

PERFORMANCE SPECIFICATION
COPPER-NICKEL (70-30), WIRE ARC, DIRECTED ENERGY DEPOSITION,
ADDITIVELY MANUFACTURED

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

1. SCOPE

1.1 Scope. This specification covers additively manufactured (AM) copper-nickel (CuNi) (70-30) material made using the wire arc directed energy deposition (DED) process and an interpass temperature of 350 °F.

1.2 Classification. AM material is of the following grades and classes, as specified (see 6.2):

1.2.1 Grades.

- a. Grade A – Material manufactured in compliance with S9074-A4-GIB-010/AM-WIRE DED.
- b. Grade B – Material manufactured in compliance with manufacturer or industry standards (see 6.3).

1.2.2 Classes.

- a. Class 1 – Material manufactured using wire feedstock that is in compliance with MIL-DTL-21562, type MIL-EN67.
- b. Class 2 – Material manufactured using wire feedstock that is in compliance with AWS A5.7/A5.7M, ERCuNi.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. 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, 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 cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-21562 - Electrodes and Rods – Welding, Bare, Nickel, Nickel Alloy, Copper-Nickel Alloy

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-1684 - Control of Heat Treatment

(Copies of these documents are available online at <https://quicksearch.dla.mil>.)

Comments, suggestions, or questions on this document should be addressed to Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard, DC 20376-5160 or emailed to CommandStandards@navy.mil, with the subject line “Document Comment”. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

AMSC N/A

AREA AMPR

Distribution Statement A. Approved for public release: distribution is unlimited.

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 of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

- S9074-A4-GIB-010/AM-WIRE DED - Requirements for Metal Wire-Fed Directed Energy Deposition Additive Manufacturing
- S9074-AR-GIB-010/278 - Requirements for Fabrication Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels

(Copies of these documents are available online via Model Based Product Support (MBPS) at <https://mbps.navseaplms.navy.mil/Windchill/app/>. To gain access to MBPS, obtain an account with National Help Desk Service Management (NHDSM) at <https://nhdsm.navair.navy.mil> (a valid CAC is required to access this website) and submit a SAAR-N Request. Refer questions, inquiries, or problems to (888) 292-5919. This document is available for ordering (hard copy) via the Naval Logistics Library (NLL) at <https://nll.navsup.navy.mil>. For questions regarding the NLL, contact the NLL Customer Service at nllhelpdesk@navy.mil, (866) 817-3130, or (215) 697-2626/DSN 442-2626.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN WELDING SOCIETY (AWS)

- AWS A5.01M/A5.01 - Welding and Brazing Consumables – Procurement of Filler Metals and Fluxes
- AWS A5.7/A5.7M - Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes

(Copies of these documents are available online www.aws.org.)

ASTM INTERNATIONAL

- ASTM E8/E8M - Standard Test Methods for Tension Testing of Metallic Materials
- ASTM E478 - Standard Test Methods for Chemical Analysis of Copper Alloys

(Copies of these documents are available online at www.astm.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, 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 Feedstock. Feedstock shall be procured in the form of wire spools or drums suitable for the DED process. Wire feedstock shall be in accordance with the standards of the appropriate class (see 1.2). Each manufacturing lot (see 4.3) shall be produced from the minimum practicable number of lots of feedstock. Unless otherwise specified (see 6.2), feedstock lots from separate heats shall not be used in the same manufacturing lot. Feedstock lots and heats are defined in accordance with AWS A5.01M/A5.01.

3.2 Build platform. Unless otherwise specified (see 6.2), the build platform shall not be integrated into the printed material. If a material other than S-34 CuNi, as defined in S9074-A4-GIB-010/AM-WIRE DED, is used for a non-integrated build platform, a minimum of 0.5 inch of discardable AM build material shall separate the build platform from the final component's attached dimensional surface. Methods used for removal of the build platform (e.g., band saw, water jet, or electro-discharge machining with recast layer removed) shall not affect the mechanical properties of the AM material.

3.3 Chemical composition. DED material shall conform to the compositions specified in [table I](#). See 4.4.1 and 4.5 for composition analysis requirements.

TABLE I. Chemical composition (weight percent). ^{1/}, ^{2/}

	Class 1	Class 2
Copper plus silver ^{3/}	Balance	Balance
Carbon	0.04	*
Manganese	1.00	1.0
Iron	0.4 to 0.7	0.40 to 0.75
Sulfur	0.015	0.01
Silicon	0.25	0.25
Nickel plus cobalt ^{4/}	29.0 to 32.0	29.0 to 32.0
Titanium	0.2 to 0.5	0.20 to 0.50
Phosphorus	0.020	0.02
Lead	0.010	0.02
Other Elements, total	0.50	0.50
NOTES:		
^{1/} Analysis shall be made for the elements indicated by an asterisk (*) and those for which specific values are shown in this table. If, however, the presence of other elements is indicated during routine analysis, further analysis shall be made to determine their content. The total of these other elements shall not exceed the limits specified for the "Other Elements, total" in the last row of the table.		
^{2/} Single values are maximums.		
^{3/} Silver may or may not be present.		
^{4/} Cobalt may or may not be present.		

3.4 Heat treatment. Material shall be heat treated at 1200±25 °F for 1 hour per inch of thickness (see 6.5.2) up to a maximum of 5 hours. For material less than 1 inch thick, the material shall be heat treated for a minimum of 30 minutes. Material shall be furnace cooled to 500 °F, then air cooled to room temperature. When specified (see 6.2), heat treatment shall be in accordance with MIL-STD-1684.

3.5 Tensile properties. The tensile properties of all material shall meet or exceed the minimum values specified in [table II](#).

TABLE II. Tensile properties.

Property	Minimum value
Ultimate tensile strength (ksi)	60
Yield strength, 0.2% offset (ksi)	32
Elongation in 2 inches (%)	20

3.6 Weld repair. Unless otherwise specified (see 6.2), weld repair shall be in accordance with S9074-AR-GIB-010/278.

3.6.1 Post-weld heat treatment. When weld repairs are made to the DED material, the material shall not be post-weld heat treated unless necessary for dimensional stability. If stress relief is required, the material shall be

heat treated at 575 ± 25 °F for 1 hour per inch of thickness (see 6.5.2). For material less than 1 inch thick, the material shall be stress relieved for a minimum of 30 minutes.

3.7 Supplemental mechanical properties. Additional mechanical properties shall be as specified (see 6.2).

3.8 Surface condition. Unless otherwise specified (see 6.2), material shall be ground, machined, or otherwise finished to produce smooth surfaces.

3.9 Detrimental material controls. When needed, detrimental material controls shall be as specified (see 6.2).

4. VERIFICATION

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

a. Conformance inspection (see 4.2).

4.2 Conformance inspection. Conformance inspection shall include the examinations and tests of [table III](#).

TABLE III. Conformance inspections.

Examinations and tests	Requirement	Conformance inspection
Feedstock	3.1	4.8
Build platform	3.2	4.8
Chemical composition	3.3	4.5
Heat treatment	3.4	4.8
Tensile properties	3.5	4.6
Weld repair	3.6	4.8
Supplemental mechanical testing	3.7	4.7 and 4.8
Surface condition	3.8	4.8
Detrimental material controls	3.9	4.8

4.3 Lot size. For the purposes of inspections and tests, material produced in one build cycle, as specified in S9074-A4-GIB-010/AM-WIRE DED, and heat treated in the same furnace load shall constitute a manufacturing lot.

4.4 Sampling.

4.4.1 Chemical composition. A minimum of one sample shall be taken from each manufacturing lot for analysis, following heat treatment (see 3.4).

4.4.2 Tensile properties. A minimum of two tensile test specimens conforming to the standard round Specimen I geometry specified in ASTM E8E8M, with gauge length four times the diameter, shall be taken from each manufacturing lot for testing, with at least one specimen taken with its length in the Z orientation and at least one specimen taken with its length in either the X or Y orientation (see 6.5.1). All specimens shall be taken from heat treated material (see 3.4). Specimens shall be machined from bulk deposition or near-net shape blanks.

4.4.3 Supplemental mechanical testing. Additional test types shall be conducted with specimen quantities, geometry, and orientation as specified (see 6.2).

4.4.4 Resampling and retesting. Unless otherwise specified (see 6.2), non-conforming test results may be addressed by testing of two additional samples taken from the same manufacturing lot as the original non-conforming sample. The average of all test results shall meet specified requirements for lot acceptance. If any two samples of any type of test fail to meet the acceptance criteria, then the manufacturing lot shall be rejected. When specified (see 6.2), any manufacturing lot may be rejected based on a single tensile test.

4.5 Chemical composition. The chemical composition shall be tested and analyzed by accepted analytical methods. In case of disagreements, the referee method shall be ASTM E478.

4.6 Tensile testing. Tensile test specimens shall be tested in accordance with ASTM E8/E8M.

4.7 Supplemental mechanical tests. Additional test shall be conducted with specimen quantities, geometries, and orientations as specified (see 6.2).

4.8 Certificate of conformance. Unless otherwise specified (see 6.2), a certificate of conformance (COC) shall be provided for each lot of material offered for acceptance in accordance with the lot definition specified in 4.3. The COC shall include the following:

- a. A statement that each lot has been sampled, tested, and inspected in accordance with the requirements specified herein.
- b. For grade A material, a record of approval from the Technical Authority (see 6.5.3) or authorized representative that indicates the manufacturer is in compliance with S9074-A4-GIB-010/AM-WIRE DED.
- c. For grade B material, a statement specifying the industry standard(s) used to determine material compliance and a record of approval from the Technical Authority (see 6.5.3) or authorized representative thereof.
- d. A complete record of all heat treatments, including time, temperatures, atmosphere, and heating and cooling rates (see 3.4).
- e. A statement whether a weld repair has been performed (see 3.6), including a complete record of all repaired defects with location, weld repair inspection results, post-weld heat treatment (if any), and associated weld procedure approvals.
- f. A statement describing surface finishing method(s) used (see 3.8).
- g. When detrimental material controls are required (see 6.2), statement certifying that requirements have been met (see 3.9).
- h. A complete record of testing used to demonstrate compliance with this specification, including any failed tests.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of material is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Wire arc DED CuNi 70-30 AM material is intended as an alternative for UNS C96400 castings produced in accordance with ASTM B369 for use in Navy applications.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Grade and class required (see 1.2).
- c. When use of feedstock lots from different heats is permissible (see 3.1).
- d. Permissible material specification and grade for integrated build platform and any additional test requirements associated with its use (see 3.2).
- e. When heat treatment in accordance with MIL-STD-1684 is required (see 3.4).
- f. Weld repair requirements or restrictions (see 3.6).
- g. Acceptance criteria for supplemental mechanical property tests (see 3.7).

- h. Requirements for surface finishing (see 3.8).
- i. When needed, detrimental material control requirements (see 3.9).
- j. Sampling criteria for supplemental mechanical property tests (see 4.4.3).
- k. Requirements for resampling and retesting (see 4.4.4).
- l. Requirements for supplemental mechanical testing (see 4.7).
- m. When a certificate of conformance is not required (see 4.8).
- n. Packaging requirements (see 5.1).

6.3 DED Qualification. Grade B material requires the disclosure of a process qualification standard. Examples of appropriate commercial standards include SAE AMS7005 and AWS D20.1. These documents provide a framework to prove that the DED process is capable of producing material of consistent quality. Use of grade A material is recommended for critical applications.

6.4 Surface finish. Material produced using DED may have a rough surface finish that is associated with performance debits, particularly for corrosion resistance and fatigue life. A rough surface finish may also restrict the use of particular NDT methods (e.g., ultrasonic testing, dye penetrant testing, etc.), reducing inspectability. Material is often post-processed via machining, grinding, electrical discharge machining, polishing, and so forth to achieve the desired surface finish. To ensure good performance, prescriptive surface finishing requirements should be incorporated into acquisition requirements.

6.5 Definitions.

6.5.1 DED build orientations. The Z orientation is perpendicular to the build direction, i.e., perpendicular to the surface of the build platform if no reorientation has occurred. The X orientation is parallel to travel direction, and the Y orientation is perpendicular to travel direction and parallel to the layer plane.

6.5.2 Section thickness. The section thickness is the minimum dimension of the heaviest section of the material determined by the diameter of an inscribed sphere.

6.5.3 Technical authority. The Technical Authority has the authority, responsibility, and accountability to establish, monitor, and approve technical standards, tools, and processes in conformance to higher authority policy, requirements, architectures, and standards. NAVSEA 05S may be contacted to determine the appropriate Technical Authority for any given requirement related to equipment and systems of U.S. Navy ships and submarines.

6.6 Subject term (key word) listing.

3-D Printing
Casting Substitute
Metal Printing

CONCLUDING MATERIAL

Custodians:
Army – MR
Navy – SH

Preparing activity:
Navy – SH
(Project AMPR-2025-009)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at <https://assist.dla.mil>.