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Heat Treatment of Wrought Copper-Beryllium Alloys, Process for (Copper Alloys: Numbers C17000, C17200, C17300, C17500, and C17510)

RATIONALE

AMS-H-7199A stabilizes this document because AMS2728 contains technically equivalent requirements and is the document which will be maintained in the future by SAE AMS Committee D.

STABILIZATION NOTICE

AMS-H-7199A has been declared "STABILIZED" by AMS Committee D and will no longer be subjected to periodic reviews for currency. The last technical update of this document occurred in September 1985. Users of this document should refer any certification issues (e.g. exceptions listed on the certification report) to the cognizant engineering organization for their disposition. CAUTION: In many cases the purchaser is not the cognizant engineering organization (i.e. purchaser may be a sub tier supplier).

AMS Committee D recommends that the following technically equivalent (e.g. properties, fit, form, function) specification be used for future procurement. This listing does not constitute authority to substitute this specification for the "STABILIZED" specification.

AMS2728 Heat Treatment of Wrought Copper Beryllium Alloy Parts

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NOTICE

This document has been taken directly from U.S. Military Specification MIL-H-7199A, Amendment 2, Notice 1, and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-H-7199A, Amendment 2, Notice 1. Any part numbers established by the original specification remain unchanged.

The original Military Standard was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this technical report.

1. SCOPE:

1.1 This specification presents requirements for the heat treatment of parts and components fabricated from wrought (plate, sheet, strip, bar, rod, wire extrusions and tube and forgings) copper alloys, numbers C17000, C17200, C17300, C17500, and C17510 (see 6.7). This specification also covers "bright hardening".

2. APPLICABLE DOCUMENTS:

The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 U. S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

FED-STD-151 Metals, Test Methods

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 8 Methods of Tension Testing of Metallic Materials.

3. REQUIREMENTS:

3.1 Permissible furnace types (see 6.1):

3.1.1 Solution heat treating furnace: Acceptable furnaces for solution heat treating of copper-beryllium products include those heated by electricity, gas or oil. They may be batch, continuous or induction types, using either vacuum, controlled gas atmosphere or air (static or circulating) in a chamber or muffle. Molten salt baths shall not be used because of the susceptibility of copper-beryllium alloys to corrosive attack by molten salts at solution heat treatment temperatures. Air atmosphere furnaces shall not be used when the loss of material due to excessive scaling is detrimental to the finished part.

3.1.2 Precipitation hardening (aging) furnaces: Aging or precipitation heat treatment furnaces shall be of the controlled gas atmosphere, vacuum or neutral salt-bath types. Air chamber furnaces are permissibly only when bright lustre parts are not required, or when subsequent brightening operations used to remove oxides, stains and tarnish are not detrimental to the finished parts. Forced circulating air is then recommended.

3.1.2.1 Bright hardening: An acceptable precipitation process known as "bright hardening" utilizes a controlled non-oxidizing and non-combustible gas atmosphere in a chamber-type furnace. (The material must be clean and bright prior to hardening - the process maintains the bright luster.) (see 6.5.4.4).

3.1.3 Furnace temperature uniformity: When equipped with satisfactory temperature-control devices, the design and construction of furnaces used for heat treating copper-beryllium products shall be such that, with a normal charge, the maximum temperature limit herein specified shall at no time during heating-up and holding be exceeded at any point in the working zone. Furthermore, the minimum temperature limit herein specified shall not be violated at any point in the working zone during the holding portion of the treatment cycle.

3.2 Furnace instruments:

3.2.1 Heat-control and measuring equipment: A sufficient number of suitable automatic temperature-control devices, and also temperature-recording instruments shall be provided for all heat treating furnaces to assure adequate control and measurement of temperatures throughout the furnace working zone. Temperature recording instruments shall be of the potentiometer type, and shall be adjusted to ± 5F degrees of the true temperature, by applying corrections established by calibrated equipment in 4.2.2. If corrections greater than ±5 F degrees are indicated, the source of the error shall be determined and adjustments shall be made so that the readings represent a true temperature within ±5 F degrees or less.

3.2.2 Thermocouples shall be enclosed within suitable protecting tubes to prevent contact with furnace atmosphere or molten salt.

3.3 Quenching equipment for solution heat treatment:

3.3.1 Water baths: Cold water quenching baths of adequate size and design for the work load shall be used. The water temperature shall not exceed 95°F during operating use. Forced circulation may be needed to achieve this control. Alternate quenchants may be used providing their equivalence with respect to mechanical properties and residual stress of parts is substantiated.

3.3.2 Location of quenching equipment: To facilitate a very rapid transfer of the load from the solution treatment furnace into the water bath, the location of the bath and related equipment shall be such that a satisfactory quench of the material is obtained (see 3.7.2.2.4).

3.3.3 Quenching trays: Small parts should preferably be dumped directly into cold water; however, they may be quenched while in racks, baskets, trays or other containers, provided that the container construction will permit water to simultaneously reach all parts of the charge.

3.4 Salt bath equipment:

3.4.1 Rinse tanks: When molten salt baths are used, rinse tanks or sprays shall be provided for removing all salt from the parts. Rinse tanks shall be provided with sufficient inflow of fresh water to prevent concentration of dissolved salts.

3.4.2 Neutralizing bath: When required by 3.7.2.3.4 a neutralizing bath such as tri-sodium phosphate or other process - equipment for complete removal of active salt residues shall be provided.

3.5 Cleaning equipment:

Adequate equipment shall be provided for removal of all grease, oil, dirt or other foreign matter which might decompose during heat treatment to produce objectionable surface conditions on the material (see 6.2 and 6.3).

3.6 Acid baths and bright dipping equipment:

Adequate equipment shall be provided for the removal of oxides, scale, tarnish or stains from the surface of the material. (see 6.4)

3.7 Treatment procedures:

3.7.1 Cleaning, acid pickling and bright dipping: A satisfactory process shall be employed for the removal of detrimental amounts of grease, oil or other foreign matter from the surface of the material, prior to heat treatment. Likewise, a satisfactory process shall be employed when necessary for the removal of oxides, scale, tarnish or stains from the surface of the material, either prior to (for "bright hardening") or after precipitation or age hardening.

3.7.2 Heat treatment:

3.7.2.1 General: To achieve uniform heating and quenching, or to avoid distortion, individual pieces shall be spaced, racked or supported as necessary. The drawing or contract may specify parts or conditions which demand special handling or processing. When a bright lustre final finish is required, air-chamber furnaces shall not be used if loss of material due to brightening operations is excessive.

3.7.2.2 Solution heat treatment - (see 6.5.1):

3.7.2.2.1 General: Copper-beryllium mill products and forgings are normally supplied in a condition suitable for precipitation heat treating. For this reason, solution heat treating shall be performed only when (a) welding, brazing or other fabricating operations have rendered the material unsuitable for precipitation or age hardening, or when (b) cold-working requirements of the material demand intermediate softening treatment. In either case (a) or (b), the temper designation of the material, after solution heat treatment, shall be "A", regardless of prior designation (see 3.7.3).

3.7.2.2.2 Temperature: Copper-beryllium products covered by this specification shall be solution heat treated at the following temperatures:

Copper Alloy Nos. C17000, C17200, and C17300:	1450 ± 25°F
Copper Alloy Nos. C17500 and C 17510:	1700 ± 25°F

3.7.2.2.3 Holding time: The length of time the material is held at temperature largely determines the potential properties of the material. Insufficient time makes it impossible to achieve maximum strength after precipitation hardening, while excessive time promotes grain growth with attendant harmful possibilities. An appropriate holding time for thick sections is one hour per inch of thickness. For thin sections the time may vary from a few minutes to one hour. The effectiveness of the holding time employed shall be determined by examination of the microstructure together with a check of mechanical properties.

3.7.2.2.4 Quenching: TIme lapse during transfer of the charge from the furnace into the quenching medium must be as short as possible. Transfer times of a few seconds, and under ten seconds for large charges are being achieved in commercial practice. An agitated liquid quench may be used, whereby the charge is continuously kept in motion immediately after immersion in the quenching medium. The formation of steam films at the metal/quenchant interface must be minimized.

3.7.2.3 Precipitation or age hardening:

3.7.2.3.1 General: This process produces substantial changes in both mechanical and physical properties of the material. The extent of these changes can be controlled by the time and temperature of hardening. Therefore a suitable time-temperature selection must be made, based upon the properties specified in the contract or drawing and the temper designation and condition of the formed part. For evaluating the mechanical and physical properties of the original material, as received, or after solution heat treating, the time-temperature requirements of Table I or II shall be used.

3.7.2.3.2 Bright hardening: The provisions of 3.7.2.3.1 shall apply to parts that are bright hardened (see 3.1.2.1).

3.7.2.3.3 Cooling: After the required holding time has expired, the furnace charge may be cooled at any convenient rate, including quenching.

3.7.2.3.4 Removal of salt bath residues: When salt baths are employed for hardening, all apparent salt residues shall be removed from the material by a suitable process such as water rinse, soak or spray. The material shall then be immersed in a neutralizing solution such as tri-sodium phosphate.

3.7.3 Heat treated material designations: The material, after precipitation or age hardening shall be designated, as to temper, in accordance with Table I or II, and the material so identified for testing, shipping and application information. If the age hardened material had been previously solution heat treated, as in 3.7.2.2.1, it shall be designated “AT” only, regardless of prior temper designations, and the mechanical or physical property requirements shall be those for “AT” temper designation, as shown in applicable material specifications.

TABLE I. FOR COPPER ALLOY NUMBERS C17000, C17200, and C17300
Age Hardening Time-Temperature Conditions (see 3.7.2.3.1) and
Material Temper-Designations

MATERIAL	BEFORE AGE HARDENING	AGE HARDENING		AFTER AGE HARDENING
FORM	TEMPER DESIGNATION	Time (Hrs.)	Tempera-ture (°F)	TEMPER DESIGNATION
Plate,	A	3	600 - 625	AT
Sheet or	1/4 H b/	2	600 - 625	1/4 HT c/
Strip	1/2 H b/	2	600 - 625	1/2 HT c/
	H b/	2	600 - 625	HT c/
Forgings, a/, Tube Rod and Bar	A	3	600 - 625	AT
3/4 inch or less	H b/	2	600 - 625	HT c/
over 3/4 inch	H b/	3	600 - 625	HT c/
Wire	A	3	600 - 625	AT
	1/4 H b/	2	600 - 625	1/4 HT c/
	1/2 H b/	1-1/2	600 - 625	1/2 HT c/
	3/4 H b/	1	600 - 625	3/4 HT c/

a/ Forgings are “A” or “AT” only
b/ See 3,7,2.2.1
c/ See 3.7.3

TABLE II. FOR COPPER ALLOY NUMBERS C17500 and C17510
Age Hardening Time-Temperature Conditions (see 3.7.2.3.1) and
Material Temper-Designations

MATERIAL	BEFORE AGE HARDENING	AGE HARDENING		AFTER AGE HARDENING
FORM	TEMPER DESIGNATION	Time (Hrs.)	Tempera-ture (°F)	TEMPER DESIGNATION
Plate,	A	3	900 - 925	AT
Sheet or	1/2 H b/	2	900 - 925	1/2 HT c/
Strip	H b/	2	900 - 925	HT c/
Forgings, a/	A	3	900 - 925	AT
Tube, Rod and Bar				
3/4 inch or less	H b/	2	900 - 925	HT c/
over 3/4 inch	H b/	3	900 - 925	HT c/
Wire	A	3	900 - 925	AT
	H b/	2	900 - 925	HT c/

a/ Forgings are “A” or “AT” only
b/ See 3.7.2.2.1
c/ See 3.7.3

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all test and inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. Acceptance or approval of the supplier's equipment, temperature-control devices and procedures shall not be construed as a guaranty of the acceptance of the heat treated product. The Government reserves the right to perform any of the tests and inspections set forth herein where deemed necessary to assure that equipment and services conform to prescribed requirements.

4.2 Inspection of equipment:

4.2.1 Furnace temperature survey: Prior to heat treating copper-beryllium products, a furnace temperature survey shall be made for each furnace which will be employed, unless the results from previous operations, made within the past six (6) months, on the same furnace and same type of charge show that furnace uniformity and accuracy of temperature control and recording equipment is within the limits of this specification. A new temperature survey shall be made whenever any changes are made in the furnace or controlling which might affect operational characteristics. The survey shall be made only with calibrated instruments and thermocouples (see 4.2.2).

4.2.1.1 Air furnace: The survey shall be made with a simulated charge, such as scrap parts, typical of a normal production charge. Depending upon size of furnace and charge, a reasonable number of test thermocouples, not less than four (4), shall be placed and secured in various extremities, and central parts of the charge, and the test thermocouples suitably connected with compensating lead wire to an indicating or recording potentiometer-type instrument. (A multi-point strip-chart recorder is recommended.) The controller shall not be used to read test thermocouples. The charge shall then be placed in the furnace, and the temperature of all test thermocouples continuously recorded, or individually recorded at 5 minute intervals through-out the entire heat treat cycle (heating-up and holding). If the results conform to the requirements of 3.1.3 the furnace shall be considered as satisfactory for production use, under similar conditions. If the requirements are not satisfied, changes shall be made in the furnace, location of control temperature-sensing point or in the charge, as indicated, and the survey repeated until conformance is achieved or rejection of the use of the furnace for this operation.

4.2.1.2 Controlled-atmosphere furnace: The provisions of 4.2.1.1 shall apply to a controlled-atmosphere furnace. In addition, constant or periodic checks shall be made, as required, of the atmosphere employed, to determine flow-rate, composition and dew-point. Any variables existing in the atmosphere which might have detrimental effects on copper-beryllium products shall be controlled.

4.2.1.3 Salt-bath furnaces: This survey shall be made by using one or several (preferably) thermocouples, separately contained in suitable protection tubes, and connected with compensating lead wire to a multi-point recorder (preferred) or singe-couple temperature indicator or recorder, of the potentiometer-type, other than the controller. The salt bath controller shall be set at a temperature at least 100 F degrees below the desired operating aging temperature (precaution: avoid salt solidification at low temperatures) and when thermal equilibrium is substantially attained, the test thermocouples shall be submerged to various extremities and the center of the normal working-zone for a typical charge, and secured in position. If one couple is used, separate readings shall be taken at working-zone extremities, and center also. The controller shall then be set at the desired aging temperature and either continuous-chart, or manual and periodic (see 4.2.1.1) readings taken during heating-up of the salt, plus 15 minutes, minimum, of holding time. If all temperature readings conform to the requirements of 3.1.3 the salt bath shall be considered as satisfactory for production use under similar conditions. If the requirements are not satisfied, corrective changes shall be made, as indicated, and the survey repeated until conformance is achieved or rejection of the use of the furnace for this operation.

4.2.2 Accuracy of temperature control and measuring equipment: All inspections shall be made with a potentiometer-type instrument, cold junction compensation and test thermocouple combination which has been calibrated against Bureau of Standard's primary or secondary certified temperature-sensing elements, to an accuracy of ±2 degrees F. This equipment shall be used to determine the conformance of heat-control and measuring equipment to the requirements of 3.2.1. During production, the frequency of checks of controlling and measuring equipment shall be consistent with work-load conditions and test results, but shall not exceed a three (3) month interval.

4.2.3 Salt bath contamination: The salt bath shall be inspected at least once each month or more often if necessary to determine the presence of objectionable contaminants which attack the material. Replenishment or replacement of entire bath shall be made as required.

4.3 Control of process:

4.3.1 General: Acceptance of the heat treating process and related equipment for production use shall be determined by the results of tensile tests made on production material heat treated in accordance with the requirements of this specification and the time-temperature conditions in Tables I or II.

4.3.2 Recognition of other tests: If the contract or drawing specifies a special heat treatment, conflicting with 3.7.2.2.2 or Tables I and II, or alternate tests (hardness, conductivity, etc.) which exclude tensile requirements, such requirements will be accepted in lieu of the tensile test requirements of 4.3.1 for control of process provided that the alternate tests can be demonstrated to produce equivalent controlling results. Otherwise the alternate tests shall supplement the tensile test requirements of 4.3.1.