NOTE: DOD-STD-2185 has been redesignated as a Standard Practice. The cover page has been changed for Administrative reasons. There are no other changes to this Document.

DOD-STD-2185(SH)
28 OCTOBER 1986
SUPERSEDING
NAVSEA 0991-LP-023-3002
15 July 1982
(See 6.4)

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

REQUIREMENTS FOR REPAIR AND STRAIGHTENING OF BRONZE NAVAL SHIP PROPELLERS

AMSC N/A FSC 2010

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

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Requirements for Repair and Straightening of Bronze Naval Ship Propellers

1. This Military Standard 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.

2. 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.

FOREWORD

1. This standard contains information and requirements for the repair of bronze Naval ship propellers.

CONTENTS

CONTENTS - Continued

FIGURES

TABLES

1. SCOPE

1.1 Scope. This standard covers the requirements for straightening, welding, and heat treatment of manganese bronze, nickel-manganese bronze, nickel-aluminum bronze and manganese-nickel-aluminum bronze propellers used on Naval ships.

1.2 Approval. Facilities intending to repair bronze propellers for the U.S. Navy, in accordance with this standard, must have prior Naval Sea Systems Command (NAVSEA) approval of their technical ability for compliance. This approval shall be a part of their contract and may include documentation review or facility audits.

2. REFERENCED DOCUMENTS

2.1 Government documents.

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

SPECIFICATIONS

FEDERAL

QQ-C-390 - Copper Alloy Castings (Including Cast Bar).

MILITARY

MIL-E-278 - Electrodes, Welding, Covered, Aluminum Bronze.
MIL-E-23765/3 - Electrodes and Rods - Welding, Bare, Solid Copper Alloy.
MIL-B-24480 - Bronze, Nickel-Aluminum (UNS No. C95800) Castings For Seawater Service.

STANDARD

MILITARY

MIL-STD-248 - Welding and Brazing Procedure and Performance Qualification.
MIL-STD-271 - Nondestructive Testing Requirements for Metals.
MIL-STD-278 - Fabrication Welding and Inspection; and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels in Ships of the United States Navy.

2.1.2 Other Government publications. The following other Government publications form a part of this standard to the extent specified herein.

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)
0900-LP-003-8000 - Metals, Surface Inspection Acceptance Standards.
0944-LP-007-4010 - Marine Propellers.

(Copies of specifications, standards, and publications required by contractors 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 standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DoDISS.

AMERICAN BUREAU OF SHIPPING (ABS)
Guidance Manual for Bronze and Stainless Steel Propeller Casting.

(Application for copies should be addressed to the American Bureau of Shipping, 65 Broadway, New York, NY 10006.)

AMERICAN WELDING SOCIETY (AWS)
A2.4 - Symbols for Welding and Nondestructive Testing Including Brazing. (DoD adopted)
A3.0 - Standard Welding Terms and Definitions Including Terms For Brazing, Soldering, Thermal Spraying, and Thermal Cutting. (DoD adopted)
A5.7 - Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes. (DoD adopted)
A5.27 - Specification for Copper and Copper Alloy Rods for Oxyfuel Gas Welding.
B4.0 - Standard Methods for Mechanical Testing of Welds. (DoD adopted)

(Application for copies should be addressed to the American Welding Society, Inc., 550 NW LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

(Nongovernment standards are generally available for reference from libraries. They are also distributed among nongovernment standards bodies and using Federal agencies.)

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

3. DEFINITIONS

3.1 General. Except as noted herein, welding nomenclature and definitions shall conform to AWS A2.4 and AWS A3.0.

3.2 Definitions. The following definitions are applicable to this standard:

(a) Acceptable. Acceptable shall mean complies with or conforms to the applicable standard or specification.

(b) Activity. An activity is the physical plant of an organization performing work in accordance with a contract specification which references this document.

(c) Approved (approval). Approved (or approval) shall mean that the item under consideration has been approved by NAVSEA or its authorized representative. Unless otherwise specified, approval or approved as used herein shall be by the authorized representative.

(d) NAVSEA authorized representative. The NAVSEA authorized representative shall be the Government representative specifically authorized to approve equipment, materials, or procedures within the scope of this standard for NAVSEA and who is listed as follows:

(1) Naval Shipyard Commanders.
(2) Supervisors of Shipbuilding (SUPSHIP).
(3) Commanding Officer, Naval Ship Systems Engineering Station (NAVSSES).
(4) Naval Ship Repair Facilities Commanders.
(5) Delegated representatives of these authorities.
(6) Representatives specifically authorized by NAVSEA on a case by case basis.

(e) Cavitation erosion. Cavitation erosion is erosion resulting from the rapid formation and collapse of water vapor bubbles on metal surfaces during high relative motion of the propeller which results in a porous, spongy, and pitted metal surface. Metal surface areas with heavily concentrated porosity, and concentrated porosity associated with cavitated eroded areas, are to be interpreted and treated as part of the cavitation erosion effect.

(f) Propeller definitions.

(1) Pressure face. The pressure or aft face of the propeller blade is the blade surface that is usually adjacent to the aft end of the hub. The aft end of the hub is readily identified by the small end of the taper bore and reduced hub outside diameter.

(2) Suction face. The suction or forward face (sometimes referred to as the back) is the blade surface that is usually adjacent to the forward end of the hub. The forward end of the hub is readily identified by the large end of the taper bore, a large hub outside diameter and in most cases a bore recess in the forward face to receive the shaft sleeve, gland ring, and seal.

(3) Leading edge. The leading edge of a propeller blade is the blade edge adjacent to the forward end of the hub. This applies to both right hand and left hand propellers. The leading edge thickness is relatively heavy when compared with the thinner trailing edge.

(4) Trailing edge. The trailing edge of the propeller blade is that which is adjacent to the aft end of the hub. This applies to both right and left hand propellers. The trailing edge is the thin edge when compared to the leading edge.

(g) Minor repair definitions.

(1) Minor bends. Minor bends are those near the blade tip, normally not farther from the edge than one-tenth of the blade section length, or bends outside the 0.95 radius (R). Minor bends should be limited to blade sections under 1-1/4 inches thick and with a corrected deflection of less than 15 degrees.

(2) Minor cracks. Minor cracks are those located within 2 inches of the blade edges and with lengths less than 2 inches. In addition, surface cracks and cracks not exceeding 1/8-inch in depth or one quarter of the local thickness, whichever is less, and not greater than 2 inches in length shall be defined as minor.

(3) Minor patches. Minor patches are those patches applied to a blade where a small portion of the blade edge is missing (not over 2 square inches) and repairs may be made entirely by added weld metal.

(4) Minor cavitation erosion. Weld repair of cavitated or eroded areas less than 2 square inches in surface area and which are less than 1/2-inch deep.

(h) Major repair definitions.

(1) Major bends. Major bends are those greater than listed in 3.2(g)(1) and may involve bending in a forward or aft direction across the entire blade section.

(2) Major cracks. Major cracks are those greater than listed in 3.2(g)(2).

(3) Major patches. Major patches are those greater than listed in 3.2(g)(3), or those requiring the use of a separately cast or forged patch piece welded to replace a missing section.

(4) Major cavitation erosion. Major cavitation erosion is that which exceeds the limit as specified in 3.2(g)(4).

(i) Welding procedures. Welding procedures are written instructions designed for use in production welding and repair welding, delineating the essential elements and providing guidance to produce reliable welds.

(j) Propeller classifications.

(1) Class I, high precision. Class I propellers are those propellers normally associated with combatant or other high performance ships or craft. The noise critical type and non-noise critical type are within this classification. Propeller blade section and edge and tip gauges are normally required for repairs to these propellers.

(2) Class II, moderate precision. Class II propellers are normally associated with amphibious, auxiliary, and non-combatant ships. Propeller blade gauges may or may not be required for manufacture, but the drawing tolerances are generally in agreement with the requirements for non-combatant ship propellers.

(3) Class III, low precision. Class III propellers are those propellers for service craft, small boats and similar applications.

4. GENERAL REQUIREMENTS

4.1 Responsibility. Each activity that accomplishes work in accordance with this standard shall be familiar with its provisions and reference specifications to the extent that these provisions apply to the work being performed. Also, each activity shall be:

(a) Capable of welding, straightening and heat treatment of ship propellers. Where services of outside suppliers are utilized, the activity is responsible for assuring that the process is performed in accordance with the requirements of this specification.

(b) Responsible for the quality of workmanship and maintenance of controls and records necessary to ensure reliability and integrity of the finished propeller.

(c) Responsible for preparation of process procedures specified herein, including conducting welding qualification tests, and maintaining qualification records in accordance with MIL-STD-248 and this standard.

(d) Responsible for the proficiency of personnel and equipment to ensure conformance to the design and specification requirements.

4.2 Quality assurance.

4.2.1 General. This section contains the minimum requirements for assuring that repaired propellers meet the inspection criteria specified in this standard.

4.2.2 Quality assurance system. Each activity shall maintain an inspection system adequate to assure NAVSEA or its authorized representative that all of the requirements of this standard have been and are continuously being met. Written procedures shall be prepared to assign responsibility and provide accountability for performing work and inspection.

4.2.3 Records.

4.2.3.1 General. When specified in the contract or order, the quality control system shall be prepared for each repaired propeller (see 6.2):

4.2.3.2 Record form. A record form shall be prepared prior to the commencement of the operation which it covers. Operations shall be recorded prior to the commencement of the next operation. Each operation on the record form shall be signed by the organization's cognizant supervisor and dated. When a specific item on the record form is not applicable, the letters "N.A." (not applicable) shall be entered. Final acceptance of a propeller repair shall not be granted until all items on the record forms are prepared and completed as specified in 4.2.3.1.

4.2.4 Noncompliance. If NAVSEA or its authorized representative has evidence that the requirements of this standard are not being met, he may provide written notification that the use of any questionable materials, equipment, procedures, personnel, and so forth is suspended, until compliance with the requirements of this standard is judged satisfactory.

4.3 Welding qualifications.

4.3.1 Welding procedure qualification. When specified in the contract or order, prior to production welding, written welding procedures certified by the activity as containing the essential elements specified in MIL-STD-248 shall be prepared (see 6.2). The welding procedure shall be qualified in accordance with MIL-STD-248 except that:

(a) The lower material thickness limit for test plate thickness qualified does not apply to propeller repair. No lower limit exists.
(b) For procedures qualified on test plate thickness less than 1-1/2 inches, the upper thickness limit for production welding shall be two times the test plate thickness; however, for procedure qualified on test plate thickness 1-1/2 inches or greater, the procedure is qualified for all thicknesses.
(c) The qualification test assembly shall be of sufficient size to permit removal and testing of two transverse tensile specimens (see AWS B4.0), four side bend specimens (see AWS B4.0) and two transverse macrospecimens. The acceptance criteria shall be in accordance with MIL-STD-248 except that the tensile specimens shall meet the strength requirements of table I herein for the material qualified. Bend specimen failure may not necessarily disqualify a weld procedure. Bend specimen failure shall be reported to NAVSEA for consideration.
(d) Arc weld procedures qualified with a 600 degrees Fahrenheit (°F) preheat qualify for repair welding at a minimum of 300°F preheat.

TABLE I. Welding procedure qualification tensile requirements.

Type of propeller (alloy)	Welding process	Tensile strength lb/in^2 minimum
Manganese (Mn) bronze	Oxyfuel	40,000
Manganese (Mn) bronze	All arc processes	55,000
Nickel-manganese (NiMn) bronze	Oxyfuel	45,000
Nickel-manganese (NiMn) bronze	All arc processes	60,000
Nickel-aluminum (NiAl) bronze	All arc processes	72,000
Manganese-nickel-aluminum (MnNiAl) bronze	All arc processes	80,000

4.3.2 Welding procedure and qualification approval. The qualification test data shall be submitted to the authorized agent, as defined in accordance with MIL-STD-248, for approval. When specified in the contract or order, the welding procedure shall also be submitted for review and concurrence when qualification test data are submitted or whenever the welding procedure is prepared (see 6.2).

4.3.3 Alternate process. Welding processes, procedures and materials, other than those specified in this standard, may be used on the basis of procedure qualification tests for applications approved by NAVSEA or its authorized representative.

4.3.4 Procedure requirement. Qualification tests shall be made at each activity where it is intended to repair bronze propellers. Exceptions (a) and (b) below are to be detailed in the appropriate quality assurance system and demonstrated as controllable during prebid audit.

(a) The Naval Ship Repair Facilities and Intermediate Maintenance Activities may use welding procedures qualified by U.S. Naval Shipyards.
(b) The welding procedures qualified by a commercial establishment may be used by any of its facilities as long as procedural controls are managed by a single entity of the establishment.

4.3.5 Welder performance qualification. The welder who qualified the procedure is qualified for production welding. Additional welders shall be required to qualify, and their qualification records maintained in accordance with MIL-STD-248. For bend specimen review, see 4.3.1(c).

4.3.6 Welding equipment. All manual, semi-automatic, or automatic welding equipment shall, in the hands of a qualified welder or welding operator, consistently produce satisfactory welds under production conditions.

4.4 Atmosphere exposure. Manganese bronze or nickel-manganese bronze propellers are to be protected from prolonged exposure to industrial atmospheres (ammonia gases or solvents). The cycle of repair for these propellers shall be controlled so as to minimize such exposure. NAVSEA will consider temporary coatings to act as a barrier to industrial atmospheres. Control of exposure time will minimize the potential for stress corrosion cracking.

5. DETAILED REQUIREMENTS

5.1 Materials.

5.1.1 Materials for repair. Propeller material and welding filler metal combination shall be in accordance with table II. Propeller base material and welding filler metal shall conform to the following specifications:

(a) Propeller material:

Manganese bronze - alloy 865 in accordance with QQ-C-390
Nickel-manganese bronze - alloy 868 in accordance with QQ-C-390
Nickel-aluminum bronze - alloy 1 in accordance with MIL-B-24480
Manganese-nickel-aluminum bronze - MIL-B-24480

(b) Welding filler metal:

MIL-E-CuAl-A in accordance with MIL-E-278
ERCuAl-A2 in accordance with AWS A5.7
RCuZn-B in accordance with AWS A5.27
RCuZn-C in accordance with AWS A5.27
MIL-CuAl-A2 in accordance with MIL-E-23765/3
MIL-CuNiAl in accordance with MIL-E-23765/3
MIL-CuMnNiAl in accordance with MIL-E-23765/3
NiMn bronze strips

TABLE II. Welding processes and filler metals.

Alloy type 1/	Welding process	Filler metal			
		Type	Group 1/	Classification 2/	Specification
Mn bronze S-37A	Shielded metal arc (SMA) Gas metal arc (GMA) Gas tungsten arc (GTA) Oxyfuel	Al bronze Al bronze Al bronze Low fuming brass	A-37A A-36B A-36B A-35B	MIL-E-CuAl-A MIL-CuAl-A2 ERCuAl-A2 RCuZn-B RCuZn-C	MIL-E-278 MIL-E-23765/3 AWS A5.7 AWS A5.27 AWS A5.27
NiMn bronze S-37B	Shielded metal arc (SMA) Gas metal arc (GMA) Gas tungsten arc (GTA) Gas tungsten arc (GTA) Oxyfuel or hot flow	Al bronze Al bronze Al bronze Same as propeller Same as propeller	A-37A A-36B A-36B NA NA	MIL-E-CuAl-A MIL-CuAl-A2 ERCuAl-A2 NA NA	MIL-E-278 MIL-E-23765/3 AWS A5.7 NA NA
NiAl bronze S-36A	Shielded metal arc (SMA) Gas metal arc (GMA) Gas tungsten arc (GTA)	Al bronze NiAl bronze NiAl bronze	A-37A A-37B A-37B	MIL-E-CuAl-A MIL-CuNiAl 3/ MIL-CuNiAl 3/	MIL-E-278 MIL-E-23765/3 MIL-E-23765/3
MnNiAl bronze S-36B	Shielded metal arc (SMA) Gas metal arc (GMA) Gas tungsten arc (GTA)	Al bronze MnNiAl bronze MnNiAl bronze	A-37A A-37B A-37B	MIL-E-CuAl-A MIL-CuMnNiAl MIL-CuMnNiAl	MIL-E-278 MIL-E-23765/3 MIL-E-23765/3

1/ The "S" and "A" designations for alloy type and filler metal group refer to designations in accordance with tables I and II of MIL-STD-278.
2/ Equivalent AWS electrodes may be used, subject to acceptance by the government representative.
3/ MIL-CuAl-A2 may be substituted with NAVSEA approval.

5.1.2 Material substitution approval. Unless otherwise specified in the Government specifications, material acquired in accordance with AWS, ASTM, ABS or ASME standards (or approved substitution material list) may be used for materials as specified in 5.1.1 subject to approval by NAVSEA or its authorized representative.

5.1.3 Specification deviations. Unless otherwise specified in the applicable contract or specification, deviations from the requirements of governing material specifications must be approved by the contracting agent as concurred with by NAVSEA.

5.1.4 Propeller material identification. On most propellers, material identification is stamped on the hub. Material determination shall be performed prior to any repair operation in the following cases:

(a) When the material identification stamped on the hub has been obliterated.
(b) When the propeller material is manganese bronze or nickel-manganese bronze and repairs by welding are anticipated.
(c) When there is reason to believe the stamped hub data is inaccurate.
(d) At the request of the NAVSEA representative.

5.1.5 Zinc equivalent and alpha/beta determination.

5.1.5.1 Zinc equivalent. The amount of aluminum and the zinc equivalent exert a major influence on the weldability of manganese bronze and nickel-manganese bronze. Values of zinc equivalent less than 45 percent, calculated as follows, are indicative of a material chemistry that may be suitable for welding:

$$\text{Percent zinc equivalent} = 100 - \frac{(100 \times \text{percent copper})}{(100 + A)}$$

Where A is the algebraic sum of the following zinc replacement factors:

Tin (Sn) = + 1 X percent Sn
Aluminum (Al) = + 5 X percent Al
Manganese (Mn) = -0.5 X percent Mn
Iron (Fe) = -0.1 X percent Fe
Lead (Pb) = 0.0
Nickel (Ni) = -2.3 X percent Ni
Silicon (Si)1/ = + 9.0 X percent Si

1/ Only that portion of the silicon which is in solid solution can be counted for zinc replacement. Normal chemical analysis includes the silicon which is present as silica or silicates; rarely will more than half of this total amount be present as silicon in solid solution.

5.1.5.1.1 Zinc equivalent requirement. A determination of zinc equivalent is required for manganese and nickel-manganese bronze propeller.

5.1.5.1.2 Zinc equivalent sampling plan. For manganese and nickel-manganese bronze propellers, one zinc equivalent check shall be taken from each blank, or renewal section of blank to be repaired. The sample shall be taken in reasonable proximity to the repair. Only one sample is required for each blank or section. If zinc equivalent is greater than 45 percent, request guidance from NAVSEA.

5.1.5.2 Alpha/beta determination. When the alpha phase content of a manganese bronze or nickel-manganese bronze specimen taken from an area which is to be repaired by welding, or from the end of the acceptance test bar, is determined by microscope measurement to be 20 percent or more, this is indicative of material good weldability.

5.1.5.2.1 Alpha/beta requirement. Alpha/beta determination is required for manganese and nickel-manganese bronze propellers.

5.1.5.2.2 Alpha check sampling plan. For manganese bronze and nickel-manganese bronze propellers, one alpha check shall be taken from each blade, or renewal section of blade, prior to weld repair. The sample shall be taken in base material at a reasonable proximity to the repair. The sample shall be taken in the vicinity of the zinc equivalent check. Only one sample may be required for each blade or section in the case of multiple repairs per blade or section. If alpha is less than 20 percent, NAVSEA guidance shall be required. The recommended method for alpha check shall be the replica technique (see 5.1.5.2.3), although regular metallographic sampling may be used. After weld repair and after stress relief, an alpha check shall be taken in the vicinity of one weld and in one 3 to 6 inch region from that one weld per propeller. It shall be taken in the vicinity of the test prior to welding. Results shall be reported to NAVSEA in accordance with the data ordering document included in the contract or order (see 6.2).

5.1.5.2.3 Replica technique for determination of alpha/beta content. The replica technique (or plastic imprint method) is a step-by-step documentation procedure of the method as developed by Mr. Y. Umezu of Yokosuka Naval Ship Repair Facility. It is used to determine the alpha/beta composition.

(a) Preparation of the blade shall be as follows:
  (1) Rough grind the regions to be tested to ensure a flat surface at the area to be sampled.
  (2) Polish the surface of the test regions with a 64 grit sanding paper. Then sand with successively finer grit papers (240, 360, 400, and finally 600 grit) rotating the direction of sanding 90 degrees with respect to the direction used with the preceding grit paper, and continue with one grit until all marks of the previous larger grit are removed.
  (3) Prepare a polishing paste by adding water to a chrome oxide powder. Apply with a felt cloth and finish polish the three surface areas. Wrapping the cloth over a wooden paddle may be useful in maintaining an even pressure during polishing.

(b) Etching shall be as follows:
  (1) Using a 7X loupe (or higher magnification), locate regions within the polished area which have minimal scratches. It is recommended that two samples be taken from each area.
  (2) Etch areas with nitric acid leaving the acid on the surface only 2 or 3 seconds followed by a water rinse each time. Etch the area three or four times, observing the etched region after each rinse. Once the areas are sufficiently etched, finish rinse with acetone and air dry.

(c) Plastic imprinting shall be as follows:
  (1) Apply acetone to one side of a piece of plastic (approximately 3/4 by 3/4 by 1/16 inch) wetting it for about 30 seconds. Place plastic, acetone side down, on the blade surface and press down approximately 30 seconds. Leave in place for 15 to 20 minutes. Carefully remove the specimens by prying up an edge and place the specimens in individually marked bags.

(d) The plastic replica is placed on the metallograph stage and a mirror is placed above it to increase the contrast in the image.

(e) It is recommended that only one area be etched at a time as the polished area will continue to corrode even after the acetone rinse.

(f) Alpha/Beta content shall be determined by standard metallographic techniques.

5.2 Propeller handling.

5.2.1 General. The handling, lifting, and turning of propellers shall be in accordance with NAVSEA 0944-LP-007-4010.

5.3 Welding.

5.3.1 Welding prerequisite. Prior to performing any repair welding on bronze propellers covered by this standard, the welding procedure and welding operator shall be qualified in accordance with MIL-STD-248 and as specified in 4.3.1, 4.3.2, 4.3.3, 4.3.4, and 4.3.5.

5.3.2 Preheat. The preheat temperature ranges for the various welding processes and propeller alloys shall conform to table III. The preheat temperature shall be measured in the area to be welded and on the opposite side of the blade. The difference in temperature between both sides of the blade shall not exceed 50°F. The preheat temperature shall extend 12 inches in all directions from the repair area so that a maximum temperature gradient of about 100°F per foot can easily be maintained in the surrounding area. Soft gas torches (soft neutral or slightly reducing flame) or electrical resistance (strip) heaters are recommended for preheating rather than oxyacetylene torches, and the temperature should be checked at frequent intervals by means of temperature indicating crayons or contact pyrometers. The preheat temperature shall be maintained throughout the entire welding operation. Adequate support for the propeller shall be provided during the preheat and welding operations.

5.3.3 Welding requirements. The processes, filler metal types, and heating procedures for the repair of bronze propellers shall conform to tables II and III for the alloy type indicated. SMA, GMA and GTA welding processes are satisfactory for all major and minor repairs on all types of propellers. Oxyfuel gas welding is permitted on manganese bronze and nickel-manganese bronze propellers, but it shall be limited to the repair of edges on the outer one-third of the propeller radius and in general to sections under 1-1/4 inches thick. The welding operation on manganese-nickel-aluminum bronze propellers shall be performed as expeditiously as possible to avoid prolonged heating at the adjacent area, which may cause embrittlement.

TABLE III. Welding processes and heating requirements.

Alloy type	Welding process	Preheat temp (°F)	Stress relief temp (°F)
Mn bronze and NiMn bronze	Shielded metal arc (SMA)	1/ 2/	6/ 725-825
	Gas metal arc (GMA)	1/ 2/	6/ 725-825
	Gas tungsten arc (GTA)	1/ 2/	6/ 725-825
	Oxyfuel	600-800	6/ 725-825
NiAl bronze	Shielded metal arc (SMA)	60 Min 2/	None
	Gas metal arc (GMA)	60 Min 2/	None
	Gas tungsten arc (GTA)	60 Min 2/	None
MnNiAl bronze	Shielded metal arc (SMA)	3/ 4/ 100-300	5/ 1050-1150
	Gas metal arc (GMA)	3/ 4/ 100-300	5/ 1050-1150
	Gas tungsten arc (GTA)	3/ 4/ 100-300	5/ 1050-1150

1/ A 600 to 800°F preheat shall be required within a 1-foot band around the propeller blade outside of the 0.7 radius. The other area will require a 300°F preheat.
2/ Cool slowly after welding by wrapping with insulating blankets.
3/ Cool in still air after welding.
4/ Interpass temperature 400°F maximum.
5/ Minor repairs, as defined in 3.2(g) and welds of prairie air channel cover plates need not be stress relieved.
6/ Furnace stress relief as defined in 5.5.2.1 is the only acceptable method.

5.3.4 Repairs to critical areas. No welding in way of the critical area of a blade is to be undertaken without prior approval by NAVSEA or authorized representative. As shown on figure 1, the critical area is defined as the area in the pressure face of the blade between the fillet and 0.4R and starting at the leading edge encompassing 80 percent of the chord length taken at 0.4R. Repairs in these areas shall be made by means of arc welding when approved.

5.3.5 Joint design and position. Repairable defects shall be air-carbon-arced, chipped, or ground to sound metal, and recommended grooves (see figures 2 and 3) provided for welding in the flat (down hand) position.

5.3.6 Peening. All layers of weld metal may be peened to help control distortion or relieve stresses. Adequate propeller support shall be used when peening of the first layer is performed. Peening of the last layer is permitted provided this layer is subsequently ground to remove all evidence of peening prior to visual and liquid penetrant inspection.

5.3.7 Repair exceptions. The repair of defects by means of soft solders or silver-brazing alloys shall not be permitted.

5.3.7.1 Small defects. Repair of small defects for sake of appearance shall be avoided. Cavities with a maximum depth of 1/8-inch shall be left undisturbed (see 5.3.8).

5.3.8 Weld repair inspection. All welds shall be visually inspected after weld repair and before stress relief (if stress relief is required). Visual inspection is again required after stress relief. Liquid penetrant inspection, in accordance with MIL-STD-271, shall be performed as an aid to visual inspection in locating discontinuities. Discontinuities located by liquid penetrant inspection shall be evaluated for repair based on actual size of the discontinuity and not on the indication size developed during the liquid penetrant inspection. Weld repairs shall be evaluated in accordance with table I of NAVSEA 0900-LP-003-8000 with the following exceptions:

(a) Combatant noise critical propellers. Surface porosity shall be limited to 0.010 inch in size in a 1 inch wide band on each face along the leading edge, and at the break of the knuckle along the trailing edge.

(b) All propellers. A propeller will be considered acceptable even though it exceeds the limits specified in table I of NAVSEA 0900-LP-003-8000 under the following conditions:

(1) Service and subsequent inspection has confirmed that there are no cracks in the affected area. This may be in the original casting or previous weld repair areas.

(2) Provided no actual cracks are detected, existing linear indications outside the weld repair area are acceptable.

(c) 5.3.8(a) takes precedence over 5.3.8(b).

5.4 Straightening.

5.4.1 General. The appropriate straightening procedures given in table IV shall be followed in making repairs to the types of propeller alloys listed.

5.4.2 Cold straightening. Cold straightening (temperature below 400°F) by means of dynamic loads shall be used only to repair minor bends. The straightening operation, in the case of manganese bronze, nickel-manganese bronze and manganese-nickel-aluminum bronze propellers, shall be followed by a suitable stress relief treatment in accordance with table IV and 5.5.1 through 5.5.4.

TABLE IV. Heating requirements for straightening.

Alloy type	Type of repair	Loading 1/ method	Straightening temp °F	Stress relief temp °F
Mn bronze	Minor	Dynamic or slowly applied	400 max 2/	8/ 725-825
NiMn bronze	Minor	Dynamic or slowly applied	400 max 2/	8/ 725-825
NiAl bronze	Minor	Dynamic or slowly applied	400 max	None
	Major or minor	Dynamic or slowly applied	2/ 5/ 6/ 1400-1650	None
MnNiAl bronze	Very minor only	Dynamic or slowly applied	400 max 3/	3/ 4/ 1050-1150
	Major or minor	Dynamic or slowly applied	3/ 6/ 7/ 1450-1550	3/ 4/ 1050-1150 3/ 4/ 1050-1150

1/ A dynamic load is one which is moving prior to contact with the propeller. A slowly applied load is in constant contact with the propeller when stress is applied.
2/ Cool slowly after straightening.
3/ Cool in still air after straightening and stress relief operation.
4/ Minor repairs as defined in 3.2(g) need not be stress relieved.
5/ Temperature must be reached and maintained during the complete straightening operation.
6/ In order to obtain a temperature within the 1400 to 1650°F range the following heating controls are recommended.
(a) Heat with propane torches for not less than 3 hours.
(b) Heat should be applied over a large area and should extend 1-1/2 feet beyond the bend area.
(c) Oxyacetylene torches should be used to implement heating for straightening.
7/ A generous area in which straightening is to be done is to be heat soaked prior to applying load.
8/ Furnace stress relief as defined in 5.5.2.1 is the only acceptable method.

5.4.3 Hot straightening. Hot straightening may only be applied as noted in table IV. The portion of the propeller which is being straightened should be kept within the recommended temperature range as specified in table IV during the course of the repair by means of soft gas torches (soft neutral or slightly reducing flame), supplemented when necessary with heat from moving oxyacetylene torches. A generous area surrounding the section to be straightened shall be heated through its entire thickness to the required temperature. The required straightening temperature and stress relief requirements shall be in accordance with table IV and 5.5.1 through 5.5.4.

5.4.4 Inspection after straightening. The straightening repairs shall be visually inspected after straightening and then again after stress relief (if stress relief is required). Liquid penetrant inspection shall be performed as an aid to visual inspection in locating discontinuities. The acceptance standards and exceptions shall be as specified in 5.3.8.

5.5 Stress relief.

5.5.1 General. Welding or straightening repairs made on manganese bronze, nickel-manganese bronze and manganese-nickel-aluminum bronze propellers shall be stress relieved within the appropriate temperature range shown in tables II and IV. Although the stress relieving treatment is usually carried out immediately after repairing, no harm is to be expected if the repaired area on manganese bronze or nickel-manganese bronze is first allowed to cool slowly to room temperature by wrapping in an asbestos free insulation blanket. The heating and cooling of manganese-nickel-aluminum bronze shall be such as to avoid the 660 to 1050°F temperature range which may cause embrittlement. A stress relieving treatment should be given as soon as practicable. A furnace stress relief is required for all weld repairs and straightening operations on manganese bronze and nickel-manganese bronze base material. For manganese-nickel-aluminum bronze furnace stress relief is strongly recommended where repairs in heavy sections or fillet areas have been made. Manganese and nickel-manganese bronze propellers being reconditioned that have been in service over 7 years or that have been in storage and cannot be certified as having been stress relieved at the time of reconditioning or prior to storage, to these requirements shall be furnace stress relieved. Nickel-aluminum bronze propellers do not require the stress relief treatment.

5.5.1.1 Manganese-nickel-aluminum bronze propellers. Stress relieving of manganese-nickel-aluminum bronze (superston 40) propellers is required subsequent to straightening or weld repairs, except for the welds of prairie air channel cover plates and minor defects in noncritical areas (see 5.3.4).

5.5.2 Furnace stress relief.

5.5.2.1 Furnace stress relief of manganese bronze and nickel-manganese bronze. Furnace stress relief shall be accomplished by slow uniform heating to a holding temperature of 725 to 825°F. Application of heat shall be controlled (a) so that the heating rate does not exceed 50°F per hour at any thermocouple on the propeller; and (b) so that a temperature differential of 100°F is not exceeded among any of the attached thermocouples. Time at the holding temperature shall begin when all attached thermocouples are within 50°F of each other

and are within the 725 to 825°F range. This control (50°F maximum differential within the 725 to 825°F range) shall be maintained for a minimum of 12 hours prior to the start of cooldown. Cooling shall be controlled (a) so that the cooling rate does not exceed 50°F per hour at any thermocouple on the propeller; and (b) so that a temperature differential of 50°F is not exceeded among the attached (without welding) thermocouples. Control of cooling and the monitoring of temperatures shall continue until the maximum temperature of the thermocouples attached to the hub is within 100°F of ambient air temperature outside the furnace.

5.5.2.2 Furnace stress relief of manganese-nickel-aluminum bronze. This method is recommended where possible and shall be accomplished by heating the entire propeller in a furnace. Stress relief shall be effected by slow uniform heating to a holding temperature in the stress relief temperature range as required by table II or IV. The heating rate shall be controlled so that a temperature gradient of 100°F is not exceeded among the thermocouples attached to the propeller for monitoring temperatures. In addition, the surface on which the propeller is placed shall be constructed in such a manner to permit circulation of the hot gases through the propeller bore. Time at the holding temperature shall start when all attached thermocouples read within a temperature differential of 100°F and are within the stress relieving range. This degree of control shall be maintained during the holding period for a minimum of 12 hours prior to the start of cooling. During the cooling cycle, control of the temperature gradient shall be maintained so that the differential does not exceed 50°F. Monitoring of propeller temperature shall continue until hub temperatures are within 100°F of ambient air temperature outside the furnace.

5.5.2.3 Temperature recording. A record of furnace air temperatures as well as propeller temperatures shall be obtained during the stress relief heat treatment cycle at intervals not exceeding 1 hour. Propeller temperatures shall be monitored by thermocouples located in the following positions:

(a) On the top face of the hub.
(b) On the bottom face of the hub.
(c) At the center (mid-length) of the bore.
(d) On the outside center (mid-length) of the hub.
(e) At the center (0.6R and mid-chord) of the pressure and suction faces of two opposite blades.
(f) Within 1 inch of the tip at the centerline on the underside of all blades located to measure furnace ambient (air) temperature.
(g) Located to measure furnace ambient (air) temperature and furnace floor temperature.

5.5.2.3.1 Thermocouple attachment. Thermocouples shall be attached to the propeller in such a manner that their removal will not result in damage to the attachment areas and they shall be insulated from the atmospheric temperature where welding is utilized in conjunction with manganese bronze or nickel-manganese bronze appropriate inspection is to be made to ensure that no cracking has developed.

5.5.3 Local stress relief.

5.5.3.1 General. Local stress relief may be performed when furnace stress relief is not practical, or the scope of the weld repair is such that furnace stress relief is not required. Local stress relief may also be performed if minor repairs are required after furnace stress relieving or when repairs (welding or straightening) have been partially accomplished but repair must be interrupted and set aside for a period of time. In the latter case an interim local stress relief prior to furnace stress relief is recommended to minimize in-process cracking. Local stress relief is not permitted on manganese bronze and nickel-manganese bronze.

5.5.3.2 Major repairs. In order to effect a suitable local stress relief, a band approximately 24 inches wide and extending across the entire width and through the entire thickness of the blade shall be slowly heated to the stress relieving temperature so that a temperature gradient of 100°F per foot is not exceeded outside this band. The band shall be so located that the repair area is on the centerline of the band width and the heating shall be accomplished by means of soft gas torches (soft neutral slightly reducing flame) or electrical resistance (strip) heaters rather than by oxyacetylene torches. The holding (soaking) time at temperature shall be at least 20 minutes per inch of base metal thickness at the repaired area for manganese bronze or nickel-manganese bronze propellers. The holding time for manganese-nickel-aluminum bronze propellers shall be no longer than what is necessary to meet the minimum 20 minutes per inch requirement. The repaired section of manganese bronze or nickel-manganese bronze propellers shall be slowly cooled so that a temperature gradient of 50°F per hour is not exceeded. Slow cooling from the stress relieving temperature shall be accomplished by wrapping or covering with insulation blankets. The cooling of manganese-nickel-aluminum bronze shall be in still air at room temperature.

5.5.3.3 Minor repairs. For a local stress relief of minor repairs in areas subject to low working stresses, such as the blade edges and tips, the stress relief treatment shall consist of a gradual spreading and maintaining of the heat by means of soft gas torches or electrical resistance (strip) heaters in the repaired area so that the stress relief temperature extends through the entire thickness for a distance of about 12 inches on all sides of the repaired area, while not exceeding a temperature gradient of about 100°F per foot. Cooling from the stress relief temperature shall be accomplished as stated in 5.5.3.2.

5.5.4 Propeller support. Adequate support shall be provided during preheat, welding, straightening, or any stress relieving operations to minimize distortion.

5.5.5 Grinding. When grinding on manganese bronze or nickel-manganese bronze, the contractor or shipyard shall maintain a temperature profile in the area of grinding of 50°F maximum above ambient.

6. NOTES

6.1 Intended use. This standard is used for repair and straightening of bronze Naval ship propellers.

6.2 Data requirements. When this standard is used in an acquisition which incorporates a DD Form 1423, Contract Data Requirements List (CDRL), the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved CDRL incorporated into the contract. When the provisions of DoD FAR Supplement, Part 27, Sub-Part 27.410-6 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this standard are cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
4.2.3.1 and 5.1.5.2.2	End item final inspection record	DI-R-4809	----
4.3.1	Procedure, welding	UDI-H-23383	----
4.3.2	Qualification data, welding procedure	UDI-H-23384	----

(Data item descriptions related to this standard, and identified in section 6 will be approved and listed as such in DoD 5010.12-L., AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.3 The quality control system should include preparing and maintaining written records of at least the following items:

(a) Propeller identification (ship class and serial number).
(b) Material type, base and filler, chemical analysis, and alpha/beta check if required.
(c) Type of repair (straightening or welding) including location (face, radius and chordwise location).
(d) Class of repair (minor or major).
(e) Repair procedure used.
(f) Heat treatment (include preheat, any interpass and post heat treatment). Post weld heat treatment data shall be collected and provided in the form of graphical or tabulated temperature versus time data. The record shall be annotated with the location and identification of the thermocouples.
(g) Identification of personnel performing repair and inspection.
(h) Inspection procedures used.
(i) Inspection results. Subsequent repairs shall be recorded.
(j) Disposition of repair.
(k) Microstructure analysis when required with metallographic record.
(l) Weld repair documentation:

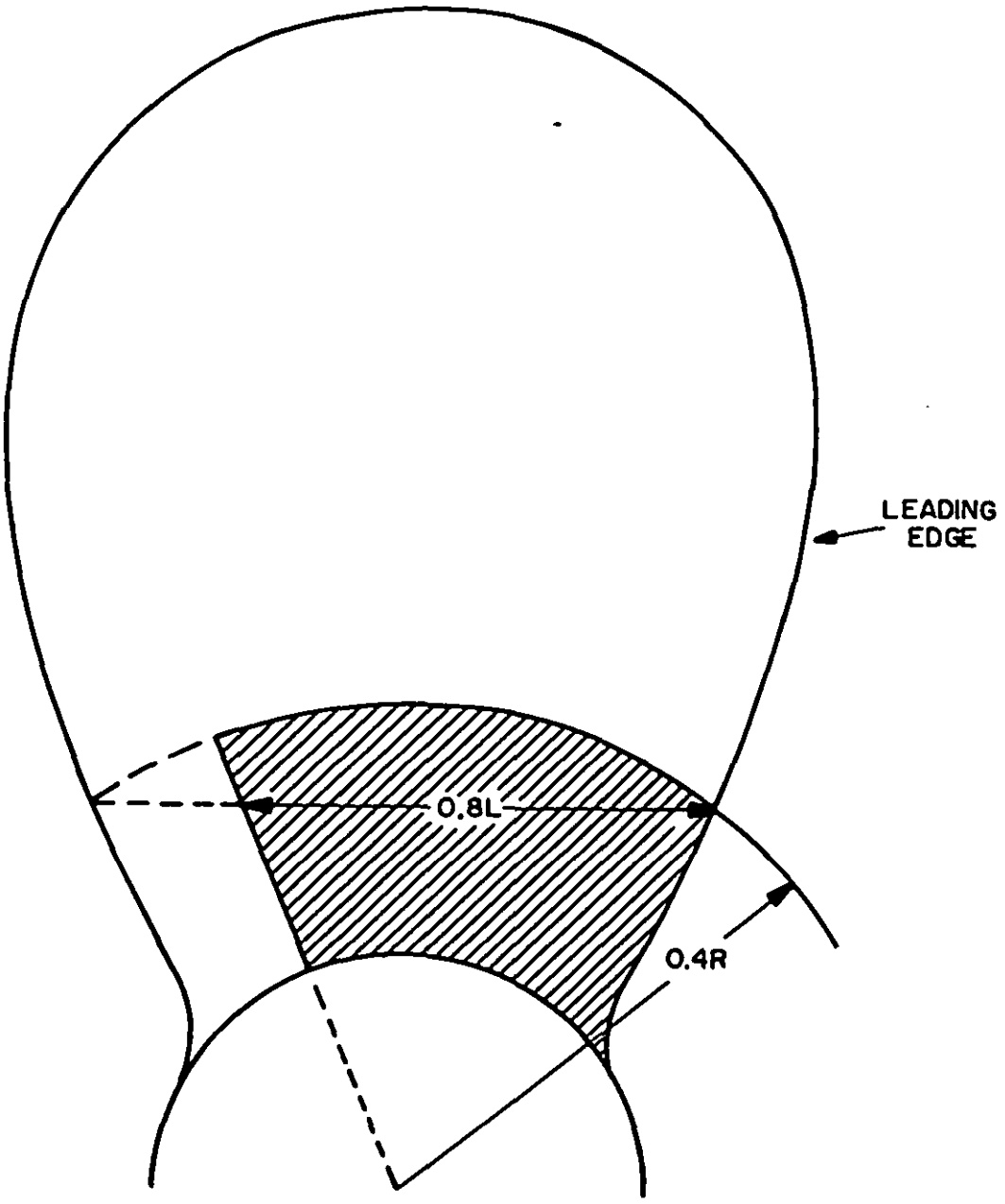
(1) Filler material
(2) Subsequent repairs
(3) Welder identification
(4) Welding dates

6.4 Subject term (key word) listing.

Bronze propellers, welding
Cavitation corrosion
Inspection, weld repair
Propellers, welding requirements
Straightening, propellers
Welder performance qualification
Welding procedures

6.5 Supersession. This document supersedes NAVSEA 0991-LP-023-3000, amendment 2 dated 15 July 1982, ACN 1/3 dated 19 July 1983, ACN 4 dated 12 September 1984 and its clarification letter dated 18 March 1985.

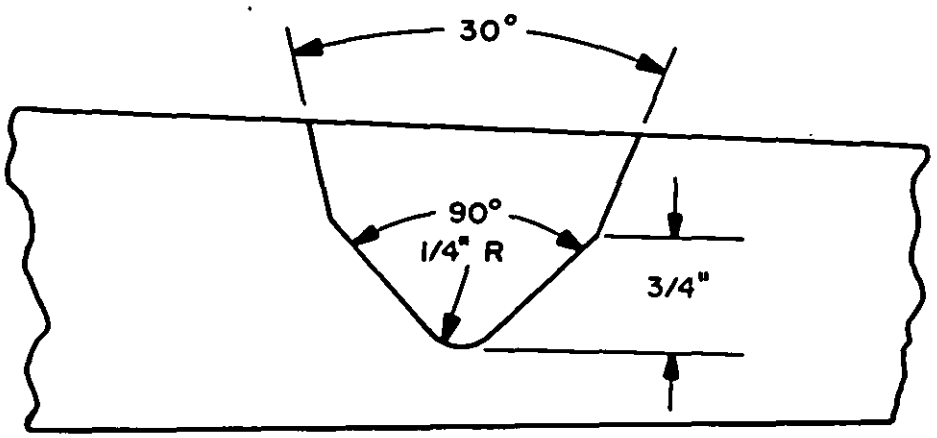
Preparing activity:
Navy - SH
(Project 2010-N024)



L = CHORD LENGTH AT 0.4R

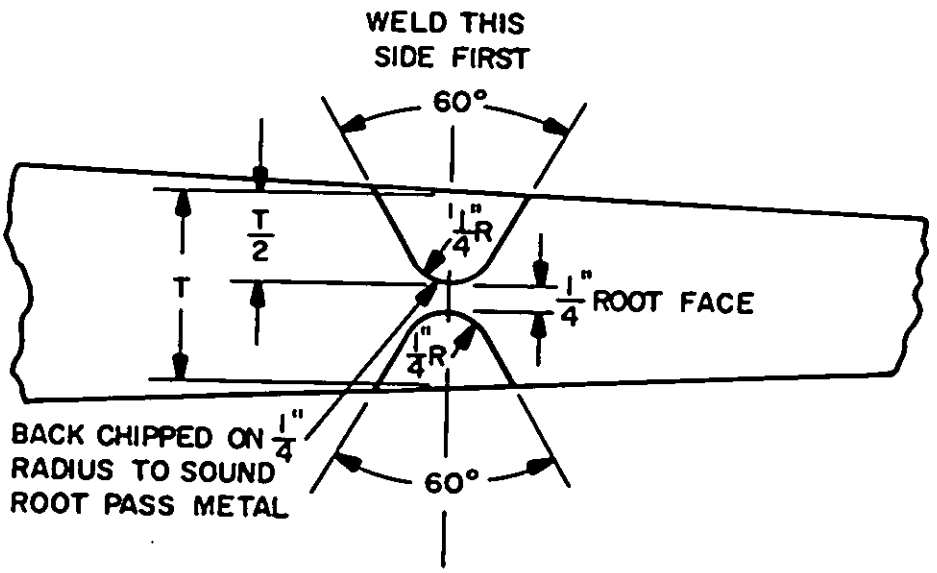
SH 13025

FIGURE 1. Blade critical area.



SH 13026

FIGURE 2. Typical gouge preparation for welding repair.



SH 13027

FIGURE 3. Typical joint design for blade tip repair.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
KOD-STD-2185(SH)	Requirements For Repair And Straightening Of Bronze Naval Ship Propellers

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)

DD FORM 82 MAR 1426

PREVIOUS EDITION IS OBSOLETE.