INCH-POUND

MIL-C-49514
16 February 1993

MILITARY 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.

2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents form a part of this specification.

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, Directorate for Technology, Technology Development Division, AMSTE-TC-D, APG, MD 21005-5055, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 1090

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

2.1.1 Specifications, standards and handbooks.

STANDARDS

FEDERAL

Fed. Test Method Std. No. 151b	-	Metals; Test Methods

MILITARY

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	-	Marking for Shipment and Storage

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.1.2 Other government documents.

QSTAG - 607	-	Crusher-Type Pressure Gauges for Measurements of Gun and Mortar Pressures.

2.2 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 B 170 - Oxygen-Free Electrolytic Copper - Refinery Shapes

ASTM B 193 - Resistivity of Electrical Conductor Materials

ASTM E8 - Tension Testing of Metallic Materials

ASTM E112 - Determining Average Grain Size

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

Technical society and technical association specifications and standards are generally available for reference in libraries. They are also distributed among technical groups and using Federal agencies.

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 0.035mm.

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 B 170 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 3.8 x 10^5kPa (55,000 psi) and a 1% minimum elongation in a 25cm (10 inch) gauge length. Tensile properties shall be measured according to Federal Test Method Std. No. 151b.

3.4 Resistivity. The resistivity at 20°C of copper (annealed) shall not exceed 0.15176 ohm-grams/m^2 as measured by the method ASTM B 193.

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

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 60cm (2 ft) sample from each end of each coil and identify with coil and lot numbers.

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"

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" with Stone Lap.

B. Barrel clean and dry to remove oil.

Step 5. Finish grind.

Grind to 0.188" with Stone Lap.

Step 6. Barrel.

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

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 0.015mm and 0.035mm. 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 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."

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

Step 10. Pack and Ship. See Section 5.

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

3.8.1 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.

3.8.2 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 Primary Standardization Office, Park Center II, Suite 275, 4401 Ford Avenue, Alexandria, VA 22302-1401; telephone (703) 756-1376. 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.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3, 4, and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspections, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the government to accept defective material.

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 5 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 suppler, 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 60cm (2-foot) samples (one from the beginning and one from the end of each copper wire coil) properly identified to each coil, is to be furnished 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 Federal Test Method Standard No. 151b, ASTM E 8. Electrical resistivity shall be determined by the methods prescribed in Federal Test Method No. 151b, ASTM B 193.

4.3.4 Acceptance of wire. Acceptance inspection 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 suppler shall be notified to proceed with the processing of the wire coils into copper spheres.

4.3.5 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, 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 MIL-STD-105 (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).

5. PREPARATION FOR DELIVERY

5.1 Packing. 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 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).

5.2 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.

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 shall consist of all spheres made from wire coil of one billet. Under no circumstances shall lots be mixed during any operation.

6.1.2 Batch. A batch shall consist of all copper crushers annealed in the same furnace charge and made from one lot. Under no circumstances shall 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 purposes is based on statistical procedures frequently involving critical expert judgement 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 Combat Systems Test Activity, STECS-EN-P, 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.

APPENDIX

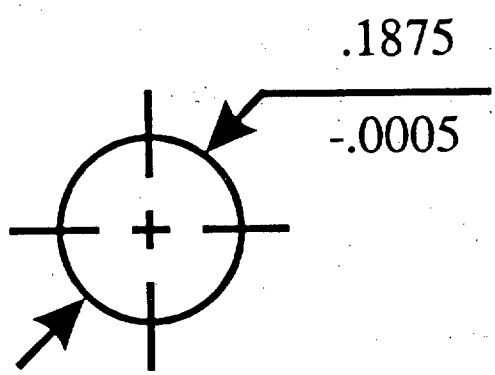
FIGURES

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
SPECIFICATION NO.
(SPECIAL WORK ONLY)

FIGURE 1. Dimensions of copper sphere (inches).

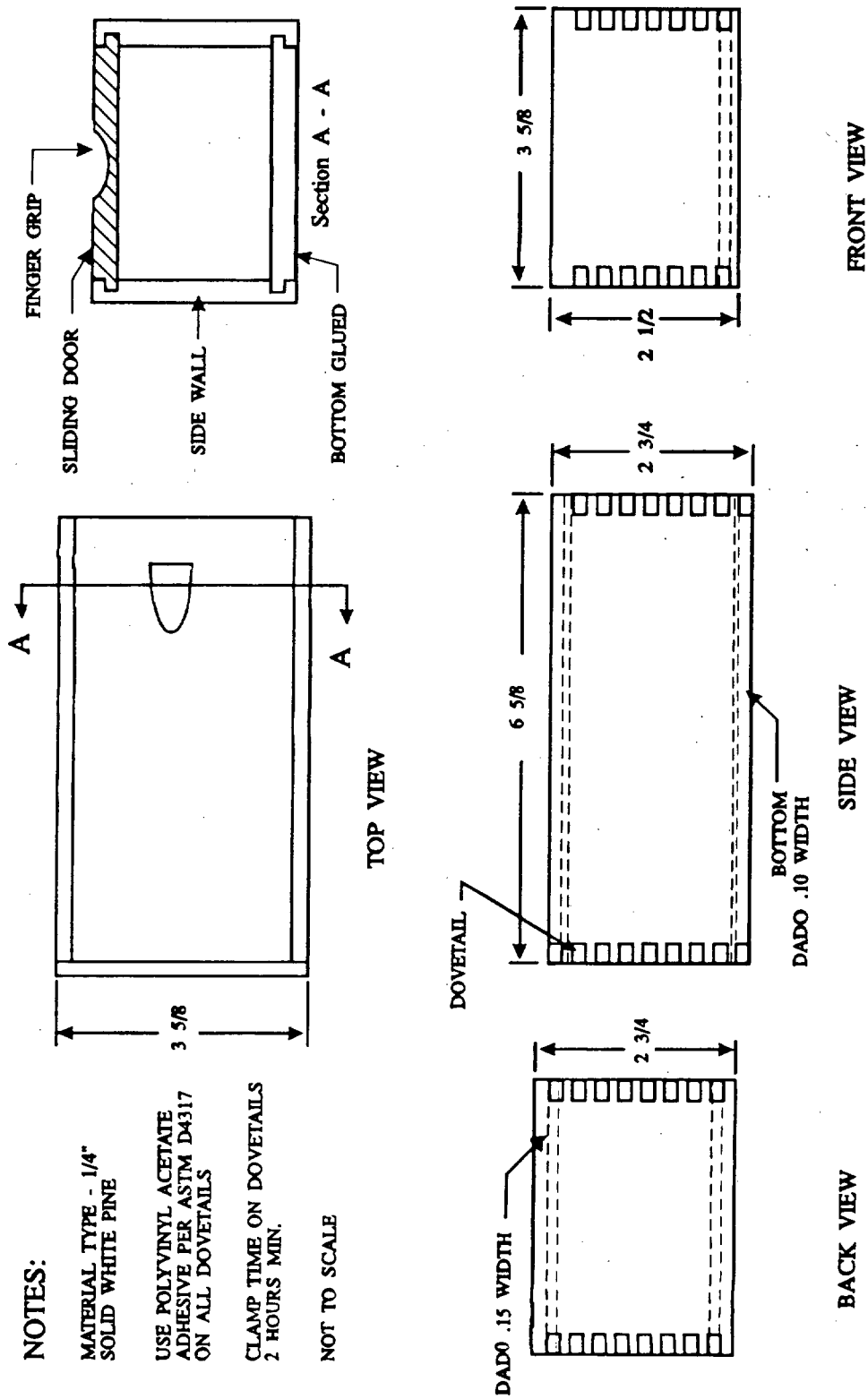


FIGURE 2. Specification of wooden box for copper crusher sphere.
(Dimensions are in inches.)

Custodians:
Army - TE
Marine Corps - MC
Air Force - 99

Review activities:
Army - TE, AL
Navy - OS

User activities:
Army - AR, TE
Navy - OS
Marine Corps - MC
Air Force - 99

Preparing activity:
Army - TE

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER: MIL-C-49514
2. DOCUMENT DATE (YYMMDD): 930216
3. DOCUMENT TITLE: Copper Crusher Spheres for Cannon and Mortar Pressure Gauges, General Specification for

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*

b. ORGANIZATION

c. ADDRESS *(Include Zip Code)*

d. TELEPHONE *(Include Area Code)*
(1) Commercial
(2) AUTOVON *(If applicable)*

7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME: U.S. Army Test & Evaluation Command

b. TELEPHONE *(Include Area Code)*
(1) Commercial: 410-278-1476
(2) AUTOVON: DSN 298-1476

c. ADDRESS *(Include Zip Code)*
Commander, U.S. Army Test & Evaluation Command
ATTN: AMSTE-TC-D
Aberdeen Proving Ground, MD 21005-5055

IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:
Defense Quality and Standardization Office
5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466
Telephone (703) 756-2340 AUTOVON 289-2340