

PROJECT PECULIAR DOCUMENT

COPPER-NICKEL (70-30), LASER POWDER BED FUSION, 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) copper-nickel (CuNi) (70-30) using the laser powder bed fusion (LPBF) process. (see also 6.1)

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

1.2.1 Grades. (see 4.8)

- a. Grade A – Material manufactured in compliance with S9074-A2-GIB-010/AM-PBF.
- 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 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-A2-GIB-010/AM-PBF - Requirements for Metal Powder Bed Fusion 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.

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>.

ASTM INTERNATIONAL

- ASTM B369 - Standard Specification for Copper-Nickel Alloy Castings
- ASTM E3 - Standard Guide for Preparation of Metallographic Specimens
- ASTM E8/E8M - Standard Test Methods for Tension Testing of Metallic Materials
- ASTM E478 - Standard Test Methods for Chemical Analysis of Copper Alloys
- ASTM E562 - Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count
- ASTM E1245 - Standard Practice for Determining the Inclusion or Second-Phase Constituent Content of Metals by Automatic Image Analysis

(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. Feedstock shall be metal powder characterized by size distribution, apparent density, and tap density.

3.1.1 Powder production. Unless otherwise specified (see 6.2), all melting, atomization, or spheroidization of the metal powder shall be performed using a fixed gas composition consisting primarily of argon, helium, or nitrogen. Unless otherwise specified (see 6.2), the melt chamber atmosphere shall be vacuum or a fixed gas composition.

3.1.2 Powder purity. The metal powder shall be free from detrimental amounts of inclusions and impurities, and its chemical composition shall be adequate to yield, after processing, the final chemical composition specified in [table I](#). No substance shall be added to the powder at any time to aid powder flowability, spreadability, or any other powder characteristics.

3.2 Chemical composition. The chemical composition of builds shall conform to the percentages by weight specified in [table I](#).

TABLE I. Chemical composition (weight-percent).

	UNS C96400/ASTM B369	
	Minimum (%)	Maximum (%)
Copper	---	Remainder
Lead	---	0.01
Iron	0.25	1.5
Phosphorus	---	0.02
Nickel	28	32
Carbon	---	0.15
Manganese	---	1.5
Sulfur	---	0.02
Silicon	---	0.5
Niobium	0.5	1.5

3.3 Heat treatment. When specified (see 6.2), all materials shall be heat-treated in furnaces in accordance with the pyrometry requirements of SAE AMS-2750 in a class 5 furnace or better.

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

TABLE II. Tensile properties.

Property	Minimum value
Ultimate tensile strength (ksi)	60
Yield strength, 0.5% offset (ksi)	32
Elongation (%)	20

3.5 Weld repair. Unless otherwise specified (see 6.2), weld repair shall be prohibited.

3.6 Relative density. Unless otherwise specified (see 6.2), the relative density of the material shall be not less than 99.8 percent.

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
Chemical analysis	3.2	4.5
Tensile properties	3.3 and 3.4	4.6
Weld repair	3.5	4.84.7
Relative density	3.6	4.8

4.3 Lot size. Unless otherwise specified (see 6.2), material produced in one build cycle shall constitute a lot. When heat treatment is required (see 3.3), material produced in one build cycle and 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.

4.4.3 Relative density. A minimum of one sample shall be taken from each lot for analysis. The sample shall be extracted in the Z orientation. The sample shall include at least one external surface and interior material.

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. Tension tests shall be carried out in accordance with ASTM E8/E8M on a machined gauge section. Unless otherwise specified (see 6.2), tension test coupons shall conform to the standard geometries described in ASTM E8/E8M and shall be machined from bulk deposition, machined from bars, or taken from near net shape specimens. Tension test specimens shall be tested following heat treatment if heat treatment is required.

4.7 Relative density. Unless otherwise specified (see 6.2), relative density shall be evaluated by examining metallographic specimen(s). Metallography shall be performed in accordance with ASTM E3. Relative density shall be measured by using stereographic methods according to ASTM E562 or ASTM E1245. For ASTM E562 or ASTM E1245, the test procedure shall be carried out on ten 50x images from a representative cross-section of the sample. For ASTM E562, the number of fields measured and the grid size used shall attain a relative accuracy of 10 percent.

4.8 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 material is 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-A2-GIB-010/AM-PBF. For grade B material, the COC shall state manufacturer or industry standards used for powder and to manufacture the material. 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 3.3). If weld repair is permitted (see 3.5), a complete record of all repaired defects including their location, weld repair inspection results, post-weld heat treatments, and associated weld procedure approvals 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. LPBF CuNi AM material is intended for replacement of UNS C96400 and ASTM B369/B369M 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. Grade required (see 1.2).
- c. Alternative powder production methods (see 3.1.1).
- d. When heat treatment is required (see 3.3).
- e. When weld repair is permitted (see 3.5).
- f. Relative density if other than specified (see 3.6).
- g. Variable lot size when required (see 4.3).
- h. Number of samples and orientation if other than specified (see 4.4.2).
- i. Dimensions of non-standard tensile test specimens, when required (see 4.6).
- j. Acceptable methods for measuring relative density if other than specified (see 4.8).
- k. When a certificate of conformance is not required (see 4.8).
- l. Packaging requirements (see 5.1).
- m. Surface finish requirements (see 6.4).

6.3 Navy technical publication. The LPBF manufacturing process is sensitive to process instabilities. Material produced by this process is difficult to inspect through conventional nondestructive evaluation techniques due to finely distributed porosity and the complex, near-net shape parts that the process is uniquely suited to produce. Therefore, the qualification framework described in S9074-A2-GIB-010/AM-PBF is recommended to ensure material of consistent quality for critical applications.

6.4 Surface finish. Material produced using LPBF 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. Surface finish requirements should be as specified (see 6.2).

6.5 Subject term (key word) listing.

3-D Printing
Casting Substitute
Metal Printing
Powdered Metal