

PROJECT PECULIAR DOCUMENT

NICKEL ALUMINUM BRONZE, 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 material made from additively manufactured (AM) nickel aluminum bronze using the wire arc directed energy deposition (DED) process. This material will typically require machining and/or other types of surface finishing prior to inspection, assembly, and use. It is intended that material produced to this specification can be used as an alternative to MIL-B-24480 and ASTM B148 castings (UNS C95800).

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

1.2.1 Feedstock classes.

- a. Class 1 - Wire feedstock in accordance with MIL-E-23765/3, MIL-CuNiAl.
- b. Class 2 - Wire feedstock in accordance with AWS A5.7/A5.7M, ERCuNiAl.

1.2.2 Grades. (see 4.7)

- 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.

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-E-23765/3 - Electrodes and Rods – Welding, Bare, Solid, Copper Alloy

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

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.

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 usn.ncr.comnavseasyscomdc.mbx.command-standards@us.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>.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) PUBLICATIONS

S9074-A4-GIB-010/AM-WIRE DED - Requirements for Metal Directed Energy Deposition Additive Manufacturing

(Copies of this document 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 A5.7/A5.7M - Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes

(Copies of this document are available online at <https://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/.)

SAE INTERNATIONAL

SAE AMS2750 - Pyrometry

(Copies of this document are available online at www.sae.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 composition. Feedstock shall be provided in the form of nickel aluminum bronze wire spools suitable for the DED process.

- a. Class 1 - Class 1 feedstock shall be in accordance with MIL-E-23765/3, MIL-CuNiAl.
- b. Class 2 - Class 2 feedstock shall be in accordance with AWS A5.7/A5.7M, ERCuNiAl.

3.2 DED build requirements.

3.2.1 Feedstock heat. Each production lot shall be produced from a single heat of feedstock.

3.2.2 Build platform. Unless otherwise specified (see 6.2), integrated build platform material for DED AM builds shall be S-36A nickel aluminum bronze in accordance with S9074-A4-GIB-010/AM-WIRE DED.

3.2.3 Sacrificial build platform. If a material other than S-36A nickel aluminum bronze is used for the sacrificial build platform, a minimum of 1 inch of discardable AM build material shall separate the sacrificial build platform from the final component's attached dimensional surface.

3.2.4 Platform removal. Non-integrated build platform removal from the AM part shall use methods that will not affect the mechanical properties of the AM material (e.g., band saw, water jet, electro-discharge machining with recast layer removed).

3.3 Chemical composition. Feedstock and all DED material shall conform to the compositions specified in [table I](#).

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

Feedstock class	Class 1	Class 2
Specification/Classification	MIL-E-23765/3 MIL-CuNiAl	AWS A5.7/A5.7M ERCuNiAl
Copper ^{3/}	Balance	Balance
Zinc	*	0.10
Tin	*	*
Manganese	0.60 to 3.50	0.60 to 3.50
Iron	3.00 to 5.00	3.0 to 5.0
Silicon	*	0.10
Nickel ^{4/}	4.00 to 5.50	4.0 to 5.5
Phosphorus	*	*
Aluminum	8.50 to 9.50	8.50 to 9.50
Lead	0.020	0.02
Total other elements	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 “total other elements” in the last row of the table.		
^{2/} Single values are maximums.		
^{3/} Including silver.		
^{4/} Including cobalt.		

3.4 Heat treatment. Unless otherwise specified (see 6.2), all material shall be heat-treated in furnaces in accordance with the pyrometry requirements of SAE AMS2750 class 5 or better. Material shall be heated to 1250 °F for a minimum of 6 hours. Material shall be furnace cooled to 500 °F, then air-cooled to room temperature.

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

TABLE II. Tensile properties.

Property	Minimum value
Ultimate tensile strength (ksi)	85
Yield strength, 0.5% offset (ksi)	35
Elongation (%)	15

3.6 Weld repair. When specified (see 6.2), weld repair shall be in accordance with S9074-A4-GIB-010/AM-WIRE DED.

3.6.1 Post-weld heat treatment. When weld repairs are made to the DED material, the material shall be heat-treated by the same procedure specified in 3.4. Redetermination of mechanical properties is not required after post-weld heat treatment.

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	4.7
DED build requirements	3.2	4.7
Chemical analysis	3.3	4.5
Tensile properties	3.4 and 3.5	4.6
Weld repair	3.6 and 3.6.1	4.7

4.3 Lot size. Unless otherwise specified (see 6.2), for the purposes of inspections and tests, material produced in one build cycle, as defined in S9074-A4-GIB-010/AM-WIRE DED, and heat-treated in the same furnace load shall constitute a lot.

4.4 Sampling.

4.4.1 Chemical composition. A minimum of one sample shall be taken from each lot for analysis.

4.4.2 Tensile property. Unless otherwise specified (see 6.2), for each lot, a minimum of one sample shall be taken that was built in the Z orientation and one sample shall be taken that was built in either the X or Y orientation.

4.5 Chemical analysis. The chemical composition of each lot shall be tested and analyzed by accepted analytical methods. In case of disagreements, the referee method shall be ASTM E478. The chemical composition of each lot shall conform to the compositions shown in [table I](#).

4.6 Tensile properties. The tensile properties shall be tested after heat treatment in accordance with ASTM E8/E8M and shall meet the requirements of [table II](#) (see 3.5). Unless otherwise specified (see 6.2), tension test coupons shall conform to the standard geometries specified in ASTM E8/E8M and shall be machined from bulk deposition material or taken from near net shape specimens.

4.7 Certificate of conformance. Unless otherwise specified (see 6.2), a certificate of conformance (COC) shall be prepared for each lot of material offered for acceptance in accordance with the lot definition specified herein. The COC shall state that each lot has been sampled, tested, and inspected in accordance with the requirements specified herein. The COC shall also state that powder feedstock and DED build materials are in accordance with the requirements herein. For grade A material, the COC shall also provide the date of NAVSEA approval indicating the manufacturer is in compliance with S9074-A4-GIB-010/AM-WIRE DED. For grade B material, the COC shall state manufacturer or industry standards used to determine material compliance. If heat treatment is required, a complete record of all heat treatments, including time, temperatures, atmosphere, and heating and cooling rates shall be included in the COC (see 3.4 and 3.6.1). If weld repair is permitted (see 3.6), a complete record of all repaired defects including their location, weld repair inspection results, post-weld heat treatments, and associated weld procedure approvals in accordance with S9074-A4-GIB-010/AM-WIRE DED shall be included in the COC.

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 nickel aluminum bronze AM material is intended for replacement of MIL-B-24480 and ASTM B148 castings for new construction and repair of Navy submarines and surface platforms.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Feedstock class and grade required (see 1.2).
- c. Requirement for build platform material that is other than S-36A nickel aluminum bronze (see 3.2.2).
- d. When heat treatment is not required (see 3.4).
- e. When weld repair is permitted (see 3.6).
- f. Variable lot size when required (see 4.3).
- g. Number of samples and orientation if other than specified (see 4.4.2).
- h. Tension test coupon requirements if other than specified (see 4.6).
- i. When a certificate of conformance is not required (see 4.7).
- j. Packaging requirements (see 5.1).

6.3 Navy technical publication. The directed energy deposition (DED) manufacturing process is sensitive to process instabilities. Material produced by this process is difficult to inspect through conventional nondestructive evaluation techniques that the process is uniquely suited to produce. Therefore, the qualification framework described in S9074-A4-GIB-010/AM-WIRE DED is recommended to ensure material of consistent quality 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. Material is often post-processed via machining, grinding, electrical discharge machining, polishing, and so forth to achieve desired surface finish. This specification does not address material performance in anything but the machined condition.

6.5 Subject term (key word) listing.

3-D Printing
Casting Substitute
Metal Printing