

DOD-E-699D **METRIC**
 9 January 1978
 SUPERSEDING
 MIL-E-699C
 20 December 1967
 (See 6.8)

MILITARY SPECIFICATION
 ENAMEL, EXTERIOR, DECK, GRAY
 (FORMULA NO. 20) (METRIC)

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

1. SCOPE

1.1 Scope. This specification covers gray exterior deck enamel for shipboard use. This product may be used where air pollution regulations apply.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL

TT-R-266 - Resin, Alkyd; Solutions.
 TT-T-291 - Thinner-Paint, Volatile Spirits, Petroleum Spirits.
 PPP-P-1892 - Paint, Varnish, Lacquer, And Related Materials: Packaging, Packing, And Marking Of.

MILITARY

MIL-M-15173 - Pigment, Magnesium Silicate; Dry (Paint Pigment).
 MIL-S-15191 - Silica, Diatomaceous (Flatting-extender Pigment).
 MIL-V-15218 - Varnish, (Mixing, Phenolic).
 MIL-2-15486 - Zinc Oxide, Technical (Acicular, Paint Use).

STANDARDS

FEDERAL

FED-STD-141 - Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling, and Testing.
 FED-STD-313 - Material Safety Data Sheets, Preparation and the Submission of.
 FED-STD-595 - Colors.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring 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. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 34 - White Pigments, Chemical Analysis of.
 D 93 - Flash Point by Pensky-Martens Closed Tester, Test for.
 D 185 - Coarse Particles in Pigments, Pastes, and Paints, Tests for.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Ship Engineering Center, SEC 6124, Department of the Navy, Washington, DC 20362 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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- D 209 - Lampblack, Spec. for.
- D 562 - Consistency of Paints Using the Stormer Viscosimeter, Test for.
- D 563 - Phthalic Anhydride Content of Alkyd Resins and Resin Solutions, Test for.
- D 600 - Liquid Paint Driers, Spec. for
- D 1210 - Fineness of Dispersion of Pigment-Vehicle Systems, Test for.
- D 1296 - Odor of Volatile Solvents and Diluents, Test for.
- D 1308 - Effect of Household Chemicals on Clear and Pigmented Organic Finishes, Test for.
- D 1475 - Density of Paint, Varnish, Lacquer, and Related Products, Test for.
- D 1542 - Rosin in Varnishes, Qualitative Tests for.
- D 2088 - Low Concentrations of Lead in Paint, Determination of.
- D 2369 - Volatile Content of Paints, Test for.

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

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

3. REQUIREMENTS

3.1 Toxicity. The material shall have no adverse effect on the health of personnel when used for its intended purpose (see 4.5). Questions pertinent to this effect shall be referred by the procuring activity to the appropriate service medical department which will act as advisor to the procuring activity.

3.2 Description. The enamel shall be ready-mixed and prepared in accordance with the table I formula designated as Navy Standard Formula No. 20. When Formula No. 20 is specified, the enamel shall conform to this specification.

3.3 Composition. The enamel shall consist of ingredients conforming to the applicable specifications in the proportions shown in table I, except the amount of lampblack may be varied as necessary to meet the color requirement. Additionally, to assist in meeting brushing, condition in container, and storage stability requirements, small amounts of antisepting, anti-sagging, and antiskinning agents may be added provided that all the other requirements of the specification are met and the exact formula used is furnished in the record required by method 1031 of FED-STD-141.

TABLE I. Formula No. 20.

Ingredients	Specification	(Pounds) ^{1/}	Kilograms
Zinc oxide	MIL-Z-15486	59.091	(130)
Titanium dioxide ^{2/}		16.818	(37)
Lampblack ^{3/}		5.909	(13)
Silica ^{4/} , 5/		45.455	(100)
Magnesium silicate	MIL-P-15173, type B	63.636	(140)
Varnish solution	MIL-V-15218, type II	113.636	(250)
Alkyd resin solution ^{6/}		102.273	(225)
Paint thinner	TT-T-291, type II, grade A	75.0	(165)
Lead naphthenic drier	ASTM D 600, class B	4.545	(10)
Cobalt naphthenic drier	ASTM D 600, class B	0.909	(2)
Manganese naphthenic drier	ASTM D 600, class B	0.456	(1)

^{1/} The formula is given slightly in excess of 100 gallons to allow for normal manufacturing loss (see 6.6).

^{2/} The titanium dioxide pigment shall be an aluminum oxide, modified chalk resistant, rutile titanium dioxide containing no less than 90 percent titanium dioxide and no less than 1.8 percent aluminum oxide. Silicon dioxide and zinc oxide may also be present.

^{3/} Use "Raven 8000" by Columbian Carbon Company or equal.

^{4/} The silica shall show no less than 98 percent of silica (SiO₂), shall not lose more than 1.5 percent on ignition at 950°C ± 50°C, and coarse particles shall not exceed 3 percent retained on a No. 325 sieve. Under 300-power magnification, the silica

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shall show crystals having sharp angles indicative of material made from crushed quartz of a variety of sizes of particles.

5/ In order to meet the gloss requirement of this specification, a maximum of 35 percent of the pulverized silica may be replaced by diatomaceous silica conforming to AIL-S-15191.

6/ The alkyd resin solution shall conform to type I, class A of TT-R-266. In addition, it shall conform to the solvent requirements of TT-R-266, applicable to alkyd resin solutions intended for use in coating used in areas with regulations controlling the emission of solvents into the atmosphere (see 6.5).

3.4 Manufacture. The component raw materials shall be mixed and dispersed, as required to yield a product which is uniform and in full conformity to the requirements of this specification.

3.5 Volatile portion. The volatile portion of the enamel shall conform to the following requirements by volume:

- (a) A combination of hydrocarbons, alcohols, aldehydes, ethers, esters, or ketones having an olefinic or cycloolefinic type of unsaturation except perchloroethylene: 5 percent maximum.
- (b) A combination of aromatic compounds with eight or more carbon atoms to the molecule except ethylbenzene, methyl benzoate, and phenyl acetate: 8 percent maximum.
- (c) A combination of ethylbenzene, ketones having branched hydrocarbon structures, trichloroethylene, or toluene: 20 percent maximum.

3.6 Quantitative requirements. The enamel shall conform to the quantitative requirements in table II when tested in accordance with 4.4.

TABLE II. Quantitative requirements.

Characteristics	Requirements	
	Minimum	Maximum
Pigment, percent by weight of enamel	38.5	42.0
Volatiles, percent by weight of enamel	28.5	32.0
Nonvolatile vehicle, percent by weight of enamel (calculated by difference)	29.0	32.5
Phthalic anhydride, percent by weight of nonvolatile vehicle	11.0	---
Water, percent by weight of enamel	---	0.5
Coarse particles and skins (as residue retained on No. 325 sieve), percent by weight of enamel	---	0.5
Consistency, Krebs-Stormer shearing rate 200 RPM: grams	130	160
equivalent Krebs units	68	78
Weight per gallon, kg (pounds)	4.727 (10.4)	4.902 (10.8)
Drying time		
set to touch, hours	---	2.0
drying hard, hours	---	7.0
Fineness of grind	4	---
Flash point, °C	38	---
Gloss, 60-degree specular	---	35
Zinc oxide, percent by weight of pigment	29.5	---
Titanium dioxide, percent by weight of pigment	7.3	---
Lead, percent by weight of total nonvolatile	---	0.5

3.7 Qualitative requirements.

3.7.1 Brushing properties. The enamel, when tested as specified (see 4.4.6), shall be capable of being brushed out and laid off without excess drag on the brush. When dry, the brushed surface shall be free from sags and runs and shall show a minimum of brush marks.

3.7.2 Spraying properties. The enamel, when tested as specified (see 4.4.7), shall spray satisfactorily in all respects and shall show no running, sagging, or stroking. The film shall show no dusting, mottling, or color separation.

3.7.3 Flexibility. A film of enamel, prepared and tested as specified (see 4.4.8), shall withstand bending without cracking or flaking when observed at seven-diameter magnification.

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3.7.4 Water resistance. A film of enamel, prepared and tested as in 4.4.9, shall show no wrinkling or blistering immediately after removal of the panel from water. The enamel shall be only slightly affected with regard to hardness and adhesion when observed 2 hours after removal from the water. After 24-hours air drying, the portion of the panel which was immersed shall be almost indistinguishable with regard to hardness, adhesion, and general appearance from the portion of the panel that was not immersed.

3.7.5 Color. The color shall match color No. 26008 of FED-STD-595 when tested as specified (see 4.4.10).

3.7.6 Condition in container. A freshly opened, full container of enamel when tested as specified (see 4.4.11), shall be free from lumps, abnormal thickening, or livering and shall show no more pigment settling or caking than can be readily reincorporated to a smooth, uniform state.

3.7.7 Storage stability.

3.7.7.1 Partially full container. A three-quarter filled, closed 250-milliliter (mL) glass jar of enamel shall show no skinning at the end of 48 hours when tested as specified (see 4.4.12.1). After aging 7 days as specified (see 4.4.12.1), the enamel shall show no livering, curdling, hard caking, or gummy sediment. It shall mix readily to a smooth, uniform state and skins formed shall be continuous and easily removed.

3.7.7.2 Full container. Enamel in original, unopened containers shall be usable for a period of 1 year of normal warehouse storage after date of manufacture. The enamel, when tested as specified (see 4.4.12.2), shall be capable of being readily broken up with a paddle to a smooth, uniform consistency, shall be free from livering, curdling, gelling, or other objectionable properties, shall not exceed 90 Krebs units in viscosity, shall not exceed 7-hours dry hard time, and shall match the standard color.

3.7.8 Dilution stability. When thinned as specified (see 4.4.13), the enamel shall remain stable and uniform, showing no precipitation, curdling, or separation. Slight pigment settling shall be permitted.

3.7.9 Rosin and rosin derivatives. The enamel shall give a negative test for the presence of rosin and rosin derivatives when tested as specified (see 4.4.14).

3.7.10 Phenolic resins. The enamel shall give a positive test for the presence of phenolic resins when tested as specified (see 4.4.15).

3.7.11 Odor. The odor shall be characteristic of the volatiles permitted when tested in accordance with 4.4.

3.7.12 Surface appearance. A flow-out film on glass of the mixed enamel, after drying for 24 hours, shall exhibit a surface smooth in appearance and free of defects, such as pinholes, coarse particles, skins, or agglomerates of any kind when tested in accordance with 4.4.16.

3.7.13 Material safety data sheet. The procuring activity shall be provided a material safety data sheet (MSDS) at the time of contract award. The MSDS is DD Form 1813 found in and part of FED-STD-313. The MSDS shall be included with each shipment of the material covered by this specification.

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 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 and any additional test deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Quality conformance inspection. Quality conformance inspection shall be provided in accordance with method 1031 of FED-STD-141 as hereinafter supplemented. Submission of forms in accordance with the method 1031 shall cover complete tests other than the 1 year stability in full container test. The stability requirement (see 3.7.7.2) shall apply for 1 year after manufacture regardless of other testing or prior acceptance of material.

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4.2.1 Manufacturing control. In addition to the other requirements of method 1031 of FED-STD-141, the manufacturers shall forward to the cognizant inspection office and testing laboratory a copy of the certification that each ingredient raw material conforms to the applicable specification.

4.2.2 Ingredient materials. When requested by the testing laboratory or other controlling authority (see 6.2), 1 pint of each ingredient in the formula specified (see table I) shall be supplied for test purposes.

4.3 Acceptance. Acceptance of the enamel shall be based upon conformance of the enamel to the requirements of this specification. Failure to pass any test shall be cause for rejection of the lot.

4.4 Test procedures. The following tests shall be made in accordance with the methods specified.

Test	Applicable FED-STD-141 method	Applicable ASTM test method
Pigment content	4021	---
Volatiles	---	D 2369
Nonvolatile vehicle content	4053	---
Phthalic anhydride	---	D 563
Water	4081	---
Coarse particles	---	D 185, section 6
Consistency	---	D 562
Weight per gallon	---	D 1475
Drying time	4061	---
Fineness of grind	---	D 1210
Flash point	---	D 93
Gloss	6101	---
Zinc oxide	---	D 34
Brushing properties	4321	---
Spraying properties	4331	---
Flexibility	6221	---
Water resistance	---	D 1308, section 5
Color	4250	---
Condition in container	3011	---
Stability in partially full container	3021	---
Dilution stability	4203	---
Rosin	---	D 1542, section 4
Phenolic resin	5141	---
Odor	---	D 1296
Lead content in nonvolatile content	---	D 2088

4.4.1 Phthalic anhydride. Phthalic anhydride shall be determined by ASTM D 563. A suitable portion of the vehicle, collected during the determination of pigment and evaporated on a steam bath to approximately 10 mL, shall be used as the sample. The alcoholate precipitate obtained shall be corrected for carbonates by the use of the procedure specified in ASTM D 563.

4.4.2 Drying time. Drying time shall be determined by method 4061 of FED-STD-141, except that the specified conditions of temperature and humidity shall apply only for referee tests in case of dispute. All other tests shall be conducted under prevailing laboratory conditions.

4.4.3 Gloss, 60-degree specular. Gloss shall be determined in accordance with method 6101 of FED-STD-141 with panels prepared as specified (see 4.4.10).

4.4.4 Pigment analysis.

4.4.4.1 Zinc oxide. Zinc oxide shall be determined in the extracted pigment by ASTM D 34, except using a 0.5 gram (g) sample and filtering the solution just prior to adding methyl orange indicator in order to remove lampblack and other insoluble material which could make the end point difficult to perceive.

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4.4.4.2 Titanium dioxide. Weigh, to the nearest 0.1 milligram (mg), about 1 g of the extracted pigment and transfer to a porcelain crucible. Ignite in a muffle furnace at $600^{\circ}\text{C} \pm 50^{\circ}\text{C}$ for 1/2 hour. Transfer the contents of the ignited crucible to a 250-ml Erlenmeyer flask. Add 15 g of ammonium sulfate and slowly add 20 ml of concentrated sulfuric acid. Heat on a very high temperature hot plate until sulfuric acid fumes reflux from the neck of the flask. Dilute to volume with water and 4 ml of 30 percent hydrogen peroxide in a 200-ml volumetric flask. Mix well. Filter a portion of this solution through a dry filter paper of fine porosity discarding the first 35 ml. Determine the absorbance of the orange solution in a spectrophotometer at 406 nanometers with 3.6 N sulfuric acid in the reference cell. If the absorbance does not fall between 0.150 and 0.600, take an appropriate aliquot and dilute with 3.6 N sulfuric acid to a measured volume and run as before. Calculate the percent titanium dioxide from a formula derived by analysis of titanium dioxide of known purity on the same instrument used for the pigment analysis.

4.4.5 Lead content in nonvolatile. Determine lead content of total nonvolatile of enamel in accordance with ASTM D 2088.

4.4.6 Brushing properties. Apply the enamel as packaged in accordance with method 4321 of FED-STD-141 and observe for compliance with 3.7.1.

4.4.7 Spraying properties. Reduce eight parts by volume enamel with one part by volume of thinner conforming to TT-T-291, type II, grade A. Spray on a steel panel to a dry film thickness of 0.00204 centimeter (cm) to 0.00279 cm and observe for spraying properties in accordance with method 4331 of FED-STD-141 and for compliance with 3.7.2. For referee test, use automatic application in accordance with method 2131 of FED-STD-141.

4.4.8 Flexibility. Determine flexibility in accordance with method 6221 of FED-STD-141.

4.4.8.1 Panel preparation. Prepare a flat tin plate panel in accordance with method 2012 of FED-STD-141, using the petroleum naphtha ethylene glycol monoethyl ether mixture. Apply a 5.08-cm wide film of enamel on the tin plate with a film applicator that will give a dry film thickness of $0.00356 \text{ cm} \pm 0.00076 \text{ cm}$. Air dry the enamel in a horizontal position for 2 hours; then bake for 24 hours at $105^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Condition the panel for at least 1/2 hour as specified in method 6221 of FED-STD-141.

4.4.8.2 Procedure. Bend 180 degrees over a 0.318-cm mandrel and examine the coating for cracks over the area of the bend in a strong light at a seven-diameter magnification for compliance with 3.7.3.

4.4.9 Water resistance. Determine water resistance in accordance with section 5 of ASTM D 1308 as follows:

4.4.9.1 Panel preparation. Prepare a tin panel in accordance with method 2012 of FED-STD-141, using the petroleum naphtha ethylene glycol monoethyl ether mixture. Draw a film of the enamel to obtain a dry film thickness of $0.00254 \text{ cm} \pm 0.00076 \text{ cm}$. Air dry the enamel for 48 hours.

4.4.9.2 Procedure. Immerse in distilled water at $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 18 hours in accordance with ASTM D 1308. Examine for compliance with 3.7.4 at 2 hours and at 24 hours after removal from the water.

4.4.10 Color. Prepare panel for test by applying a single drawdown coat of the enamel to a planar piece of opaque white glass using a doctor blade with a clearance of 0.0152 cm (designed to give a wet film thickness of approximately 0.0076 cm). After a 48-hour drying period, compare the panel with color No. 26008 of FED-STD-595 in accordance with method 4250 of FED-STD-141. If doubt exists as to the acceptability of the match, determine the color difference by instrument as specified in ASTM D 2244. An acceptable color match shall be within two units (see 6.7).

4.4.11 Condition in container. Determine package condition in accordance with method 3011 of FED-STD-141 and observe for compliance with 3.7.6.

4.4.12 Storage stability.

4.4.12.1 Partially full container. Skinning shall be determined in accordance with method 3021 of FED-STD-141. Seal and age for 7 days at 24°C and observe for compliance with 3.7.7.1.

4.4.12.2 Full container. A 1-gallon container of enamel shall be stored in the original, unopened container or containers for 12 months from the date of manufacture at standard conditions and then shall be tested to determine compliance with the requirement of 3.7.7.2.

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4.4.13 Dilution stability. Reduce one part by volume of enamel as packaged with one part by volume of paint thinner conforming to type II, grade A of TT-T-291. Test according to method 4203 of FED-STD-141 for compliance with 3.7.8.

4.4.14 Rosin and rosin derivatives. Test for rosin and rosin derivatives in accordance with ASTM D 1542. Use a portion of the separated, nonvolatile vehicle for the test.

4.4.15 Phenolic resins. Test for phenolic resins in accordance with method 5141 of FED-STD-141. Use a portion of the separated, nonvolatile vehicle for the test.

4.4.16 Surface appearance. Prepare a flow-out film of the enamel, pouring approximately 15 mL of the mixed enamel across a glass panel near the upper edge while the panel is lying flat. Then tilt the panel so as to allow the coating to spread over all but the upper edge. Next place the panel in an almost vertical position and allow to drain. After 24 hours, examine the film for compliance with 3.7.12. Coarse particles, skins, and agglomerates are characterized by being larger than the dispersed pigment in particle size and extending beyond the plane of the film.

4.5 Toxicity. A manufacturer of material shall disclose the formulation of his product to the Navy Bureau of Medicine and Surgery, Navy Department, Washington, DC 20372. The disclosure of proprietary information, which shall be held in confidence by the Bureau of Medicine and Surgery, shall include: the name, formula, and approximate percentage by weight and volume of each ingredient in the product; the results of any toxicological testing of the product; identification of its pyrolysis products; and any such other information as may be needed to permit an accurate appraisal of any toxicity problem associated with the handling, storage, application, use, or disposal of the material.

4.6 Inspection of preparation for delivery. The packaging, packing, and marking of the enamel shall be inspected to determine compliance with section 5.

5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements.)

5.1 Packaging, packing, and marking. The enamel shall be packaged, packed, and marked in accordance with PPP-P-1892. The level of packaging shall be level A, B, or C and the level of packing shall be level A, B, or C, as specified (see 6.2). The enamel shall be furnished in 1-gallon cans or 5-gallon pails as specified (see 6.2).

5.1.1 Special marking. In addition to other markings required on the containers there shall be the following statement: "The volatile content of the material in this container is not photochemically reactive as defined by Rule 102 of the South Coast Air Quality Management District". (See 6.4.)

6. NOTES

6.1 Intended use. The enamel covered by this specification is intended for use as a gray finish coat on exterior deck surfaces of ships.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Special samples if required (see 4.2.2).
- (c) Level of packaging and packing required (see 5.1).
- (d) Size of container (see 5.1).
- (e) Special marking required (see 5.1.1).

6.2.1 Level B packaging. Level B packaging is intended to provide economical but limited protection and should be specified only when it is determined that the enamel will be held in covered storage no more than 1 year from date of initial packaging.

6.3 Unit quantities. The enamel should be purchased by volume, the unit being 1 U.S. gallon (231 cubic inches) at 15.6°C.

6.4 Volatile content. Although the container marking specifically refers to the South Coast Air Quality Management District, the enamel may be used anywhere else an enamel complying with 3.5 is required. This includes other air pollution control districts or similar areas controlling the emission of solvents into the atmosphere. Information concerning Rules 102, 442, and 443 may be obtained from: South Coast Air Quality Management District, Metropolitan Zone, 434 South San Pedro Street, Los Angeles, California 90013.

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6.5 If it is desired to use alkyd resin solution conforming to the requirements for type I, class B of TT-R-266, intended for use in coating used in areas with regulation controlling the emission of solvents into the atmosphere, the weight of alkyd resin solution, as specified herein should be multiplied by 1.17 and the paint thinner reduced by 0.17 times the weight of alkyd resin solution.

6.6 Composition by volume. For information only and with the understanding that weight-volume relationships of ingredients may vary slightly, the following approximation of composition by volume is included.

TABLE IV. Composition by volume.

<u>Ingredient</u>	<u>Gallons</u>
Zinc oxide	2.8
Titanium dioxide	1.1
Lampblack	0.9
Silica	4.5
Magnesium silicate	5.9
Varnish solution	32.9 (17.7) ^{1/}
Alkyd resin solution	28.4 (18.0) ^{1/}
Paint thinner	24.7
Lead naphthenate drier	1.0
Cobalt naphthenate drier	0.25
Manganese naphthenate drier	0.13
Total volume 102.6	

^{1/} Figures in parentheses refer to volume of resin solids (nonvolatile).

6.7 Normally the third and fourth digits of a color number in FED-STD-595 approximate the color's reflectance value (lightness). Color No. 26008 is an exception.

6.8 Changes from previous issue. The symbol "*" is not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodians:

Army - MR
Navy - SH
Air Force - 99

Preparing activity:

Navy - SH
(Project 8010-0766)

Review activities:

Army - ME
Navy - YD

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REPLACES EDITION OF 1 JAN 66 WHICH MAY BE USED

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