inch below the surface of the side of the welded test assembly represented by the specimen. The 5/8 inch DT specimens shall have the notch perpendicular to the welded assembly top surface and the top surface of each specimen shall be 1/16 inch below the surface of the side of the welded test assembly represented by the specimen. No specimens shall be removed from within 3/4 inch of the ends of the welded test assembly. Specimen location from each side shall be as illustrated in Figure 3 (A).

6/ For retests, when tensile and impact properties do not both need to be retested, the length of the plate may be decreased below the minimum length, but shall not be less than 24 inches.

7/ See Main Body 3.15 for additional welding requirements.



(A) PLAN VIEW OF TEST SPECIMEN LAYOUT FOR SINGLE-V AND EACH SIDE OF DOUBLE-V TEST PLATES



(B) GROOVE PREPARATION OF SINGLE-V TEST PLATE
SHOWING ORIENTATION OF CHARPY V-NOTCH AND DYNAMIC TEAR TEST SPECIMENS

Figure 3. Welded joint test specimen layout

NOTES:
1/ See tables IX, X, XI, XII and XIII as appropriate. Note that no specimens shall be removed from within 3/4-inch of the ends of the welded test assembly.

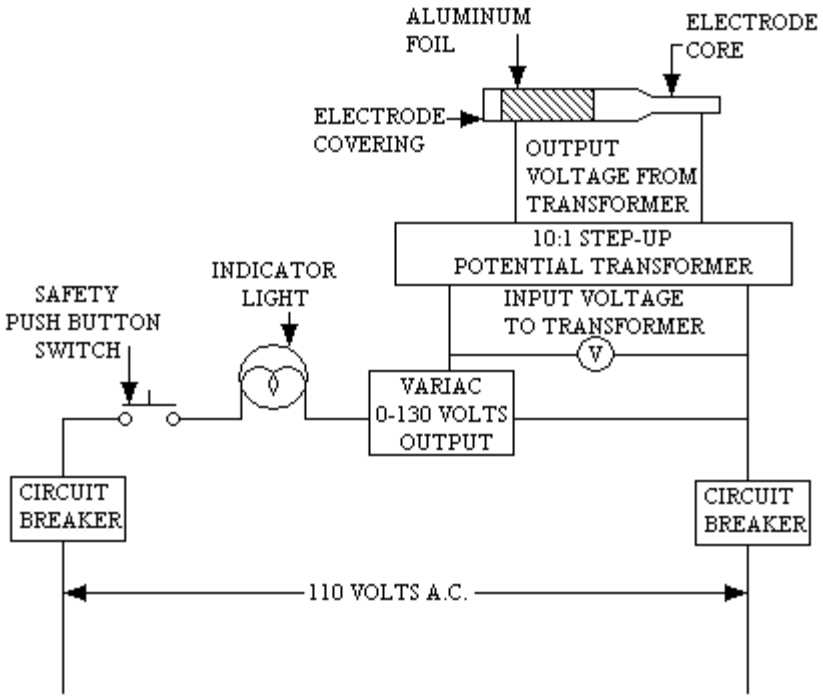


Figure 4. Circuit for dielectric strength determination.

NOTES:
1/ Wrap conducting aluminum foil around 6-inch length of electrode.
2/ Place electrode with grip-end on one lug and foil covered section on other.
3/ Close circuit breaker; press safety button and slowly rotate variac control.
4/ Record maximum voltage before breakdown.
5/ Dielectric strength is recorded voltage, multiplied by 10 (transformer ratio).
6/ When dielectric strength is below 300V, connect appropriate voltmeter across electrode terminals.

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