

INCH-POUND

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DETAILED SPECIFICATION

**COPPER CRUSHER SPHERES
FOR CANNON AND MORTAR PRESSURE GAUGES,
GENERAL SPECIFICATION FOR**

This specification is approved for use by the U.S. Army Test and Evaluation Command based upon currently available technical information, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers copper crusher spheres for use in crusher gauges, primarily intended for use in measuring pressures in weapons.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be used in improving this document should be addressed to Commander, U.S. Army Test and Evaluation Command, 2202 Aberdeen Blvd, ATTN: CSTE-TM, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil. 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

FSC 1090

DISTRIBUTION STATEMENT A. Approved for public release; distribution unlimited.

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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.

INTERNATIONAL STANDARDIZATION AGREEMENTS

- STANAG 4113 - Pressure Measurements by Crusher Gauges
 QSTAG - 607 - Crusher-Type Pressure Gauges for Measurements of Gun and Mortar Pressures.
 ITOP 3-2-810(2) - FR/GE/UK/US Copper Crusher Measurement of Weapon Chamber Pressure.

DEPARTMENT OF DEFENSE STANDARDS.

- MIL-STD-129 - Military Marking for Shipment and Storage

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

2.3 Non-Government Publications. The following documents form a part of this specification unless otherwise indicated in the invitation for bids.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

- ASTM B170 - Oxygen-Free Electrolytic Copper - Refinery Shapes
 ASTM B193 - Resistivity of Electrical Conductor Materials
 ASTM E8/E8M - Tension Testing of Metallic Materials
 ASTM E112 - Determining Average Grain Size

Standards are available from ASTM through their website (<http://www.astm.org/>)

AMERICAN SOCIETY FOR QUALITY (ASQ) STANDARDS

- ANSI/ASQ Z1.4 - Sampling Procedures and Tables for Inspection by Attributes

Standards are available from ASQ through their website (<http://asq.org/index.aspx>)

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3. REQUIREMENTS

3.1 Material. The starting material for copper crushers shall be wire coil stock ranging in diameter from 0.1340 to 0.1360 in. and in grain size from 0.015 to 0.035 mm.

3.1.1 Workmanship. Wire coil stock used for copper crushers shall be hard drawn and be free from seams, draw scratches, and flaws.

3.2 Chemical composition. Chemical composition for crushers shall be within the limits of ASTM B170 for grade 1 copper. Chemistry of all residuals, including silver and oxygen, is to be quantitatively identified by the contractor and a certified analysis is to be provided to the Government.

3.3 Mechanical properties. Unless otherwise specified in the contract or order, the mechanical properties of wire coil stock shall have a minimum tensile strength of 55,000 psi (379.2 MPa) and a 1% minimum elongation in a 10 in. (25 cm) gauge length. Tensile properties shall be measured according to ASTM E8.

3.4 Resistivity. The resistivity at 20 °C of copper (annealed) shall not exceed 0.15176 Ω -g/m² as measured by the method ASTM B193.

3.5 Heat treatment. Crushers shall be bright annealed. The depth of cold work in crushers shall not exceed 0.0015 in. (see 6.2).

3.6 Dimensions and Tolerances.

3.6.1 Dimensions. Crushers shall comply with the dimensions specified in Figure 1 in the Appendix.

3.6.2 Weight. Crushers shall not weigh less than 0.5000 g.

3.7 Processing Controls.

3.7.1 Copper Crushers. The method of manufacture shall adhere to best commercial practice and unless specified in the contract, follow the steps outlined below.

- Step 1. Receiving.**
- A. Verify weight, coil and lot (see 6.1) identification.
 - B. Tag each coil by number 1, 2, 3, etc.
 - C. Cut a 2 ft (60 cm) sample from each end of each coil and identify with coil and lot numbers.

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D. Submit samples of coil ends identified by coil and lot numbers to Government contracting officer's representative for examination and analysis in accordance with 3.1 through 3.4.

E. Hold the material in Receiving until released by the Government contracting officer's representative.

Step 2. Heading.

A. Head to size 0.194-0.198 in.

B. Send a minimum of 12 sample headed balls from each coil identified by coil and lot numbers to the Government contracting officer's representative for evaluation and approval (see 6.4).

Step 3. Flash.

Flash to remove trace of equator and poles.

Step 4. Rough grind.

A. Grind to 0.189-0.190 in. with Stone Lap.

B. Barrel clean and dry to remove oil.

Step 5. Finish grind.

Grind to 0.188 in. with Stone Lap.

Step 6. Barrel.

A. Barrel finish in heavy slurry of Maizo/Lime Size "Std. to + 0.0002 in."

B. Send a minimum of 12 sample barrel finished balls from each coil identified by coil and lot numbers to Government contracting officer's representative for examination and approval.

Step 7. Heat treat.

Bright anneal at 402 °C for one-half hour. The furnace charge shall not exceed 60 lb. The furnace temperature shall be closely controlled. Heat treat furnace recorder must be calibrated to an accuracy of at least ± 1 % of scale reading. After heat treatment and metal processing, the annealed crushers shall show a grain size between 0.015 mm and 0.035 mm. A record of the date, temperature, and duration of the anneal of each batch (see 6.2) of crushers processed shall be furnished to the Government by the contractor. An additional thermocouple shall be placed at the geometric center of the furnace charge during anneal of at least the first batch of crushers. Response from this thermocouple shall be used to ensure the required time (30 minutes) at temperature (402 °C). If a standard geometric

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configuration can be maintained for each successive furnace charge and once correlation has been established, use of the monitoring thermocouple at the center of the charge may be discontinued.

Step 8. Barrel dip. Use a 20 % solution of phosphoric acid. Barrel finish to 0.1870-0.1875 in.

Step 9. Inspection. Conduct a 100 % inspection for visual defects. Any visible surface blemish shall be cause for rejection.

3.8 Packaging. The copper pressure spheres shall be packed by the contractor, 2000 spheres to a wooden box appropriately labeled indicating quantity, size, lot number, coil number, annealing temperature and time, and year of manufacture. The wooden box shall comply with the dimensions specified in Figure 2 in the Appendix. The method of packing is to sprinkle about 1/8 inch of clean, dry hardwood sawdust (or equivalent) on the bottom of the inside of the box. Four hundred spheres (the number determined by weight) are to be put irregularly into the box on top of the sawdust (or equivalent). Sufficient sawdust (or equivalent) is then sprinkled over the spheres so that they are completely covered. The layer is then covered with a cardboard sheet (approximately 1/32 inch thick) and the process of applying sawdust, spheres, and sawdust is repeated until 2000 spheres have been packaged. An additional cardboard sheet should be placed on top of the last layer of sawdust and any additional headspace in the box should be reduced to less than 1/16 inch by further insertion of sheets of cardboard. Purchase of spheres by the Government will not require tarage tables be furnished by the manufacturer (see 6.6).

3.9 Marking. Each shipping container shall be marked with the name of the material, the lot number, the diameter, the weight contained, this specification number, the name of the contractor and the number of the contract or purchase order, and in addition, shall be marked in accordance with MIL-STD-129.

3.10 Tarage table. The appropriate tarage table or tables for reading the pressures of crushers shall be constructed after first consulting U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, Maryland (see 6.6).

3.11.1 Government generated tarage tables. The Government reserves the right to generate its own tarage table or tables when crushers are used in the testing and certification of Army weapons. This specification does not obligate the Government to accept tarage tables prepared by the manufacturer, his agent or contractor.

3.11.2 NATO Standardization Agreement – 4113. The U.S. has ratified STANAG 4113 “Pressure Measurement by Crusher Gauges” which is available from the NATO Standardization Office (NSO). Inquiries for copies can be made through their website <https://nso.nato.int/nso/>. Crusher gauges will be used and calibrated in accordance with procedures outlined in this STANAG and all associated documents when pressure measurements will be passed to another nation.

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3.11.3 Quadripartite Standardization Agreement - 607. The U.S. has ratified QSTAG 607 “Crusher - Type Pressure Gauges for Measurement of Gun and Mortar Pressures” which is available from the ABCA Armies’ Program Office, Suite 1080, 2521 South Clark Street, Arlington, VA 22202-3926; telephone 703.601.0104; email abca.programoffice@us.army.mil. Crusher gauges will be used and calibrated in accordance with procedures outlined in this QSTAG whenever the pressure data are to be passed on to Australia, Canada, or the United Kingdom.

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4. Verification

4.1 Conformance Inspection. Conformance inspection shall include the packaging inspection of 4.2 and the testing of 4.3. Sampling for inspection is indicated for each specified inspection.

4.2 Packaging inspection. The items shall be inspected before and after packaging to determine compliance with the preservation, packaging, packing and marking requirements specified in Section 3 herein.

4.3 Method of inspection and test.

4.3.1 Material. Prior history of all the copper wire coil, as delivered to the manufacturer's plant by his supplier, shall be furnished to the Government contracting officer's representative for technical review and approval before processing the wire into copper spheres. The purpose of this review is to provide assurance that the wire bars from which the wire was made all have the same basic chemical composition, the same heat treatment at the same facility, and that the resulting wire bars are as identical as good commercial practice permits. The prior history shall include as a minimum, a certified chemistry, tensile strength, minimum elongation, resistivity and density.

4.3.2 Wire samples. Two 60 cm (2 ft) samples (one from the beginning and one from the end of each copper wire coil) properly identified to each coil, is to be furnished to the Government contracting officer's representative to perform mechanical and electrical tests and to examine grain size and orientation of grains. Experience has shown that properties from opposite ends of a coil do not normally differ significantly. However, if a significant (more than 5 %) variation is noted, additional samples may be required from along the length of the wire. The metallurgical examination of grain size and orientation is to provide the customer or his designated representative with information on the amount and effects of cold working on the copper wire before it is subsequently processed into copper spheres. The contractor will not proceed to manufacture spheres without written approval that the property requirements for the wire have been met.

4.3.3 Wire tests. Tensile and elongation properties shall be determined by the methods prescribed in ASTM E8. Electrical resistivity shall be determined by the methods prescribed in ASTM B193.

4.3.4 Acceptance of wire. Acceptance of the copper wire coils shall consist of satisfactory completion of 4.3.1 through 4.3.3. When these steps are completed and the wire coils found acceptable, the supplier shall be notified to proceed with the processing of the wire coils into copper spheres.

4.3.5 Testing and Acceptance of spheres.

4.3.5.1 Sampling test. The spheres shall be submitted in batches of 30,000 to 150,000 units segregated into boxes of 2000 spheres (see 5.1). From each box of a batch,

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randomly select (as closely as possible) two samples of equal number of spheres such that the total number of spheres in each sample is 500. These are the test samples for gaging and weighing. Accept/reject batch criteria shall be based on adherence to ANSI/ASQC Z1.4 general inspection level III (Table III-A, AQL= 1.0) summarized in Table 1.

TABLE 1. Batch accept/reject criteria

	Cumulative	Number of Failures		
		Accept	Reject	Resample
First 500	500	7	11	8, 9 or 10
Second 500	1000	18	19	

4.3.5.2 Measurement of cold work. From a batch of 30,000 to 150,000 units randomly select two boxes of 2000 spheres. From each box of a batch randomly select two spheres. These are the test samples for the measurement of cold work by x-ray diffraction procedures (see 6.3).

4.3.5.3 Acceptance of spheres. Complete results of all measurements from paragraphs 4.3.5.1 and 4.3.5.2 shall be supplied to the Government contracting officer's representative for review and acceptance.

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5. PREPARATION FOR DELIVERY

5.1 **Packaging.** For acquisition purposes, the packaging requirements shall be as specified in the contract or order. When packaging of materiel 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 **Definitions.**

6.1.1. **Lot.** A lot consists of all spheres made from wire coil of one billet. Under no circumstances will lots be mixed during any operation.

6.1.2 **Batch.** A batch consists of all copper crushers annealed in the same furnace charge and made from one lot. Under no circumstances will batches be mixed during any operation.

6.2 **Annealing in the manufacturing sequence.** Past experience has shown that annealing should be the final or next-to-last step in the manufacturing sequence to assure that the final product is essentially free of cold work. Annealing in an inert atmosphere is preferred. Pickling, tumble dipping, or similar cleaning processes to remove all traces of scale and give a uniformly bright appearance is permissible subsequent to annealing if the cleaning process causes no additional cold working and has no adverse effect on sphericity and final diameter of the copper crushers.

6.3 **Measurement of cold work.** The depth of cold work in spheres may be determined by X-ray line broadening measurements or by the Laue back reflection X-ray method.

6.4 **Required processing.** Suggested processing of the wire coil into spheres would include cutting the wire into cylindrical slugs and the resulting slug then headed (cold formed) into spherical blanks. Past experience has shown that both a finer grain size results and the possibility of hollow spheres is eliminated by the heading operation.

6.5 **Reference lot.** A lot should be set aside for reference use as required.

6.6 **Construction of tarage tables.** Calibration of spheres for tarage table

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purposes is based on statistical procedures frequently involving critical expert judgment and the use of heavy weapons, and of a specially designed dynamic pressure generator. The expertise in the construction of tarage tables in the Government currently resides with U.S. Army Aberdeen Test Center, TEDT-AT-CS, Aberdeen Proving Ground, MD 21005-5059.

6.7 Subject term (key word) listing.

Weapons
Weapons Testing
Pressure Sensing Spheres
Metallurgical Processing
Metallurgical Controls

6.8 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensive nature of the changes.

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APPENDIX A

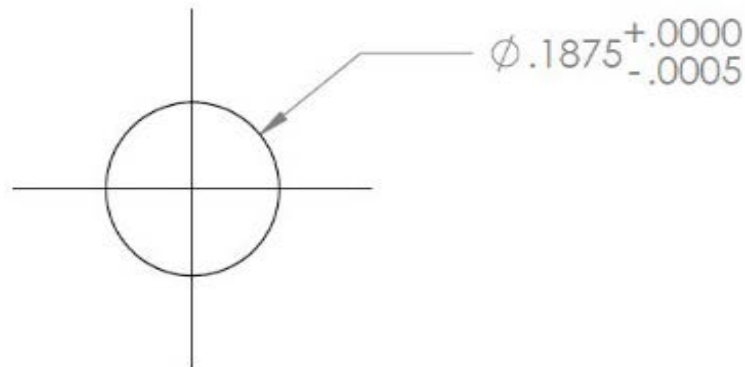
FIGURES

10. SCOPE

10.1 Scope. This appendix provides figures showing dimensions for copper spheres and wooden boxes for packing and delivery of copper spheres. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. FIGURES



SPHERE, PRESSURE, (ANNEALED) COPPER

FIGURE 1. Dimensions of copper sphere (in.)

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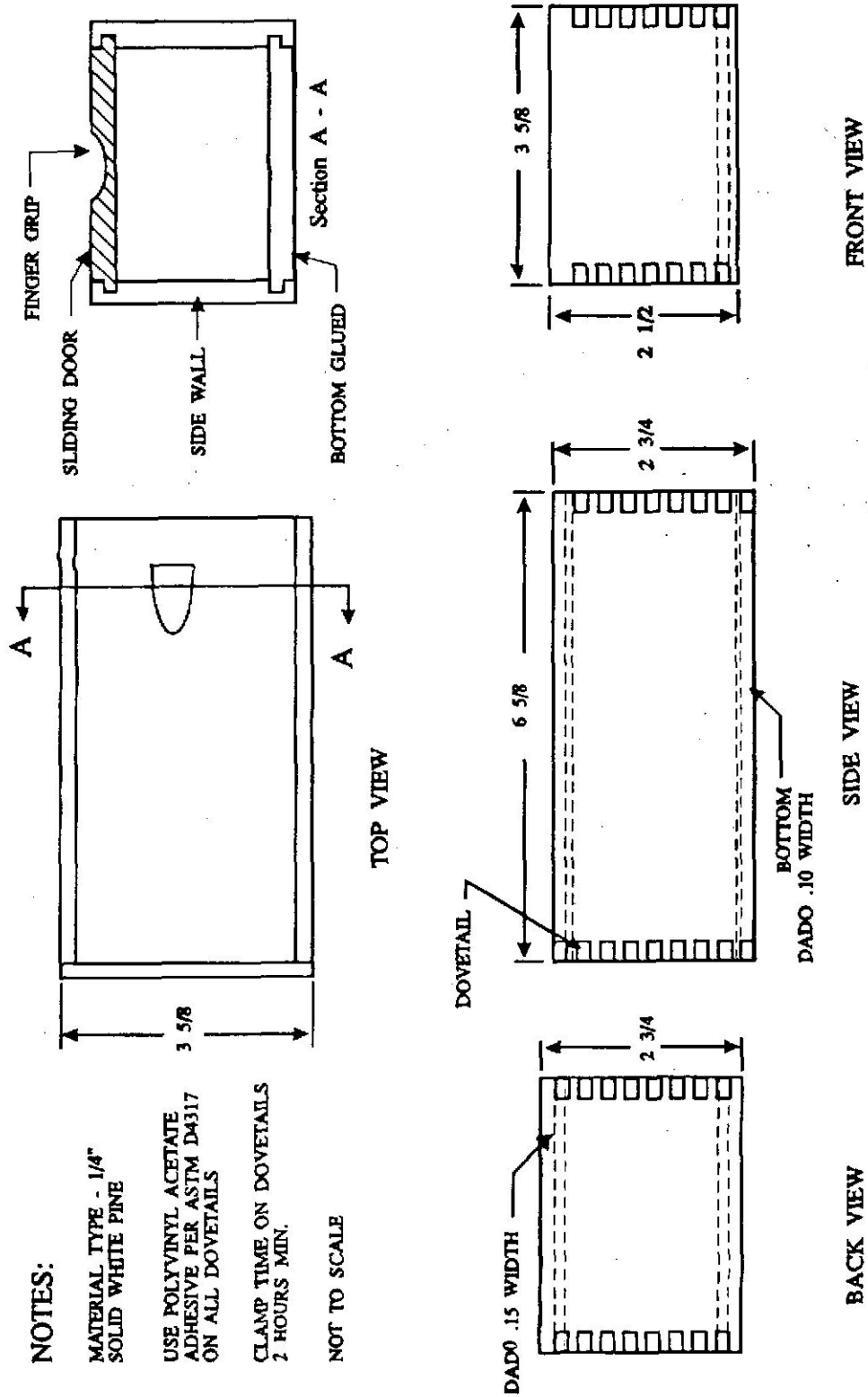


FIGURE 2. Specification of wooden box for copper crusher sphere.
 (Dimensions are in inches.)

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Custodians:

Army – TE
Marine Corps – MC
Air Force – 99

Preparing activity:

Army – TE
(Project 1090-2016-001)

Review Activities:

Army – AR

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>.