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*Superseding NAVSSES*
*Specification No. 962-101B, 3 March 1994*

# CRITICAL ITEM PRODUCT FABRICATION SPECIFICATION FOR ANTENNA FAIRED MAST

**Prepared by**

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## REVISIONS

| REVISIONS | DESCRIPTION | DATE |
|---|---|---|
| C | The following documents have been deleted:<br><br>MIL-C-9084 Cloth, Glass, Finished, for Resin Laminates<br><br>MIL-R-9300 Resin, Epoxy, Low-Pressure Laminating<br><br>MIL-P-17549 Plastic Laminate, Fibrous, Glass-Reinforced Marine, Structural<br><br>MIL-P-25421 Plastic Material, Glass Fiber Base-Epoxy Resin, Low-Pressure Laminating<br><br>FED-STD-129 Plastic, Methods of Testing<br><br>The following documents have been added:<br><br>ASTM D618 Conditioning Plastics and Electrical Insulating Materials for Testing<br><br>ASTM D2520 Standard Test Methods for Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650°C<br><br>Section 3.2.3.1.6 Lifting has been changed to Section 3.2.3.2.<br><br>Section 3.2.3.1.7 Clamping has been changed to Section 3.2.3.3. | 6/2/94 |

**REVISIONS (Continued)**

| REVISIONS | DESCRIPTION | DATE |
|---|---|---|
| C | Section 3.2.3.3.4 Dielectric Constant has been added.<br><br>Section 3.2.3.2 Bending has been changed to Section 3.2.3.5.<br><br>Table 2. Quality Assurance Matrix has been changed to Quality Conformance Matrix. Also 3.2.3.1, 3.2.3.1.1-7 have been deleted from the table. Section 4.3.2 Production Bend Test has been added.<br><br>Section 4.3 Special Tests and Examinations has been changed to Quality Conformance Tests and Inspections.<br><br>In Section 4.3, ASTM D618 has been added in place of MIL-P-17549. This also occurs in Table 3.<br><br>Section 4.4 Quality Conformance Inspections has been Changed to 4.3.3<br><br>Section 4.4 First Article Bend Test has been added. | 6/2/94 |
| B | Combined NAVSSES Spec. No. 062-101A with NAVSSES Spec. No. 062-105.<br><br>Page 2 Other Publications NAVSEA SE110-BK-MMO-010 Procedures for Inspection, Repair and Painting Fiberglass mast Assemblies superseded NAVSEA 0900-LP-023-8070.<br><br>Section 3.2.3.1 Enviromental Conditions added. | 3/3/94 |

## REVISIONS (Continued)

| REVISIONS | DESCRIPTION | DATE |
|---|---|---|
| B | Section 3.3.3.2 ASTM D2563 inserted for classification of visual defects. Also added to standards page 3.<br><br>Table 1, Barcol Hardness (Min.) added to the unit value.<br><br>Table 2 Quality Assurance Matrix added.<br><br>Figure for Tensile Test specimen deleted. Specimens should be IAW ASTM D638.<br><br>Section 4.3.1.c Compression Test sample should be IAW ASTM D695. | 3/3/94 |

# CRITICAL ITEM PRODUCT FABRICATION SPECIFICATION FOR ANTENNA FAIRED MAST

## CDNSWC SPECIFICATION NO. 962-101C

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# LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| Avg. | Average |
| CDNSWC | Carderock Division, Naval Surface Warfare Center |
| °F | Degrees Fahrenheit |
| Dwg. | Drawing |
| Fig. | Figure |
| ft. | Foot |
| Hz | Hertz |
| Ident. | Identifier |
| lb. | Pound |
| Max. | Maximum |
| Min. | Minimum |
| NAVSEA | Naval Sea Systems Command |
| No. | Number |
| psi | Pound Per Square Inch |
| QA | Quality Assurance |
| Std. | Standard |

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# CRITICAL ITEM PRODUCT FABRICATION SPECIFICATION FOR ANTENNA FAIRED MAST

## 1. SCOPE AND CLASSIFICATION

**1.1 SCOPE.** This specification establishes requirements for the manufacture, test, and acceptance of faired masts for antenna assemblies on SSN and SSBN class submarines.

**1.2 CLASSIFICATION.** Faired masts shall be furnished in the following types as specified.

| | |
|---|---|
| Type I | Faired mast for the AN/BRD-7 antenna system (Assembly No. 2 and No. 8 on Dwg. No. SS-128-4491143) |
| Type II | Faired mast for the AN/BRA-34 antenna system (Assembly No. 3 and No. 9 on Dwg. No. SS-128-4491143) |
| Type III | Faired mast for the TRIDENT OE-207/BR antenna system (NAVSEA Dwg. No. 9000501) |
| Type IV | Faired mast for pre-SSN-688 class submarines with minor axis of 10-5/8" and major axis of 29-9/16" (various drawings) |

## 2. APPLICABLE DOCUMENTS

### 2.1 GOVERNMENT DOCUMENTS.

**2.1.1 Specifications and Standards.** The issue of the following documents in effect on the date of the invitation for bids or request for proposal form a part of the specification to the extent specified herein.

Specifications

Military

| | |
|---|---|
| MIL-I-45208 | Inspection System Requirements |

Standards

Military

| | |
|---|---|
| MIL-STD-129 | Marking for Shipment and Storage |
| MIL-STD-167-1 | Mechanical Vibrations of Shipboard Equipment |
| MIL-STD-454 | Standard General Requirements for Electronic Equipment |
| MIL-STD-490 | Specification Practices |
| MIL-STD-810 | Environmental Test Methods and Engineering Guidelines |

**2.1.2 Other Government Publications and Drawings.** The following Government drawings form a part of this specification to the extent specified herein.

Publications

NAVSEA

| | |
|---|---|
| SE110-BK-MMO-010 | Procedure for Inspection, Repair and Painting Fiberglass Mast Assemblies |
| SE110-B3-MMA-010 | Safety Requirements for Attaching Lifting, Backup, Safety Clamps and Slings to Submarine Antenna Masts and Periscopes |
| 0939-LP-000-0010 | Inspection Manual, Fibrous Glass Reinforced Plastic Laminates |

Drawings

NAVSEA

| | |
|---|---|
| SS-128-4491143 | Mast Fairing Assembly |
| SS-904-4398614 | Lifting Clamps and Slings for Antenna Masts and Periscopes |
| 53711-9000501 | Faired Mast Assembly - TRIDENT |

**2.2 NON-GOVERNMENT STANDARDS.** The following standards form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids or request for proposal shall apply.

STANDARDS

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM D618 | Standard Practice for Conditioning Plastics and Electrical Insulating Materials for Testing |
| ASTM D638 | Standard Test Method for Tensile Properties of Plastics |
| ASTM D695 | Standard Test Method for Compressive Properties of Rigid Plastics |
| ASTM D790 | Standard Test Method for Flexural Properities of Unreinforced and Reinforced Plastics and Electrical Insulating Materials |
| ASTM D2520 | Standard Test Method for Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650°C |
| ASTM D2563 | Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts |
| ASTM D2583 | Standard Test Methods for Indentation Hardness of Rigid Plastics by Means of Barcol Impression |
| ASTM D2584 | Standard Test Method for Ignition Loss of Cured Reinforced Resins |
| ASTM D2734 | Standard Test Methods for Void Content of Reinforced Plastics |
| ASTM D3846 | Standard Test Methods for In-Plane Shear Strength of Reinforced Plastics |

# 3. REQUIREMENTS

3.1 ITEM DEFINITION. The outer faired mast (hereinafter called mast) is the structural support member for the submarine antenna assembly.

3.2 CHARACTERISTICS.

**3.2.1 Performance.** The mast shall meet the performance requirements specified herein. The mast is a structural member that supports and maintains the alignment of the antenna.

**3.2.1.1** *Structural Loading.* The mast shall be capable of withstanding the test loads applied in accordance with 3.2.3 of this specification. Acceptance will be based on the tests and examinations of 4.4.

**3.2.2 Mechanical and Physical Properties.** The mast shall meet the mechanical and physical properties presented in Table 1. Test specimens shall be taken from material from access openings and ends of the mast. These specimens shall be cut and tested in accordance with 4.3.

**TABLE 1. MECHANICAL AND PHYSICAL PROPERTIES AND TEST REQUIREMENTS**

| PROPERTY TO BE TESTED | UNIT OF VALUE | VALUE REQUIRED SHELL | CENTER SECTION |
|---|---|---|---|
| Tensile Strength | psi (min. avg.) | 62,000 | 62,000 |
| Modulus of Elasticity (Flexural Modulus) | psi (min. avg.) | $4.5 \times 10^6$ | $4.5 \times 10^6$ |
| Flexural Strength | psi (min. avg.) | 85,000 | 85,000 |
| Compressive Strength | psi (min. avg.) | 62,000 | 62,000 |
| Void Content | Percent (max.) | 1.0 | 1.0 |
| Resin Content Range | Percent (max.) | 20 - 35 | 20 - 35 |
| Shear Strength | psi (min. avg.) | 4,000 | 4,000 |
| Barcol Hardness | Points (min.) | 65 | 65 |

**3.2.3 First Article Test Performance.** The contractor shall manufacture one mast for examination and testing to prove, prior to starting production, that his production methods will produce masts that comply with the requirements of this specification. Examinations and tests shall be conducted by the supplier prior to start of production. First article tests will be waived if the contractor has successfully built a mast within the past two years.

**3.2.3.1** *Environmental Conditions.* The mast shall meet the environmental and design requirements specified herein without structural or mechanical degradation.

**3.2.3.1.1** *Temperature.* The mast shall provide service without deterioration when subjected to the following temperatures:

*a.* In air: -80 ° to +160 °F

*b.* In seawater: +28 ° to +90 °F

High temperature tests shall be performed in accordance with MIL-STD-810, Method 501.3, Procedures I and II. Low temperature tests shall be performed in accordance with MIL-STD-810, Method 502.3, Procedures I and II.

3.2.3.1.2 *Vibration.* The mast shall be able to withstand, without damage, the vibration requirements specified in MIL-STD-167-1, Type 1, Table II, up to 25 Hertz (Hz). The mast shall be subjected to the Type I vibration test specified in MIL-STD-167-1(SHIPS). The upper vibration frequency shall be as specified in Table II of MIL-STD-167-1(SHIPS), up to 25 Hz.

3.2.3.1.3 *Solar Radiation.* The mast shall be able to withstand, without damage, exposure to solar radiation. The mast shall be subjected to the solar radiation test specified in MIL-STD-810, Method 505.3, Procedure I.

3.2.3.1.4 *Fungus.* The materials used in the construction of the mast shall not support fungal growth. Components used in the construction of the mast that are made of materials listed in Group II in Table 4-1 of MIL-STD-454, Requirement 4, shall be subjected to the fungus test specified in MIL-STD-810, Method 508.4, for 28 days.

3.2.3.1.5 *Wind Loads.* The mast shall be able to withstand, without damage, winds having a relative velocity as great as 100 knots. With the mast assembly mounted in its operating configuration, wind tests shall be conducted in accordance with test plans and procedures approved by the procuring activity.

3.2.3.1.6 *Thermal Shock.* The materials used in the construction of the fairing assembly shall not deteriorate when subjected to sudden low and high temperature thermal shock. Low temperature thermal shock ranges from -80 ° in air to +28 °F in seawater. High temperature thermal shock ranges from 68 ° in seawater to 160 °F in air. After the completion of the thermal shock test the fairing assembly shall be inspected/tested for laminate defects and material property requirements covered in 3.3.3.2 and 3.2.2 respectively.

3.2.3.1.7 *Hydrostatic Pressure Water Absorption.* The materials used in the construction of the fairing assembly shall not show signs of deterioration when exposed to an external 1,050 psig hydrostatic pressure. After the completion of the hydrostatic water pressure absorption test the fairing assembly shall be inspected for laminate defects covered in 3.3.3.2 and shall not exceed 50 parts per million water gain.

3.2.3.2 *Lifting.* The mast shall be able to withstand, without damage, the forces generated by its own weight and components when lifted. This force varies by type and will be as specified in SE110-B3-MMA-010. The lifting arrangement will be as specified in SE110-B3-MMA-010, assembly 2.

3.2.3.3 *Clamping*. The mast shall be able to withstand, without damage, the clamping forces generated when two lifting clamps are placed along the length of the mast. Clamp bolts will be torqued to 60 ft/lb each (safety factor of 2). The clamps used will be per Drawing SS-904-4398614, assembly 2.

3.2.3.4 *Dielectric Constant*. The material that the mast is constructed of must have a dielectric constant between 3.6 and 4.0. The dielectric constant shall be tested according to ASTM D2520 using Method B. The test frequency shall be 9.0 $\pm$0.375 GHz.

3.2.3.5 *Bending*. The bend test shall be in accordance with 4.3.2, except that Load "F" of Table 4 will apply.

## 3.3 DESIGN AND CONSTRUCTION

**3.3.1 Production Drawings.** Drawing No. SS-128-4491143 is the contract drawing for mast Types I and II, and Drawing No. 53711-9000501 is the contract drawing for the Type III mast. Type IV mast shall be built in accordance with the proper assembly shown on its respective contract drawing. Each class of mast shall be built in accordance with the proper assembly shown on its respective contract drawing.

**3.3.2 Standards of Manufacture.**

3.3.2.1 *Glass-Reinforced Plastic Material Requirements*. Glass-reinforced plastic material shall meet the requirements of this specification.

3.3.2.1.1 All glass-reinforced plastic shall be made from plies of glass reinforcement impregnated with epoxy resin, except as noted in 3.3.2.1.2. Plies shall be arranged to produce a laminate that will meet all the requirements of this specification.

3.3.2.1.2 Other types of glass reinforcement shall be used where necessary to improve the quality of the laminate, provided they meet all the requirements of this specification and produce a laminate equal to that of glass fibers impregnated with epoxy resin.

3.3.2.2 *Process Specifications*. The contractor shall prepare process specifications in accordance with MIL-STD-490, Type D. Process specifications shall exclude proprietary information.

3.3.2.3 *Secondary Bonding*. No secondary bonding shall be allowed without prior CDNSWC approval. Bonding of the shells to the center section is permitted only on Type III masts.

3.3.2.4 *Machining*. The contractor shall take necessary care to ensure that no surface layers have been machined away, either externally or internally, that will destroy or seriously lessen the strength characteristics of the mast, cause delaminations, or degrade the laminate in any other way.

3.3.2.5 *Grounding*. When specified by the contract drawing, the mast shall be provided with a grounding screen embedded in the inner wall of the teardrop-shaped shell. This screen shall be made from commercial bronze. Continuity of screen sections shall be provided by soft-soldered attachments to the screen interconnected with grounding bars.

3.3.2.5.1 When specified, two internal grounding strips shall be soft-soldered to the screen. Two external grounding strips shall be attached through the wall of the teardrop shell to provide structural integrity and electrical continuity with the internal grounding strip. Since the grounding strips operate with sliding contacts, the exposed surfaces must be smooth and free of any protrusions. Grounding strips must not buckle or yield under structural loading.

3.3.2.5.2 The grounding strips shall be mounted as shown on the contract drawing.

3.3.2.6 *Length*. The overall length of the finished mast shall be as indicated on the contract drawing, and there shall be sufficient additional length to provide the necessary test specimens.

3.3.2.7 *Tolerances*. Unless otherwise required by contract or contract drawing, the following general tolerances shall apply:

*a*. Length of mast or individual sections to be ±1/8 inch.

*b*. Depth of screw heads to be .030 inch to .110 inch below surface.

*c*. Assembly screw pattern layout to be ± 1/16 inch.

3.3.2.8 *Surface Finishes*. All bearing surfaces as designated on the contract drawing shall have a 32-microinch finish. All other external surfaces shall have a maximum of a 125-microinch finish. All other internal surfaces shall have a maximum of a 500-microinch finish.

3.3.2.9 *Bearing Surfaces*. A 10-inch long master bearing block for each of the bearing surfaces, shaped in accordance with the offsets shown on production drawings, shall indicate a 50-percent area contact in any 10-inch length increment when rubbed along the full length of the mast. The bearing block may be lapped to the mast contour but must remain within the tolerance for the Table of Offsets. The bearing block, being an inspection device, should be calibrated, serialized, and tagged. Areas of noncontact shall not be continuous and shall not be larger than 2 square inches in area. In no case shall any 5 square inches of bearing surface have more than 60 percent of noncontact area.

**3.3.2.10** *Straightness*. Mast straightness shall be as shown in Figure 1. No element of the bearing surface shall deviate more than 0.040 inch from a straight line, nor exceed a maximum local variation of 0.010 inch per foot. Measurements to certify straightness of the assembled mast throughout the entire length shall be taken on all bearing areas, with readings at intervals of approximately 12 inches along all bearing surfaces. See Figure 2. Deflection from the mast's own weight is not included.

**3.3.2.11** *Sealing*. Internal and external mast surfaces, particularly machined edges and holes in laminates, shall be sealed by coating with a suitable resin formulate. The resin shall be compatible with the laminate and attain a full cure at 70 °F.

**3.3.2.12** *Painting*. Painting is not required unless otherwise stated in the contract. When required by contract, painting shall be performed in accordance with NAVSEA SE110-BK-MMO-010.

**3.3.2.13** *Identification Plates*. For Types I through III, identification plates shall be attached to each mast in accordance with the contract drawing and shall include the following data: drawing number, assembly number, revision letter, contract, and serial number. For Type IV, an identification plate carrying an identifying number in 1/4-inch raised letters shall be embedded in epoxy resin on the inside of the fairing near the lower edge. The material shall be .012-inch thick CRES in accordance with QQ-S-766, Class 304, Condition A. Identifying numbers will consist of four parts separated by a dash. Part one is the serial number (two digits) assigned by the procurement document. Part two is the last seven digits of the drawing number. Part three is the drawing revision letter. Part four is the assembly number specified by the procurement document.

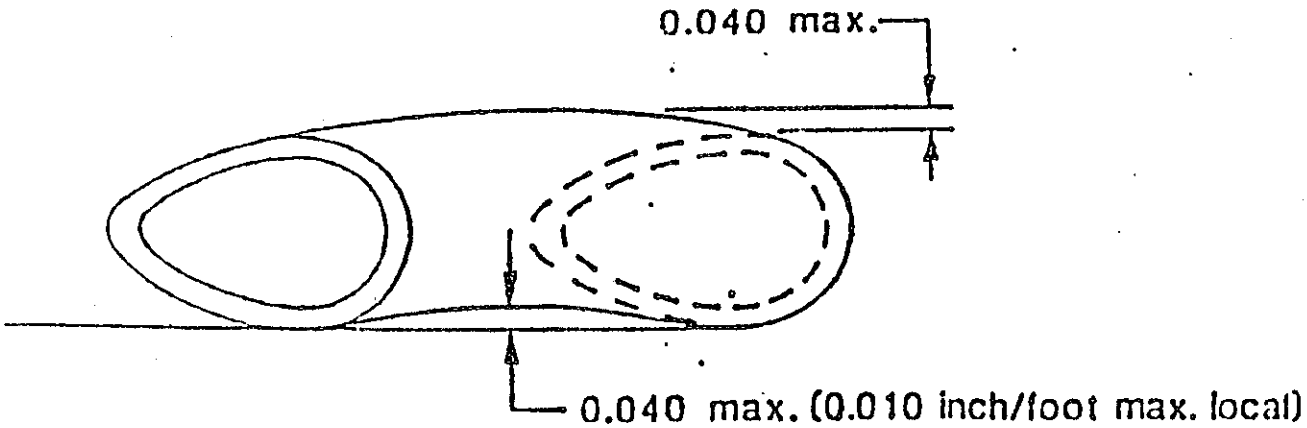


**Figure 1. Mast Fairing Straightness**

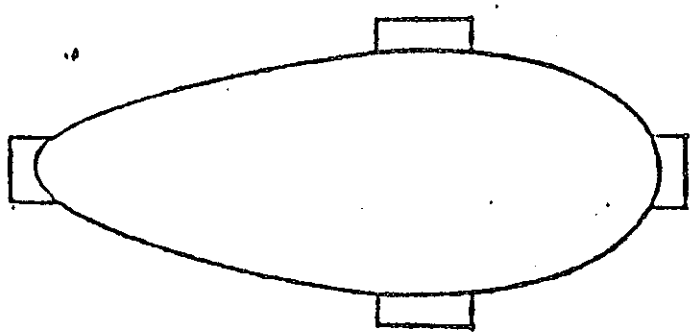

**Figure 2. Bearing Arrangement**

**3.3.3 Workmanship.**

3.3.3.1 *General Appearance.* The mast shall be uniform in appearance and free from foreign matter. Burrs and sharp edges shall be removed.

3.3.3.2 *Laminate Defects.* The fairing shall be inspected in accordance with ASTM D2563 for uncured areas, gaps, holes, cracks, unbonded areas, blisters, resin-rich and resin-starved areas, tackiness, excess surface resin, wrinkles, delamination, air or gas pockets, patches, porosity, or other similar defects. The visual acceptance level for allowable defects shall be Level III.

3.3.3.3 *Repairs.* No repair shall be permitted in high-stress areas or in other areas where such repair may impair the performance of the unit, as determined by CDNSWC. In any case, repairs shall not be permitted without prior CDNSWC approval.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 GENERAL. The supplier shall provide and maintain a quality program acceptable to the Government for supplies and services covered by this specification. The quality program shall be in accordance with MIL-I-45208.

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

4.1.1.1 *Responsibility for Compliance.* All products or supplies submitted to the Government for acceptance shall comply with all applicable requirements of this specification. The inspection required by this specification shall be incorporated into the contractor's overall inspection system or quality program. The absence of any specific inspection requirements in this specification shall not relieve the contractor of the responsibility for ensuring compliance with all requirements of the contract. Sampling, as a quality assurance method for determining conformance, does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.1.2 *Government Verification.* All quality assurance (QA) operations performed by the contractor shall be subject to Government verification at any time. Verification will consist of, but is not limited to, the following:

*a.* Surveillance of the operations to determine that the practices, methods, and procedures of the written quality program are being properly applied.

*b.* Government product inspection to measure quality and safety of the product to be offered for acceptance.

*c.* Government inspection of delivered products to ensure compliance with all inspection requirements of this specification.

Failure to promptly correct deficiencies discovered by the contractor or of which the contractor is notified shall be cause for suspension of acceptance until corrective action has been taken or until conformance of the product to the prescribed criteria has been demonstrated.

**4.1.1.3** *Quality Assurance Terms and Definitions.* Quality assurance terms used in this specification shall be as defined in MIL-STD-109.

**4.1.1.4** *Test Equipment Calibration.* All tools and test equipment required for inspections, tests, and maintenance shall be calibrated in accordance with MIL-STD-45662.

**4.2 QUALITY ASSURANCE METHODS.** Quality assurance for this specification shall be demonstrated by the following three methods of evaluation:

*a.* Certification of compliance

*b.* Inspections

*c.* Acceptance tests

The contractor shall provide the required quality assurance to validate the requirements of Section 3 of this specification in accordance with Table 2.

**4.2.1 Certificate of Compliance.** The certificate of compliance shall state that the applicable requirements of Section 3 have been met. The contractor shall provide a certificate of compliance where required. Each certificate of compliance shall be augmented with a proof of performance. The proof of performance shall be a statement that the equipment has been successfully operated and has demonstrated the applicable requirements. If the certificate of compliance does not substantiate compliance with all the applicable requirements of Section 3, a test shall be conducted and the test results recorded to indicate compliance with the applicable requirements.

**4.2.2 Inspections.** The contractor shall establish a comprehensive inspection system to perform inspections in accordance with Table 2. In-plant and final inspections shall be performed to ensure that all applicable requirements of Section 3 have been met. Required inspection systems shall be developed in accordance with MIL-I-45208.

**4.2.3 Acceptance Tests.** The contractor shall conduct acceptance testing in accordance with the contractor-prepared, Government-approved test plans. The acceptance testing shall consist of those tests identified in Table 2 and Section 4 of this specification. The acceptance tests shall demonstrate compliance with all requirements of Section 3, except for requirements covered by previously approved certificates of compliance. The type and scope of inspections and tests required will depend on the deviation from the current mast design and construction materials as determined by the collective assessment of the contractor and the Government.

**TABLE 2. QUALITY CONFORMANCE MATRIX**

| PARAGRAPH | SUBJECT TITLE | C | I | T |
|---|---|---|---|---|
| 3.2.2 | Mechanical and Physical Properties | X | X | X |
| 3.3.2 | Standards of Manufacture | X | X | |
| 3.3.2.2 | Process Specifications | X | X | |
| 3.3.2.3 | Secondary Bonding | X | X | |
| 3.3.2.4 | Machining | X | X | |
| 3.3.2.5 | Grounding | X | X | |
| 3.3.2.6 | Length | X | X | |
| 3.3.2.7 | Tolerances | X | X | |
| 3.3.2.8 | Surface Finishes | X | | |
| 3.3.2.9 | Bearing Surfaces | X | X | |
| 3.3.2.10 | Straightness | X | X | |
| 3.3.2.11 | Sealing | X | X | |
| 3.3.2.13 | Identification Plates | | X | |
| 3.3.3 | Workmanship | X | X | |
| 3.3.3.1 | General Appearance | X | X | |
| 3.3.3.2 | Laminate Defects | X | X | |
| 3.3.3.3 | Repairs | X | X | |
| 4.3.2 | Production Bend Test | X | X | X |

C: Certificate of compliance
I: Inspections
T: Acceptance tests

**4.3 QUALITY CONFORMANCE TESTS AND INSPECTIONS.** All materials used shall be approved for submarine applications and shall be verified by the provisions of this specification. Material tests shall be conducted on each mast manufactured and shall be part of acceptance requirements. Non-individual specimens tested for mechanical properties shall indicate a value lower than 80 percent of the average of the results of the specimens tested for the property.

**4.3.1 Material Property Tests and Examinations.** Test specimens shall be taken from the forward, aft, and channel sections of the mast as shown in Figure 3. Specimen thickness shall be no less than 80 percent of the drawing wall thickness. The contractor shall complete NAVSEA Form Nos. 4646 and 4647 in accordance with Chapter VII of NAVSEA 0937-LP-000-0010 and as modified by this specification. Wet properties are required for the first production unit only. Each specimen shall be conditioned in accordance with ASTM D618 and will be tested for the physical and mechanical requirements identified in Table 2. Testing will be in accordance with Table 3.

*a.* Tensile Test. Specimens shall be machined and tested in accordance with ASTM D638. Test results shall be recorded on NAVSEA Form 4646 in accordance with NAVSEA 0939-LP-000-0010, Chapter VII.

*b.* Modulus of Elasticity. Modulus of elasticity shall be calculated in accordance with ASTM D638 and D790, Method I, Procedure A. The modulus of elasticity calculated using ASTM D638 stress/strain data shall use the values obtained prior to the specimen failure. Values shall be recorded on NAVSEA Form 4646 in accordance with NAVSEA 0939-LP-000-0010, Chapter VII.

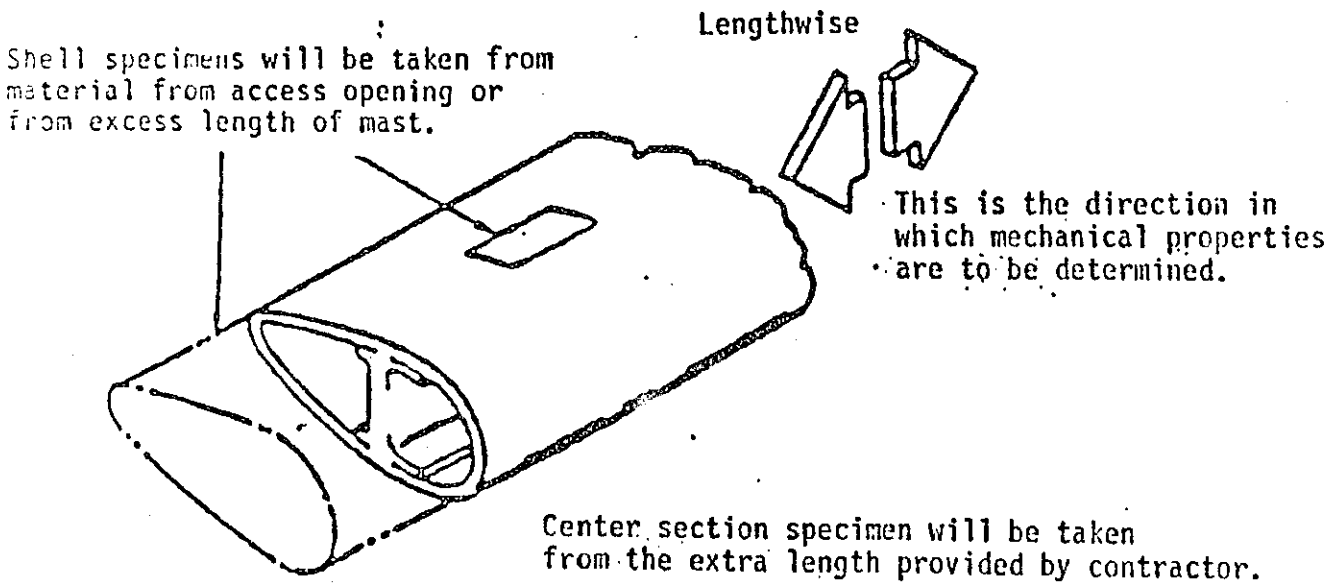


**Figure 3. Test Specimen**

*c.* Compression Test. Specimens shall be machined and tested in accordance with ASTM D695. Test results shall be recorded on NAVSEA Form 4646 in accordance with NAVSEA 0939-LP-000-0010, Chapter VII.

*d.* Void Content. The void content shall be determined on three specimens in accordance with ASTM D2734. No individual specimen tested shall exceed the maximum percentage specified in Table 3.

*e.* Resin Content. The resin content shall be determined on three specimens in accordance with ASTM D2584 and shall fall within the range shown in Table 3.

*f.* Barcol Hardness. The average of 10 Barcol hardness measurements taken on production units shall not be lower than the average values of Barcol hardness shown in Table 3 and shall not be more than 5 points lower than average Barcol hardness measurements of the first production unit.

*g.* Flexural Strength. Flexural strength shall be tested in accordance with ASTM D790, Method I, Procedure A.

*h.* Shear Strength. Shear strength shall be tested in accordance with ASTM D3846.

## TABLE 3. FAIRING MECHANICAL AND PHYSICAL PROPERTIES AND TEST REQUIREMENTS

| PROPERTY TO BE TESTED | DIRECTION (NOTE 1) | ASTM TEST METHOD | SPECIMEN | | CONDITIONING PROCEDURE (NOTES 2 AND 3) | UNIT OF VALUE (NOTE 4) | VALUE REQUIRED SHELL | CENTER SECTION (NOTE 5) |
|---|---|---|---|---|---|---|---|---|
| | | | SIZE | NUMBER | | | | |
| Tensile Strength | Lengthwise | D638 | Fig. 4 | 5 | Procedure A Standard | psi (min. avg.) | 62,000 | 62,000 |
| Modulus of Elasticity (Flexural Modulus) | Lengthwise | D638 | Std. | 5 (Note 5) | Procedure A Standard | psi (min. avg.) | $5.0 \times 10^6$ | $5.0 \times 10^6$ |
| | Lengthwise | D638 | Std. | 5 | Procedure D Wet | psi (min. avg.) | $5.0 \times 10^6$ | $5.0 \times 10^6$ |
| | Lengthwise | D790 | Std. | 5 (Note 6) | Procedure A Standard | psi (min. avg.) | $5.0 \times 10^6$ | $5.0 \times 10^6$ |
| | Lengthwise | D790 | Std. | 5 | Procedure D Wet | psi (min. avg.) | $5.0 \times 10^6$ | $5.0 \times 10^6$ |
| Flexural Strength | Lengthwise | D790 | Std. | 5 | Procedure A Standard | psi (min. avg.) | 85,000 | 85,000 |
| | Lengthwise | D790 | Std. | 5 | Procedure D Wet | psi (min. avg.) | 85,000 | 85,000 |

NOTES

1. Direction of test properties is shown in Figure 3.
2. Conditioning procedure shall be in accordance with ASTM D168.
3. Wet properties are required for the first production unit only.
4. No individual specimen shall indicate a value lower than 80 percent of the average value.
5. Tensile strength and modulus of elasticity can be determined from the same specimen.
6. Flexural strength and modulus of elasticity can be determined from the same specimen.

## TABLE 3. FAIRING MECHANICAL AND PHYSICAL PROPERTIES AND TEST REQUIREMENTS (Continued)

| PROPERTY TO BE TESTED | DIRECTION (NOTE 1) | ASTM TEST METHOD | SPECIMEN | | CONDITIONING PROCEDURE (NOTES 2 AND 3) | UNIT OF VALUE (NOTE 4) | VALUE REQUIRED SHELL | CENTER SECTION (NOTE 5) |
|---|---|---|---|---|---|---|---|---|
| | | | SIZE | NUMBER | | | | |
| Compressive Strength | Lengthwise | D695 | Std.- | 5 | Procedure A Standard | psi (min. avg.) | 62,000 | 62,000 |
| | Lengthwise | D695 | Std. | 5 | Procedure D Wet | psi (min. avg.) | 62,000 | 62,000 |
| Void Content | -- | D2734 | -- | 3 | -- | Percent (max.) | 1.0 | 1.0 |
| Resin Content Range | -- | D2584 | -- | 3 | -- | Percent (max.) | 20 - 35 | 20 - 35 |
| Shear Strength | -- | D3846 | -- | 5 | Procedure A Standard | psi (min. avg.) | 4,000 | 4,000 |
| Barcol Hardness | -- | D2583 | -- | 10 | -- | Points (min.) | 65 | 65 |

NOTES

1. Direction of test properties is shown in Figure 3.
2. Conditioning procedure shall be in accordance ASTM D618.
3. Wet properties are required for the first production unit only.
4. No individual specimen shall indicate a value lower than 80 percent of the average value.
5. Tensile strength and modulus of elasticity can be determined from the same specimen.
6. Flexural strength and modulus of elasticity can be determined from the same specimen.

4.3.2 **Production Bend Tests.** The Government reserves the right to require a bend test on any or all masts delivered. Production bend tests will be performed by the contractor. The mast shall be supported in bearings located as shown in Figures 4, 5, 6, and 7. Loads shall be applied through the jacking point attaining the required loading in a time period not to exceed that given in Table 4. The "P" required by Table 4 shall be held for a maximum time of one minute. The mast will be mounted in the test stand in such a way that the load will tend to straighten any initial mast bow. In the event that the internal and external straightness of the bearing areas conflict, the contractor is required to contact CDNSWC for direction. Tolerances for dimensions of Figures 4, 5, 6, and 7 shall be ±1/4 inch. Questions should be directed to CDNSWC, Philadelphia, Code 9622. Deflection of the mast shall be measured at the point of load application. Deflection shall be measured at the applicable load of Table 4.

4.3.2.1 *Post Bend Test Inspection.*

4.3.2.1.1 *Cracks, Crazing, Delaminations.* Cracks, crazing, or delamination in any of the masts prior to, during, or after test shall be cause for rejection.

4.3.2.1.2 *Resin inclusion.* Any resin-rich area forming resin pockets shall be cause for rejection.

4.3.2.1.3 *Permanent distortion.* Within 48 hours after test, the mast shall be thoroughly inspected to ascertain that no permanent distortion has developed to the extent that the mast does not meet drawing tolerances. For example, the mast will be rejected if any element of the bearing surfaces deviates more that 0.040 inch from a straight line or exceeds a maximum local variation of 0.010 inch per foot.

NOTE: ALL DIMENSIONS IN INCHES.

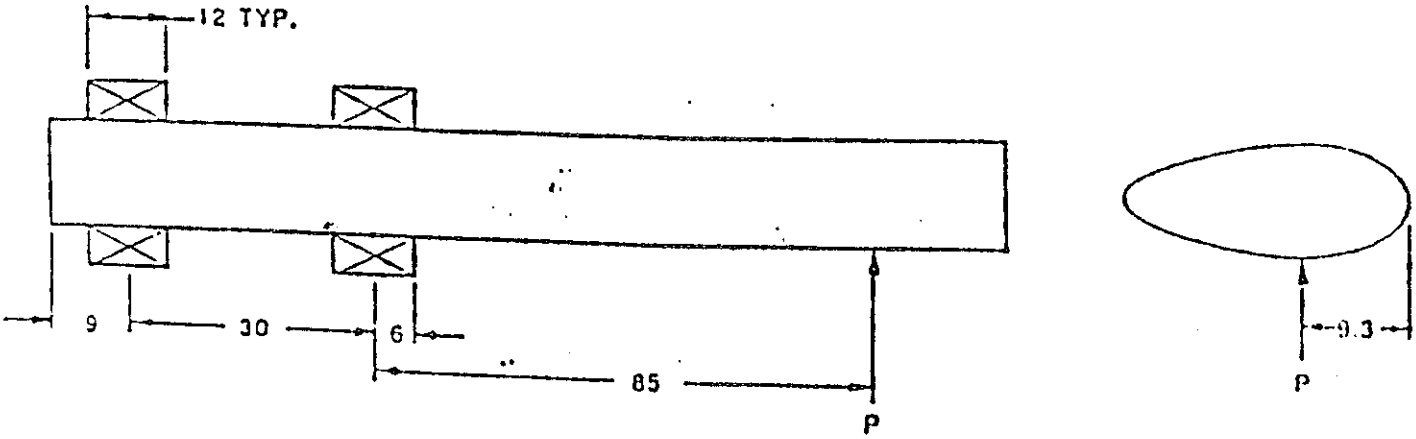


**Figure 4. Type I Bend Test Arrangement**

NOTE: ALL DIMENSIONS IN INCHES.

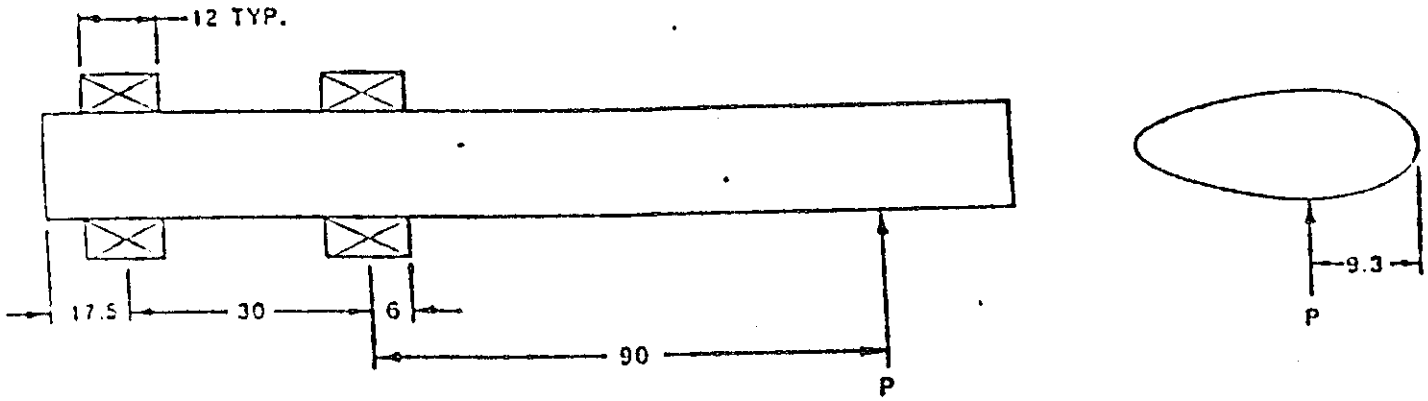


Figure 5. Type II Bend Test Arrangement

NOTE: ALL DIMENSIONS IN INCHES.

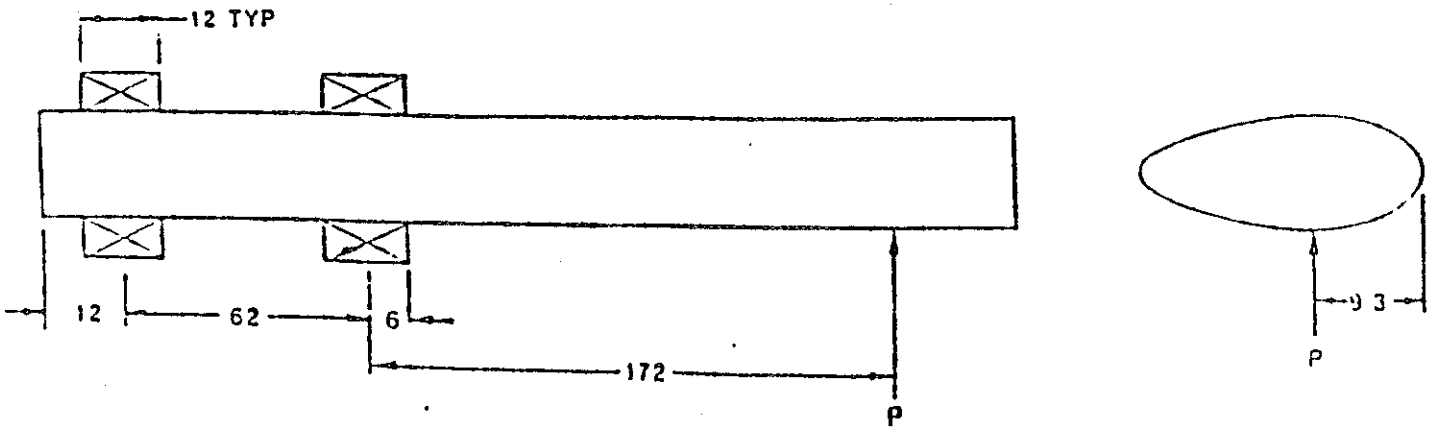


Figure 6. Type III Bend Test Arrangement

NOTE: ALL DIMENSIONS IN INCHES.

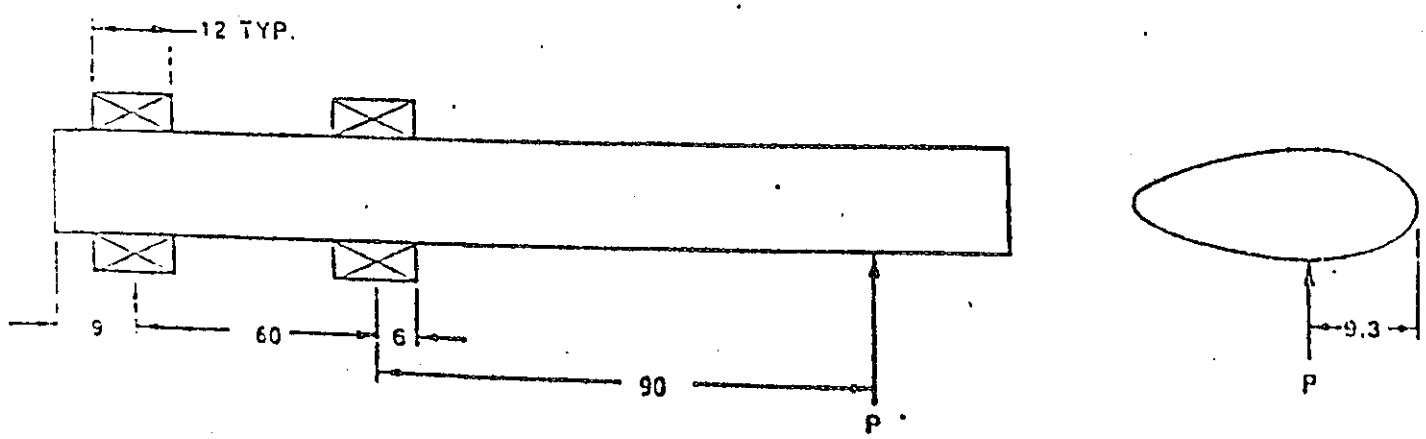


**Figure 7. Type IV Bend Test Arrangement**

**TABLE 4. WAVESLAP LOAD**

| MAST TYPE | LOAD P (LBS) | LOAD F (LBS) | TIME TO COMPLETION (MINUTES) |
|---|---|---|---|
| Type I | 26,250 | 52,500 | 30 |
| Type II | 25,700 | 51,400 | 30 |
| Type III | 25,250 | 50,500 | 30 |
| Type IV | 22,200 | 44,400 | 30 |

4.3.2.1.4 *Grounding bar distortion.* No distortion of the grounding bars is permitted. Grounding bars are to be securely fastened to the mast.

4.3.3 **Quality Conformance Inspections.** At a minimum, the following quality conformance inspections shall be performed on every mast prior to delivery to the procuring agency.

4.3.3.1 *Glass.* All reinforcing materials used for manufacture of the mast shall be inspected for quality, proper storage, foreign materials on finish, and good bonding interface between glass and resin.

4.3.3.2 *Resin Inspection.* The resin used for bonding the mast fibers shall be inspected for quality, storage life, and overaging prior to cure and foreign materials.

4.3.3.3 *Laminate Defects.* A visual inspection shall be performed in accordance with ASTM D2563 for defects such as uncured areas, gaps, holes, cracks, unbonded areas, blisters, resin-rich areas, resin-starved areas, tackiness, excess surface resin, wrinkles, delaminations, air or gas pockets, patches, porosity, or other similar defects. Any defect is cause for rejection. The visual acceptance level for allowance defects shall be Level III.

4.3.3.4 *Determination of Defects.* Defects in the mast will be determined by non-destructive testing methods in accordance with techniques from the Inspection Manual for Fibrous Glass-Reinforced Plastic Laminates, NAVSEA 0939-LP-000-010, excluding ultrasonic inspection.

4.3.3.5 *Machined Surfaces.* Inspection will be performed to certify that no surface layers have been machined away, either externally or internally, that will destroy or seriously lessen the strength characteristics of the mast, cause delaminations, or degrade the laminate in any other way. These inspections will include, but not be limited to, visual inspection for uniformity of laminate surface layer thickness, particularly near contour filled layers, and visual inspection to ensure that surface layers have not been machined away to expose layers of different fibers or fiber orientation on both internal and external surfaces.

4.3.3.6 *Dimensional.* The external and internal cross-sectional dimensions and tolerances delineated on the manufacturing drawing or called for in the requirements of this specification shall be verified by inspection.

4.3.3.7 *Bearing Surfaces.* A 10-inch master bearing block for each bearing surface shall be constructed and used in accordance with 3.3.2.9.

4.3.3.8 *Straightness.* Measurements to certify straightness of the mast throughout its entire length shall be taken on all bearing areas in accordance with 3.3.2.10. Deviation from straightness exceeding these requirements is cause for rejection.

4.3.3.9 *Wall Thickness.* The wall thickness of individual parts shall not vary from those specified on the contract drawing. Readings shall be taken at 18-inch intervals along the entire length of the part. A total indicated readout graph and thickness chart shall be furnished by the contractor for each surface checked.

4.3.3.10 *Holes and Cut-Outs.* Hole and cut-out sizes and locations shall be inspected to verify conformance with the dimensions and tolerances of the contract and manufacturing drawings.

4.3.3.11 *General Appearance.* The mast shall be inspected for uniformity of appearance and freedom from foreign matter. Burrs and sharp edges shall be removed.

4.3.3.12 *Additional Inspections.* Additional inspections shall be performed per quality assurance requirements of the procurement document.

## 4.4 FIRST ARTICLE TESTS AND INSPECTIONS.

**TABLE 5. FIRST ARTICLE TEST MATRIX**

| PARAGRAPH | SUBJECT TITLE |
|---|---|
| 4.4.1 | Environmental Conditions |
| 4.4.1.1 | Temperature |
| 4.4.1.2 | Vibration |
| 4.4.1.3 | Solar Radiation |
| 4.4.1.4 | Fungus |
| 4.4.1.5 | Thermal Shock |
| 4.4.1.6 | Hydrostatic Pressure Water Absorption |
| 4.4.2 | Lifting |
| 4.4.3 | Clamping |
| 4.4.4 | Dielectric Constant |
| 4.4.5 | First Article Bend Test |

**4.4.1 Environmental Conditions.** The mast shall meet the environmental and design requirements specified herein without structural or mechanical degradation.

4.4.1.1 *Temperature.* High temperature tests shall be performed in accordance with MIL-STD-810, Method 501.3, Procedures I and II, using applicable high temperatures from

paragraph 3.2.3.1.1. Low temperature tests shall be performed in accordance with MIL-STD-810, Method 502.3, Procedures I and II, using applicable high temperatures from paragraph 3.2.3.1.1.

**4.4.1.2** *Vibration.* The mast shall be subjected to the vibration test specified in MIL-STD-167-1, Type 1, Table II using applicable frequencies specified in paragraph 3.2.3.1.2.

**4.4.1.3** *Solar Radiation.* The mast shall be subjected to the solar radiation test specified in MIL-STD-810, Method 505.3, Procedure I to verify conformance to the requirement of paragraph 3.2.3.1.3.

**4.4.1.4** *Fungus.* Components used in the construction of the mast that are made of materials listed in Group II in Table 4-1 of MIL-STD-454, Requirement 4, shall be subjected to the fungus test specified in MIL-STD-810, Method 508.4, for 28 days to verify conformance to the requirements of paragraph 3.2.3.1.4.

**4.4.1.5** *Thermal Shock.* The thermal shock test section shall be tested as follows:

*a.* The test section shall be sealed in a manner similar to the process used on the fairing.

*b.* Determine the weight of the test section prior to the thermal shock test.

*c.* Conduct a low and high temperature thermal shock test in accordance with paragraphs 4.4.1.5.1 and 4.4.1.5.2.

*d.* The chamber shall be equipped to allow test conditions within the chamber to stabilize within 30 minutes.

**4.4.1.5.1** *Low Temperature Thermal Shock.* Before performing the low temperature thermal shock test, the contractor shall conduct a brief inspection of the test section. The test section shall be stabilized at a standard ambient temperature before the thermal shock test begins.

*Procedure* - The low temperature shock test shall be conducted as follows:

*a.* Step 1 - Reference Quality Assurance Test Record.

*b.* Step 2 -Reference Figure 8 for temperature time and duration.

*c.* Step 3 - Attach a thermocouple to the section and place the section in the temperature chamber which is stabilized at an ambient air temperature of -62 +0/-5 degrees Celsius as

indicated by the thermocouple readout. Hold for four hours to start the three cycle procedure (see Figure 8).

*d.* Step 4 - Remove the test section from the temperature chamber. Remove the thermocouple and immediately (within 5 minutes) immerse in a seawater medium at -2 +2/-0 degrees Celsius and hold for 10 minutes, as shown in Figure 8.

*e.* Step 5 - Return the test section to the temperature chamber at an ambient temperature of -62 +0/-5 degrees Celsius (see Figure 8). This constitutes one thermal shock cycle. At the end of each cycle, conduct a brief visual inspection of the test section for obvious defects or deformations. Record the results.

*f.* Step 6 - Repeat steps 3 through 5 twice.

*g.* Step 7 - Return the test assembly to room temperature (20 degrees Celsius). Clean all external moisture from the test section and conduct a detailed inspection for evidence of cracks, damage and deformation. Record the results to verify conformance to the requirements of 3.2.3.1.6.

**4.4.1.5.2** *High Temperature Thermal Shock.* Before performing the high temperature thermal shock test, the contractor shall conduct a brief inspection of the test section. The test section shall be stabilized at a standard ambient temperature before the thermal shock test begins.

*Procedure* - The high temperature shock test shall be conducted as follows:

*a.* Step 1 - Reference Quality Assurance Test Record.

*b.* Step 2 -Reference Figure 9 for temperature time and duration.

*c.* Step 3 - Attach a thermocouple to the section and place the section in the temperature chamber which is stabilized at an ambient air temperature of +71 +0/-5 degrees Celsius as indicated by the thermocouple readout. Hold for four hours to start the three cycle procedure (see Figure 9).

*d.* Step 4 - Remove the test section from the temperature chamber. Remove the thermocouple and immediately (within 5 minutes) immerse in a seawater medium at +20 +2/-0 degrees Celsius and hold for 10 minutes, as shown in Figure 9.

*e.* Step 5 - Return the test section to the temperature chamber at an ambient temperature of +71 +0/-5 degrees Celsius (see Figure 9). This constitutes one thermal shock cycle. At the end of each cycle, conduct a brief visual inspection of the test section for obvious defects or deformations. Record the results.

*f.* Step 6 - Repeat steps 3 through 5 twice.

*g.* Step 7 - Return the test assembly to room temperature (20 degrees Celsius). Clean all external moisture from the test section and conduct a detailed inspection for evidence of cracks, damage and deformation. Record the results to verify conformance to the requirements of 3.2.3.1.6.

**4.4.1.6** *Hydrostatic Pressure Water Absorption.* The absorption test section shall be hydrostatically tested as follows:

*a.* Determine the weight of the test section.

*b.* Install the test section in a hydrostatic pressure chamber capable of attaining internal pressures of 1,050 pounds per square inch gauge (psig).

*c.* Steadily increase the internal hydrostatic pressure to 1,050 psig. Maintain this pressure for 24 hours.

*d.* Decrease internal hydrostatic pressure to 0 psig and maintain for 5 minutes.

*e.* Upon completion remove the test section from the pressure chamber. Inspect the internal and external surfaces for signs of deterioration, such as cracks, delaminations or similar defects.

*f.* Weigh the test section again to determine the parts per million of weight gained to verify conformance to the requirements of 3.2.3.1.7.

**4.4.2 Lifting.** The mast shall be able to withstand, without damage, the forces generated by its own weight and components when lifted. This force will be as specified in SE110-B3-MMA-010. The lifting arrangement will be as specified in SE110-B3-MMA-010, assembly 2.

**4.4.3 Clamping.** The mast shall be able to withstand, without damage, the clamping forces generated when two lifting clamps are placed along the length of the mast. Clamp bolts will be torqued to 60 ft/lb each (safety factor of 2). The clamps used will be per Drawing SS-904-4398614, assembly 2.

**4.4.4 Dielectric Constant.** The laminate that the mast is constructed of shall have a dielectric constant of 3.6 to 4.0. Dielectric constant tests shall be performed as specified in ASTM D2520 using Method B. The test frequency shall be 9.0±0.375 GHz.

TEMPERATURE EQUIVALENTS
-62 +0/-5°C = -80 +0/-9°F
-2 +2/-0°C = +28 +4/-0°F

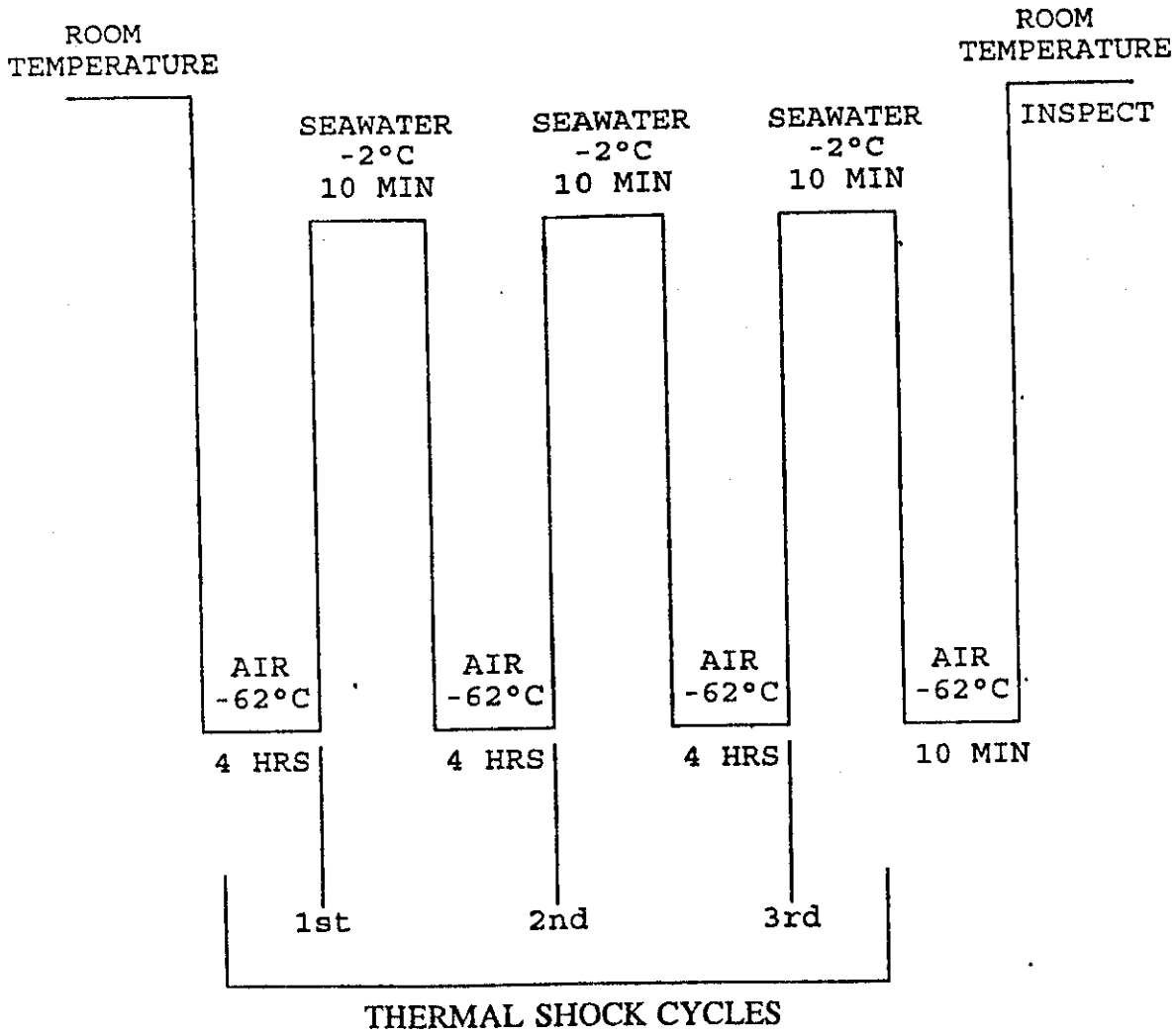


Figure 8. Thermal Shock Timing (Low Temperature)

TEMPERATURE EQUIVALENTS
+71 +0/-5°C = +160 +0/-9°F
+20 +2/-0°C = +68 +4/-0°F

THERMAL SHOCK CYCLES

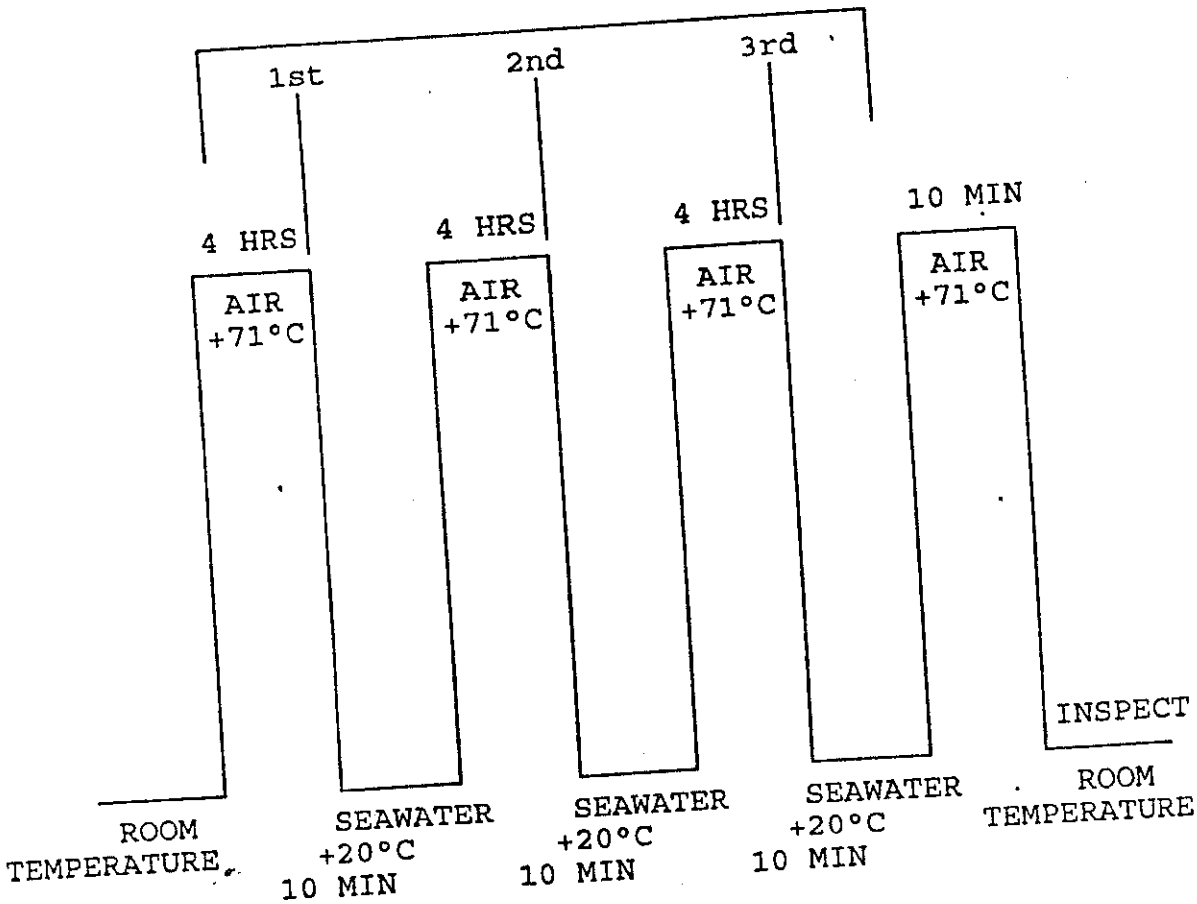


**Figure 9. Thermal Shock Timing (High Temperature)**

4.4.5 **First Article Bend Test.** The first article bend test shall be accomplished by the manufacturer. The mast shall be supported in bearings located as shown in Figures 4, 5, 6, or 7. Loads shall be applied through the jacking point attaining the required loading in a time period not to exceed that given in Table 4. The "F" required by Table 4 shall be held for a maximum time of one minute. The mast will be mounted in the test stand in such a way that the load will tend to straighten any initial mast bow. In the event that the internal and external straightness of the bearing areas conflict, the contractor is required to contact CDNSWC for direction. Tolerances for dimensions of Figures 4, 5, 6 and 7 shall be ±1/4 inch. Questions should be directed to CDNSWC, Philadelphia, Code 9622. Deflection of the mast shall be measured at the point of load application. Deflection shall be measured at the applicable load of Table 4.

4.4.5.1 *Post Bend Test Inspection.*

4.4.5.1.1 *Cracks, Crazing, Delaminations.* Cracks, crazing, or delamination in any of the masts prior to, during, or after test shall be cause for rejection.

4.4.5.1.2 *Resin inclusion.* Any resin-rich area forming resin pockets shall be cause for rejection.

4.4.5.1.3 *Permanent distortion.* Within 48 hours after test, the mast shall be thoroughly inspected to ascertain that no permanent distortion has developed to the extent that the mast does not meet drawing tolerances. For example, the mast will be rejected if any element of the bearing surfaces deviates more that 0.040 inch from a straight line or exceeds a maximum local variation of 0.010 inch per foot.

## 5. PREPARATION FOR DELIVERY

5.1 **SHIPPING CRATES.** Each mast assembly shall be packed and delivered in an individual shipping crate. The shipping crate shall be fabricated in accordance with Drawing SS-904-2113425. Necessary blocking and packing shall be supplied to prevent the mast from moving during shipment.

5.2 **MARKING.** All packages and shipping containers shall be marked in accordance with MIL-STD-129. The longitudinal center of gravity shall be marked on all shipping containers.

## 6. NOTES

6.1 **INTENDED USE.** A mast ordered under this specification is intended for antenna systems for pre-SSN-688, SSN 688 class submarines, or the TRIDENT OE-207/BR antenna system. It is the main support member for the antenna.

**6.2 ORDERING DATA.** Procurement documents shall specify the following:

*a.* Title, number, and date of this specification.

*b.* Delivery destination.

*c.* Delivery schedule.

*d.* Time frame required for the first production unit.

*e.* Exceptions to specification.

*f.* Serial letters.

*g.* Mast nomenclature.

*h.* Drawing number.

*i.* Revision.

*j.* Assembly number.

*k.* Government-furnished material.

*l.* Quality assurance provisions.

*m.* Data requirements list of DD1423.

**6.3 FIRST PRODUCTION UNIT.** The first unit shall be submitted to the Submarine Sail Systems Department, Code 961, Carderock Division, Naval Surface Warfare Center, Building 26, Philadelphia, Pennsylvania 19112-5083, for examination and testing before acceptance is given (see 3.2.3 and 4.5).

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