

MIL-H-87111A  
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 SUPERSEDING  
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# MILITARY SPECIFICATION

## HEAT SINKS, SEMICONDUCTOR DEVICES, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

### 1. SCOPE

1.1 Scope. This specification covers the general requirements for heat sinks used in conjunction with semiconductor devices (see 6.1).

1.2 Classification. Heat sinks covered by this specification shall be of the following classes, as specified (see 3.1 and 1.2.1):

| Class     | Material   | Applicable finish<br>(see 3.1 and 3.4) |
|-----------|--|--|
| 1 - - - - | Aluminum or aluminum alloy                         | A, C, H, or R                          |
| 2 - - - - | Beryllium copper                                   | B, C, D, G, or N                       |
| 3 - - - - | Beryllium copper with beryllium<br>oxide insulator | B, C, D, G, or N                       |
| 4 - - - - | Beryllium oxide                                    | Y                                      |

1.2.1 Military part number. The military part number shall consist of the letter "M" and specification sheet number, a dash (-), followed by the class (see 1.2), finish symbol (see 3.4), and a sequentially assigned number (see 3.1), as shown in the following:

|  |       |               |                                    |
|--|-------|---------------|------------------------------------|
| 87111/01-  | 1     | H             | 01                                 |
|  |       |               |                                    |
| Military designator<br>and<br>Specification sheet number | Class | Finish symbol | Sequentially<br>assigned<br>number |

### 2. APPLICABLE DOCUMENTS

#### 2.1 Government documents

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form part of this specification to the extent specified herein.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Electronic Support Directorate, AFALD/PTS, Gentile AFS, Dayton, Ohio 45444, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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## SPECIFICATIONS

## FEDERAL

- QQ-A-200 - Aluminum Alloy, Bar, Rod, Shapes, Structural Shapes, Tube, and Wire, Extruded; General Specification For.
- QQ-A-250 - Aluminum and Aluminum Alloy Plate and Sheet; General Specification For.
- QQ-B-626 - Brass, Leaded and Nonleaded: Rod, Shapes, Forgings, and Flat Products with Finished Edges (Bar and Strip).
- QQ-B-639 - Brass, Naval: Flat Products (Plate, Bar, Sheet, and Strip).
- QQ-C-533 - Copper-Beryllium Alloy Strip (Copper Alloy Numbers 170 and 172).
- QQ-N-290 - Nickel Plating (Electrodeposited).
- QQ-P-416 - Plating, Cadmium (Electrodeposited).

## MILITARY

- MIL-I-10 - Insulating Materials, Electrical, Ceramic, Class L.
- MIL-F-495 - Finish, Chemical, Black, for Copper Alloys.
- MIL-C-5541 - Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
- MIL-A-8625 - Anodic Coatings, for Aluminum and Aluminum Alloys.
- MIL-S-19491 - Semiconductor Devices, Packaging of.
- MIL-G-45204 - Gold Plating, Electrodeposited.
- MIL-C-81021 - Copper-Cobalt-Beryllium Alloy (Copper Alloy No. 175), Strip.

(See supplement 1 for list of associated specification sheets.)

## STANDARDS

## FEDERAL

- FED-STD-H28 - Screw Thread Standards For Federal Services.

## MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
- MIL-STD-1285 - Marking of Electrical and Electronic Parts.
- MIL-STD-45662 - Calibrations Systems Requirements.

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

## AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- ANSI B46.1 - Surface Texture.

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM B110-45 - Standard Method of Test for Dielectric Strength of Anodically Coated Aluminum.

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

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## ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

## Components Bulletin 5 and 5-1 - Recommended Test Procedures for Semiconductor Thermal Dissipating Devices.

(Application for copies should be addressed to the Electronic Industries Association, 2001 Eye Street, N.W., Washington, DC 20006.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

## 3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern.

3.2 Quality conformance inspection. Heat sinks shall be products that have been inspected and passed the quality conformance inspection.

3.3 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the heat sinks to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.3.1 Class 1. Aluminum or aluminum alloy shall conform to type 3003, 5052, 1100, 2024, 6061, or 6063 of QQ-A-200 or QQ-A-250.

3.3.2 Class 2 or 3. Beryllium copper shall conform to QQ-C-533 or MIL-C-81021 and brass shall conform to QQ-B-626 or QQ-B-639. The beryllium oxide used in class 3 heat sink insulators shall be at least 99.5 percent pure with a final density of at least 2.80 grams per cubic centimeter.

3.3.3 Class 4. Beryllium oxide shall conform to MIL-I-10. The beryllium oxide used in class 4 heat sinks shall be at least 99.5 percent pure with a final density of 2.80 grams per cubic centimeter.

3.4 Finish. The finish shall be in accordance with the following, and as specified (see 3.1):

- a. Finish A - Black anodize coating conforming to type I or II of MIL-A-8625.
- b. Finish B - Black chemical finish per MIL-F-495.
- c. Finish C - Thermally conductive insulating coating (over finish A for class 1 or over finish D for class 2 and 3).
- d. Finish D - Cadmium plated per QQ-P-416 (see 6.3).
- e. Finish G - Gold plated per type II, grade D, class 1 of MIL-G-45204.
- f. Finish H - Hard anodize coating conforming to type III of MIL-A-8625. Finish H shall have a minimum thickness of .001 inch hard anodize coating and shall be sodium dichromate sealed. Small holes, sharp edges, and threads may be furnished free of anodize in accordance with MIL-A-8625, but such holes, edges, and threads shall receive a chemical conversion coating per MIL-C-5541 if not anodized.

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- g. Finish N - Nickel plated per QQ-N-290, class 2.
- h. Finish R - Gold chromate coating per MIL-C-5541 (see 6.3).
- i. Finish Y - No finish as fired.

3.4.1 Color. The color of finish A, B, C, and D shall be black.

3.5 Design, construction, and dimensions. Design, construction, and dimensions of the heat sinks shall be as specified herein and on the specification sheets (see 3.1).

3.5.1 JEDEC case size. Heat sinks shall accommodate JEDEC case sizes for semiconductor devices (see 3.1 and 6.2).

3.5.2 Threaded parts. Screw threads shall be in accordance with FED-STD-H28.

3.5.3 Fins (when applicable). Heat sink fins, if present, may be rectangular, triangular, trapezoidal, serrated, staggered, or in-line, at the option of the manufacturer provided that heat sink performance is as specified, and the heat sink is within the general outline dimensions shown on specification sheet (see 3.1).

3.6 Mounting surface flatness (when specified, see 3.1). When heat sinks are tested as specified in 4.6.2, the mounting surface flatness shall be as specified (see 3.1).

3.7 Surface roughness (when specified, see 3.1). When heat sinks are tested as specified in 4.6.3, the surface roughness shall be no greater than that specified (see 3.1).

3.8 Dielectric withstanding voltage (finish C, class 1 and 2) (all finishes, class 3). When tested as specified in 4.6.4, the heat sinks shall withstand the application of test voltage with no evidence of damage, arcing, or breakdown.

3.9 Insulation resistance (finish C, class 1 and 2) (all finishes, class 3). When heat sinks are tested as specified in 4.6.5, the insulation resistance shall be not less than  $1 \times 10^9$  ohms.

3.10 Capacitance (all finishes, class 3). When heat sinks are tested as specified in 4.6.6, the capacitance shall not exceed the maximum value specified (see 3.1).

3.11 Thermal resistance. When heat sinks are tested as specified in 4.6.7, the thermal resistance shall be no greater than the maximum value specified (see 3.1).

3.12 Retention strength (retainer clip heat sinks only). When heat sinks are tested as specified in 4.6.8, the forces required to install and remove the steel slug shall be as shown in table I.

TABLE I. Retention strength.

| Force   | Steel test slug size (max dia) |             |              |
|---|--------------------------------|-------------|--------------|
|   | .330 in.                       | .500 in.    | .187 in.     |
|   | <u>T0-5</u>                    | <u>T0-8</u> | <u>T0-18</u> |
| Installation (max) - - -                      | 11 lb                          | 3 lb, 20 oz | 4 lb         |
| Removal (min) - - - - -                       | 2 lb                           | 3 lb, 20 oz | 12 oz        |
| Removal (min) (after fatigue testing) - - - - | 1 lb, 8 oz                     | 1 lb, 1 oz  | 12 oz        |

3.13 Heat resistance. When heat sinks are tested as specified in 4.6.9, there shall be no evidence of functional defects, blistering, peeling, or other damage, and when applicable, the insulation resistance shall be as specified in 3.9.

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3.14 Humidity (finish C, class 1 and 2) (all finishes, class 3). When heat sinks are tested as specified in 4.6 10, there shall be no evidence of functional defects, and the insulation resistance shall be as specified in 3.9.

3.15 Marking. Marking shall be in accordance with method I of MIL-STD-1285 except that heat sinks themselves shall not be marked; the marking shall appear on the unit package or on a tag attached to the unit package.

3.16 Workmanship. Heat sinks shall be processed in such a manner as to be uniform in quality and shall be free from surface and finish flaws that will affect life and serviceability. Class 3 heat sinks shall be finished smooth and shall have rounded edges with no evidence of chipping, cracking, deterioration, disintegration, or burrs.

#### 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 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 the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

- a. Materials and finishes inspection (see 4.3).
- b. Quality conformance inspection (see 4.5).

4.3 Materials and finishes inspection. Materials and finishes inspection shall consist of certification supported by verifying data that the materials and finishes listed in table II, used in fabricating and finishing the components, are in accordance with the applicable specifications or requirements prior to such fabrication.

TABLE II. Materials and finishes inspection.

| Material or finish                   | Requirement paragraph | Applicable specification               |
|--------------------------------------|-----------------------|--|
| Aluminum or aluminum alloy - - - - - | 3.3.1                 | QQ-A-200 or QQ-A-250                   |
| Beryllium copper- - -                | 3.3.2                 | QQ-C-533 or MIL-C-81021                |
| Brass - - - - -                      | 3.3.2                 | QQ-B-626 or QQ-B-639                   |
| Beryllium oxide - - -                | 3.3.2, 3.3.3          | MIL-I-10                               |
| Black chemical- - -                  | 3.4                   | MIL-F-495                              |
| Cadmium plate - - -                  | 3.4                   | QQ-P-416                               |
| Anodize - - - - -                    | 3.4                   | MIL-A-8625, type I or II               |
| Gold plate- - - - -                  | 3.4                   | MIL-G-45204, type II, grade D, class 1 |
| Gold chromate - - -                  | 3.4                   | MIL-C-5541                             |
| Hard anodize- - - -                  | 3.4                   | MIL-A-8625, type III                   |
| Nickel plate- - - - -                | 3.4                   | QQ-N-290, class 2                      |

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4.4 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.5 Quality conformance inspection.

4.5.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.5.1.1 Inspection lot. An inspection lot shall consist of all heat sinks of the same part number produced from the same type and batch of material (see 3.3) under essentially the same conditions for a period of 1 month, offered for inspection at one time.

4.5.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table III, in the order shown.

4.5.1.2.1 Sampling plan. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality level (AQL) shall be as specified in table III. Major and minor defects shall be as defined in MIL-STD-105.

4.5.1.2.2 Rejected lots. If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

TABLE III. Group A inspection.

| Inspection  | Requirement paragraph    | Method paragraph | AQL (percent defective) |       |
|---|--------------------------|------------------|-------------------------|-------|
|   |                          |                  | Major                   | Minor |
| Visual and dimensional inspection-                            | 3.1, 3.5, 3.15, and 3.16 | 4.6.1            | 1.0                     | 4.0   |
| Mounting surface flatness (when specified, see 3.1) - - - - - | 3.6                      | 4.6.2            | 1.0                     | -     |
| Surface roughness (when specified, see 3.1) - - - - -         | 3.7                      | 4.6.3            | 1.0                     | -     |

4.5.1.3 Group B inspection. Group B inspection shall consist of the inspections specified in table IV, in the order shown. Group B inspection shall be made on sample units selected from inspection lots which have passed group A inspection.

4.5.1.3.1 Sampling plan. Five sample units of each part number shall be selected from the first lot, and once every 6 months thereafter.

4.5.1.3.2 Failures. If one or more sample units fail to pass group B inspection, the sample shall be considered to have failed.

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TABLE IV. Group B inspection.

| Inspection  | Requirement paragraph | Method paragraph |
|---|-----------------------|------------------|
| Dielectric withstanding voltage (finish C, class 1 and 2) (all finishes, class 3) - - - - - | 3.8                   | 4.6.4            |
| Insulation resistance (finish C, class 1 and 2) (all finishes, class 3) - - - - -           | 3.9                   | 4.6.5            |
| Capacitance (all finishes, class 3) - - - - -   | 3.10                  | 4.6.6            |
| Thermal resistance - - - - -  | 3.11                  | 4.6.7            |

4.5.2 Periodic inspection. Periodic inspection shall consist of group B and group C inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see 4.5.2.1.4), delivery of products which have passed group A inspection shall not be delayed pending the results of the periodic inspection. For items which have previously passed group B and C inspections, the acquiring activity, at its discretion, may accept a certificate of compliance with groups B and C requirements in lieu of performing group B and C inspections.

4.5.2.1 Group C inspection. Group C inspection shall consist of the inspections specified in table V, in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed group A and group B inspection.

4.5.2.1.1 Sampling plan. Five sample units of each part number shall be selected from the first lot, and once every 24 months thereafter.

4.5.2.1.2 Failures. If one or more sample units fail to pass group C inspection, the sample shall be considered to have failed.

TABLE V. Group C inspection.

| Inspection   | Requirement paragraph | Method paragraph |
|--|-----------------------|------------------|
| Retention strength (retainer clip heat sinks only) - - - - -         | 3.12                  | 4.6.8            |
| Heat resistance - - - - -  | 3.13                  | 4.6.9            |
| Humidity (finish C, class 1 and 2) (all finishes, class 3) - - - - - | 3.14                  | 4.6.10           |

4.5.2.1.3 Disposition of sample units. Sample units which have been subjected to group C inspection shall not be delivered on the contract.

4.5.2.1.4 Noncompliance. If a sample fails to pass group B or C inspection, the contractor shall take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group B or C inspection shall be repeated on additional sample units (all inspections, or the inspection which the original sample failed, at the option of the Government). Group A inspection may be reinstituted; however, final acceptance shall be withheld until the full group B or C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity.

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4.5.3 Inspection of packaging. The sampling and inspection of the preservation, packing, and container marking shall be in accordance with the requirements for semiconductor accessories in MIL-S-19491.

4.6 Methods of inspection.

4.6.1 Visual and dimensional inspection. Heat sinks shall be examined to verify that the design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.5, 3.15, and 3.16).

4.6.2 Mounting surface flatness (when specified, see 3.1) (see 3.6). Mounting surface flatness shall be measured in accordance with ANSI B46.1.

4.6.3 Surface roughness (when specified, see 3.1) (see 3.7). Mounting surface roughness shall be measured in accordance with ANSI B46.1.

4.6.4 Dielectric withstanding voltage (finish C, class 1 and 2) (all finishes, class 3) (see 3.8). Heat sinks shall be tested in accordance with method 301 of MIL-STD-202 and ASTM B110-45 for finish H. The following details shall apply:

- a. Special preparation - An appropriate transistor shall be mounted in its heat sink and bolted to an aluminum or copper chassis.
- b. Magnitude of test voltage - 500 volts (or 200 volts at 500 milliamperes for finish H) for 1 minute minimum.
- c. Nature of potential - DC.
- d. Points of application of test voltage - Between transistor case and mounting plate.
- e. Maximum leakage current requirement - 20 microamperes  $\pm 5$  (or 8 microamperes  $\pm 2$  for finish H).
- f. Examination after test - Heat sinks shall be examined for evidence of flashover, mechanical damage, arcing, or breakdown.

4.6.5 Insulation resistance (finish C, class 1 and 2) (all finishes, class 3) (see 3.9). Heat sinks shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

- a. Test condition - B for a duration of 1 minute minimum.
- b. Special preparation - An appropriate transistor shall be mounted in its heat sink and bolted to an aluminum or copper chassis.
- c. Points of measurement - Between transistor case and mounting plate.

4.6.6 Capacitance (all finishes, class 3) (see 3.10). Heat sinks shall be tested in accordance with method 305 of MIL-STD-202. The following detail and exceptions shall apply:

- a. Special preparation - An appropriate transistor shall be mounted in its heat sink and bolted to an aluminum or copper chassis.
- b. Test frequency - 1 kHz.
- c. Points of measurement - Between transistor case and mounting plate.

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4.6.7 Thermal resistance (see 3.11). Thermal resistance shall be determined using the test procedures of EIA Components Bulletin Number 5. "Wafer" and "thermal link" type devices shall be tested when secured to a constant temperature heat sink. All other types shall be tested when secured to a nonmetallic chassis. Constant temperature heat sink or ambient conditions shall be held at  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ . Thermal grease shall be used during testing and test result data shall include type of grease and areas of application. All measurements shall be made in the "natural cooling" environment specified in EIA Components Bulletin Number 5 and 5-1.

4.6.8 Retention strength (retainer clip heat sinks only) (see 3.12). Heat sinks shall be installed on the applicable steel test slug shown in table I, and the installation force shall be measured using a weighted force scale. The heat sinks shall be removed from the steel test slug and the removal force shall be measured using a weighted force scale.

4.6.8.1 Fatigue. Heat sinks shall be subjected to 20 installations on and removals from the test slug in accordance with 4.6.8. Following these installations and removals, the removal force shall again be measured.

4.6.9 Heat resistance (see 3.13). Heat sinks shall be placed in an oven and heated at  $200^{\circ}\text{C}$  for 48 hours minimum. At the conclusion of the 48-hour period, the parts shall then be removed from the oven and allowed to cool to room ambient temperature, and shall then be visually inspected for functional defects. Following the visual inspection, the insulation resistance shall be measured as specified in 4.6.5 (finish C, class 1 and 2, and all finishes, class 3).

4.6.10 Humidity (finish C, class 1 and 2) (all finishes, class 3) (see 3.14). Heat sinks shall be tested in accordance with method 103 of MIL-STD-202. The following details shall apply:

- a. Measurements after conditioning - Insulation resistance as specified in 4.6.5.
- b. Test condition - B.
- c. Final measurements after drying - At the end of a 4-hour drying period, the insulation resistance shall be measured as specified in 4.6.5.

The heat sinks shall then be visually inspected for functional defects.

## 5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with the requirements for semiconductor accessories in MIL-S-19491.

## 6. NOTES

6.1 Intended use. Heat sinks covered by this specification are intended for use as a means of conducting heat away from an electrical component to an ambient, or constant temperature heat sink, printed wiring board, or other heat dissipator. Many similar sizes and shapes of heat sinks not covered by this specification are now in use. The requirements of this specification may not be suitable in all cases for direct replacement of existing heat sinks.

6.2 Ordering data. Acquisition documents should specify the following:

- a. Title, number, and date of this specification and the complete part number (see 3.2.1).
- b. JEDEC case size of semiconductor to be accommodated (i.e., TO-3, TO-66, TO-15, TO-6, etc.).
- c. Whether the manufacturer performs the group B and C inspections or provides a certificate of compliance with group B and C requirements.

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6.3 Temperature limitations of gold chromate and cadmium plate. Gold chromate finish is intended for use on those heat sinks that are required by design to be electrically conductive. Gold chromate should not be used in a corrosive or salt spray environment where the operating temperatures will exceed 60°C (140°F) and salt spray or corrosion resistance is a necessity as this temperature has an adverse effect upon the corrosion resistance of the finish. For the same reason, gold chromate treated cadmium should not be used where the service temperatures exceed 66°C (150°F) and corrosion resistance at these temperatures is a necessity.

6.4 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:

Army - ER  
Navy - EC  
Air Force - 85

Preparing activity:

Air Force - 85

(Project 5999-0139)

Review activities:

Navy - TD  
Air Force - 11, 19, 99  
DLA - ES

User activities:

Navy - AS, CG, MC, SH

Agent:

DLA - ES

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