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MIL-S-24093A(SH)

5 November 1991

SUPERSEDING

MIL-S-24093(SH)

21 September 1964

MILITARY SPECIFICATION
STEEL FORGINGS, CARBON AND ALLOY
HEAT TREATED

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all departments and agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers carbon and alloy steel forgings for general shipboard application.

1.2 Classification. The carbon and alloy steel forgings are of the types and classes, as specified (see 6.2).

1.2.1 Classes. Steel forgings are of the following classes:

| Class | Yield strength (minimum) (lb/in ²) |
|-------|---|
| A | 140,000 |
| B | 120,000 |
| C | 100,000 |
| D | 80,000 |
| E | 65,000 |
| F | 45,000 |
| G | 40,000 |
| H | 30,000 |

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| Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 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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AMSC N/A

AREA FORG

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

MIL-S-24093A(SH)**1.2.2 Types.** Steel forgings are of the following types:

| | |
|----------|-----------------------|
| Type I | Ni Cr Mo |
| Type II | Cr Mo |
| Type III | Ni |
| Type IV | Plain carbon (medium) |
| Type V | Plain carbon (low) |

2. APPLICABLE DOCUMENTS

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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS**MILITARY**

| | |
|---------------|---|
| MIL-S-24093/1 | Steel Forgings, Carbon and Alloy, Heat Treated (Class B, Alloy Steel Round Bar) |
| MIL-S-24093/2 | Steel Forgings, Carbon and Alloy, Heat Treated (Class H, Carbon Steel, Hexagonal Bar) |
| MIL-S-24093/3 | Steel Forgings, Carbon and Alloy, Heat Treated (Class B, Alloy Steel, Hexagonal Bar) |

STANDARDS**FEDERAL**

| | |
|-------------|--|
| FED-STD-183 | Continuous Identification Marking of Iron and Steel Products |
|-------------|--|

MILITARY

| | |
|-------------|---|
| MIL-STD-271 | Requirements for Nondestructive Testing Methods |
|-------------|---|

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

MIL-S-24093A(SH)

IRON AND STEEL SOCIETY

Steel Products Manual, Book Number MN02-210

(Application for copies should be addressed to the Iron and Steel Society, 410 Commonwealth Drive, Warrandale, PA 15086.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- A 307 Standard Test Methods and Definitions for Mechanical Testing of Steel Products (DOD adopted)**
- A 700 Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment (DOD adopted)**
- A 751 Standard Methods, Practices, and Definitions for Chemical Analysis of Steel Products**

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

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. 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 Material. The material from which the forgings are made shall be manufactured by the open-hearth, electric furnace, basic oxygen, or vacuum induction melting process. Unless otherwise specified (see 6.2), the material shall be continuous cast or cast in metal molds. The primary melting may incorporate separate degassing or refining and may be followed by secondary melting using electroslag remelting (ESR) or vacuum arc remelting (VAR) (see 6.2).

3.1.1 Discard. Sufficient discard shall be taken from each ingot (produced of a metal mold or continuous caster) to ensure freedom from piping and undue segregation.

3.1.2 Recovered materials. Unless otherwise specified herein (see 6.2), all equipment, material, and articles incorporated in the products covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials,

MIL-S-24093A(SH)

as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.2 Forging process.

3.2.1 Reduction. The total reduction of the cross-sectional area from ingot to forging shall not be less than 3 to 1. Palms, flanges, and other enlargements on forgings need not be reduced to the ratio of 3 to 1, but shall be reduced in a ratio of not less than 1.7 to 1. If bored ingots are used, the wall of the ingot shall be reduced to at least 1/2 of its original thickness, or the reduction of area shall be at least 3 to 1. Where an upsetting operation is employed, or the forging expanded on a mandrel, the metal shall be worked to an extent of not less than indicated above, but no fixed ratio between the cross-sectional areas of the ingot and of the forging is required.

3.2.2 Bored ingots. When the ingots are bored, the centerline of the bored hole shall include the centerline of the ingot.

3.2.3 Flame cutting. Metal removal by flame cutting or other thermal means shall not be permitted after the forging has received its final thermal treatment and final nondestructive test.

3.3 Chemical composition. The chemical composition of the steel forgings shall be as specified in table I. Both ladle and check analyses shall be performed. The check analysis shall meet the chemical composition requirements specified in table I subject to the standard variations of the ISS MN02-210.

3.4 Mechanical properties.

3.4.1 Tension test property requirements. Carbon and alloy steel forgings shall meet the requirements for the properties specified in table II.

TABLE I. Chemical composition (ladle analysis and check analysis).¹

| Type | Carbon | Manganese | Phosphorus | Sulfur | Silicon | Copper | Nickel | Chromium | Molybdenum |
|-----------------|--------|-----------|------------|--------|-----------|--------|-----------|-----------|------------|
| I | 0.44 | 0.90 | 0.025 | 0.005 | 0.20/0.35 | - | 1.65/2.00 | 0.70/0.95 | 0.20/0.30 |
| II | 0.44 | 1.10 | 0.025 | 0.005 | 0.20/0.35 | - | - | 0.80/1.10 | 0.15/0.25 |
| III | 0.40 | 0.85 | 0.025 | 0.025 | 0.20/0.35 | - | 3.25/3.75 | - | - |
| IV ² | 0.44 | 0.90 | 0.04 | 0.04 | 0.10/0.30 | - | - | - | - |
| V ² | 0.30 | 0.90 | 0.04 | 0.04 | 0.10/0.30 | 0.25 | 0.25 | - | - |

¹Maximum weight percent unless range is shown.

²Types IV and V are designed to be plain carbon steels; no intentional alloying additions are permitted.

TABLE II. Tensile Properties.

| Class | Type | Section thickness | | Yield strength (102 percent offset) | Ultimate tensile strength | | Elongation in 2 inches gauge | | Reduction of area | |
|-------|----------------|-------------------|---------|-------------------------------------|-------------------------------|-------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|-----------------------------------|
| | | Minimum (inches) | Maximum | | Minimum (lb/in ²) | Maximum (lb/in ²) | Longitudinal ¹ (percent) | Transverse ² (percent) | Longitudinal ¹ (percent) | Transverse ² (percent) |
| A | I | 10 | | 140,000 | 165,000 | 10 | | 8 | 35 | 20 |
| B | I or II | 10 | | 120,000 | 140,000 | 14 | | 10 | 35 | 25 |
| C | I or II | 10 | | 100,000 | 120,000 | 16 | | 12 | 40 | 30 |
| D | I, II, or III | 10 | | 80,000 | 100,000 | 18 | | 14 | 45 | 30 |
| E | I, II, or III | 10 | | 65,000 | 95,000 | 20 | | 17 | 45 | 30 |
| F | II, III, or IV | - | | 45,000 | 90,000 | 22 | 90,000 | 19 | 45 | 30 |
| G | IV | - | | 40,000 | 90,000 | 22 | 90,000 | 19 | 45 | 30 |
| H | V | - | | 30,000 | 90,000 | 30 | 90,000 | 25 | 45 | 40 |

¹The term longitudinal for purposes of this specification means that centerline of the test specimen shall be parallel to the direction that the steel is most drawn (parallel with metal flowlines). The term transverse means the centerline of the test specimen shall be normal to the direction that the steel is most drawn (normal to metal flowlines and parallel to the plane of the major surface).

²Transverse tensile requirement only applicable when specified (see 6.2).

MIL-S-24093A(SH)

3.4.2 Impact requirements. When specified (see 6.2), steel forgings shall meet the requirements of table III.

Table III. *Impact properties.*

| Class | Type | Test temperature | Charpy "V" notch values average of 3 test ¹ (minimum) |
|-------|---------------|------------------|--|
| | | °F ± 3° | (ft-lb) |
| A | I | 10 | 15 |
| B | I or II | 10 | 15 |
| C | I or II | 10 | 30 |
| D | I, II, or III | 10 | 30 |
| E | I, II, or III | 10 | 30 |
| F | II or III | 10 | 30 |
| G | IV | 10 | 15 |
| H | V | 10 | 15 |

¹No single test shall fall below the specified value by more than 5 foot-pounds (ft-lb).

3.5 Heat treatment.

3.5.1 Heat treatment responsibility. The contractor or manufacturer shall determine the detailed heat treatment which will produce forgings to meet the requirements of this specification (see 6.3).

3.5.2 Class restrictions. In order to develop the required properties, all classes, except class H shall be either normalized and tempered or quenched and tempered in their final heat-treated condition. Class H shall be either annealed, normalized or normalized and tempered in its final heat-treated condition. Tempering temperature shall not be below 950 degrees Fahrenheit (°F) for class A, 1000 °F for class B, and 1050 °F for class C through H.

3.5.3 Stress relieving. At the discretion of the contractor or when specified by the contracting activity a stress relief treatment may be performed on forgings after final machining, in which case the stress relief temperature shall be at least 50 °F, below the tempering temperature applied to the forging. In cases where weld repairs have been performed after final heat treatment, the need for stress relief shall be judged by the contracting activity.

3.6 Repair of defects.

3.6.1 Repair by welding. Forgings shall not be repaired without specific approval of the contracting activity. When weld repair is approved, the contracting activity shall specify the applicable fabrication document.

MIL-S-24093A(SH)

3.6.2 Repair by grinding or chipping. Defects or defective areas may be removed by grinding or chipping provided the areas involved are well faired into the surrounding areas and sufficient stock is left to allow finishing. When defects constitute a notch effect, such as cracks, seams, or ruptures, the defective volume shall be completely removed.

3.7 Dimensions. Forgings shall conform to the dimensions and tolerances as specified (see 6.2). The forgings shall have sufficient stock to permit finishing.

3.8 Identification marking. Unless otherwise specified (see 6.2) all forgings shall be legibly and indelibly marked with a forging number which will identify the manufacturer, heat, heat treatment lot, specification, class, and type of the forging. Each forging weighing greater than 250 pounds shall be marked with the contractor's name or trademark, the specification number, class, type, drawing, or die number, and heat or forging number. Unless otherwise specified (see 6.2) the markings shall be indentation stamped.

3.9 Soundness. The forgings shall be free from defects such as seams, pipe, cracks, scale, fins, nicks, gouges, porosity, excessive nonmetallic inclusions, and segregation that may detrimentally affect their suitability for the service intended, as determined by visual examination and the applicable nondestructive tests.

3.10 Nondestructive testing.

3.10.1 Magnetic particle testing. Forgings shall be magnetic particle tested. All indications over 1/8 inch in length or any 6 square inch area that exhibits 10 or more indications equal to or greater than 1/16 inch in length, shall be rejected or repaired as specified in 3.6.

3.10.2 Ultrasonic inspection. When specified (see 6.2), forgings shall be ultrasonic tested. Unless otherwise specified (see 6.2), the forgings shall be free from all discontinuities that exceed those exhibited by the calibration standards in accordance with MIL-STD-271.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order (see 6.2), 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 the 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 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 inspection, as part

MIL-S-24093A(SH)

of the 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 Sampling.

4.2.1 Lot.

4.2.1.1 Chemical analysis. For purposes of sampling for chemical or spectrographic analysis, a lot shall consist of all forgings from one heat or melt.

4.2.1.2 Mechanical and impact testing. For purposes of mechanical and impact testing a lot shall consist of the following:

- a. All forgings of the same type and size, weighing less than 1000 pounds produced from one heat, and heat treated in the same furnace charge or by a continuous process under the same conditions of treating over a period of 4 hours.
- b. Each forging weighing not less than 1000 pounds.

4.2.2 Number of test specimens.

4.2.2.1 Chemical check analysis. One chemical check analysis specimen shall be taken from each lot (see 4.2.1).

4.2.2.2 Tension testing. The number of test specimens for tension testing shall be as follows:

- a. For forgings weighing 1000 pounds or more and not less than 8 feet long, one tension test specimen shall be taken from each end of the forging.
- b. For forgings weighing 1000 pounds or more and less than 8 feet long, one tension test specimen shall be taken from the top (with respect to the as-cast ingot) of each forging.
- c. For forgings weighing less than 1000 pounds one tension test specimen shall be taken from each lot.

4.2.2.3 Impact testing. One set of three impact specimens shall be taken from each lot.

4.2.3 Location of test specimens. Prolongations shall be provided on forgings for taking tests. For small forgings, heat treated in groups, a forging may be destroyed in lieu of providing prolongations.

4.2.3.1 Chemical analysis. Samples may be taken from broken tensile specimens.

4.2.3.2 Tension testing. Specimens for tension testing shall be taken at mid-radius of rounds; mid-wall thickness of bored forgings; or mid-thickness, quarter width of other forgings.

MIL-S-24093A(SH)

4.2.3.3 Impact testing. Specimens for impact testing shall be taken from the top prolongation of the forgings with respect to the as-cast ingot. The specimens shall be taken at least 1 inch below the forged surface. The length of the specimen shall be taken in the direction that the steel is most drawn. The long direction of the notch shall be normal to the nearest forged surface.

4.2.4 Defective specimen. If any test specimen reveals obvious defective machining or obvious lack of continuity of metal, it may be discarded and another selected.

4.3 Nondestructive testing.

4.3.1 Visual and dimensional examination. Each forging shall be examined for conformance to the specified dimensions and tolerances and shall be examined by the visual method in accordance with MIL-STD-271 to determine that the requirements of this specification are met (see 3.7). Each forging shall be visually inspected over its entire surface after heat treatment, stress relief, and machining operations are completed (see 3.9).

4.3.2 Magnetic particle examination. Each forging shall be examined by the magnetic particle method in accordance with MIL-STD-271 to determine that the requirements conform to 3.10.1. For magnetic particle inspection of finished machined parts, the yoke method shall be used to prevent arc-strikes on the machined surface.

4.3.3 Ultrasonic testing. When specified (see 6.2) each forging shall be examined by the ultrasonic method in accordance with MIL-STD-271. The forging shall be tested in both axial and longitudinal direction using either a shear or longitudinal wave, whichever is applicable to the geometry of the forging (see 3.9 and 3.10.2).

4.4 Test procedure.

4.4.1 Chemical analysis. Chemical or spectrographic analysis shall be in accordance with ASTM A 751 to determine compliance with 3.3.

4.4.2 Tension test. Standard round shall be tested in accordance with ASTM A 370 to determine compliance with 3.4.1. Tension tests shall be performed after the final heat treatment.

4.4.3 Charpy "V" notch impact test. When specified (see 6.2) the Charpy "V" notch test specimen shall be tested in accordance with ASTM A 370 at the temperature specified in table III. Impact tests shall be performed after the final heat treatment.

4.5 Retests.

4.5.1 Chemical analysis retest. When a sample forging fails to meet the chemical requirements of table I, each forging in the lot may be analyzed to determine compliance with table I. The samples shall be taken as specified in 4.2.3.

MIL-S-24099A(SH)

4.5.2 Tensile and impact retests. Retests shall be permitted when:

- a. Elongation or reduction of area value is no greater than 2 percent below the minimum.
- b. Tensile and yield strength are no greater than 1000 lb/in² outside of the range limits.
- c. The impact average is no greater than 2 foot-pounds below the minimum and no single test is greater than 5 foot-pounds below the minimum.

Retest specimens shall be taken adjacent to the locations where the original specimens were taken.

4.6 Reheat treatment. When the tensile or impact specimens, or the retests of 4.5.2 fail to meet the requirements of table II or table III, reheat treatment of the lot shall be permitted. Reheat treatment shall be as specified in 3.5. After reheat treatment, the lot shall meet all the requirements of this specification.

4.7 Rejection. When any forging representing a lot fails to conform to the requirements of this specification, the lot shall be subjected to rejection, and each forging in that lot shall be tested and determined to meet the requirements of this specification.

4.8 Inspection of packaging. Sample packages and packs, and the inspection of the preservation, packing, and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition.)

5.1 Preservation. Preservation shall be sufficient to afford adequate protection against corrosion, deterioration, and physical damage during shipment from the supply source to the using activity and until early material use.

5.2 Packing. Packing shall be accomplished in a manner which will ensure acceptance by common carrier and will afford protection against physical damage during shipment from the supply source to the using activity for early material use.

5.3 Marking. Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, national stock number, contract or order number, contractor's name, and the destination.

5.4 Commercial preservation, packing, and marking. The material shall be packaged in accordance with ASTM A 700 for the levels specified (see 6.2).

MIL-S-24093A(SH)**6. NOTES**

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The carbon and alloy steel forgings covered by this specification are intended for general shipboard applications.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification
- b. The class and type of steel required (see 1.2)
- c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2)
- d. Whether special melting practices are required (see 3.1)
- e. Whether continuous casting is prohibited (see 3.1)
- f. Whether virgin raw materials are required (see 3.1.2)
- g. When transverse mechanical properties are desired (see 3.4)
- h. When impact testing is required (see 3.4.2 and 4.3.3)
- i. Dimensions and tolerances required (see 3.7)
- j. When identification marking is not required (see 3.8)
- k. When marking other than indentation stamping is required (see 3.8)
- l. When ultrasonic examination is required (see 3.10.2)
- m. Ultrasonic examination acceptance criteria if other than as specified (see 3.10.2)
- n. Preservation, packing, and marking requirements (see 5.4).

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except when DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

MIL-S-24093A(SH)

| Reference Paragraph | DID Number | DID Title | Suggested Tailoring |
|----------------------------|----------------------|----------------------------------|----------------------------|
| 3.5.1 and appendix | DI-MISC-80678 | Certification/Data report | |

The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Subject term (key word) listing.

Casting
 Ingot, as-cast
 Testing, impact
 Testing, nondestructive
 Testing, tension

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

Preparing activity:
 Navy - SH
 (Project FORG-N190)

MIL-S-24093A(SH)

APPENDIX

CERTIFICATION/DATA REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the content requirements of the certification of quality conformance. This appendix is mandatory only when data item description DI-MISC-80678 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. CERTIFICATE CONTENT

30.1 Certificate content. For each lot of material offered for acceptance, the certificate shall include actual data of specified chemical and mechanical tests and a record of final heat treatment. Qualitative results of nondestructive tests and other inspections or tests shall be recorded on the certificate. The certificate shall state that each lot has been sampled, tested and inspected as specified herein and that the manufacturer has maintained manufacturing procedures and practices to produce forgings to meet the minimum property requirements throughout the forging. The certificate shall identify the class, type, drawing or die number, heat, and heat treatment lot which are marked on the forgings to provide traceability (see 3.8). The certificate shall state that each lot meets all requirements as specified herein and shall be signed by a responsible representative of the contractor.

30.2 Nonduplication provision. Where test certificates issue by the manufacturer contain the above data requirements, a separate certificate of conformance will not be requested from the contractor.

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.

1. DOCUMENT NUMBER

MIL-S-24093A(SH)

2. DOCUMENT DATE (YYMMDD)

911105

3. DOCUMENT TITLE

STEEL FORGINGS, CARBON AND ALLOY HEAT TREATED

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

5. REASON FOR RECOMMENDATION

8. PREPARING ACTIVITY

NAME TECHNICAL POINT OF CONTACT:
Mr. John Forney, SEA 5142

b. TELEPHONE (Include Area Code)
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COMMANDER, NAVAL SEA SYSTEMS COMMAND
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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