NOTICE OF
CHANGE

METRIC
MIL-STD-2199(SH)
NOTICE 1
5 OCTOBER 1993

MILITARY STANDARD

GLASS REINFORCED PLASTIC COVERINGS
FOR PROPELLER SHAFTING (METRIC)

TO ALL HOLDERS OF MIL-STD-2199(SH):

1. The following attached pages of MIL-STD-2199(SH) have been revised and supersede the pages listed.

New Page	Date	Superseded Page	Date
1	----	1	11 May 1990
2	11 May 1990	2	REPRINTED WITHOUT CHANGE
3	----	3	11 May 1990
4	11 May 1990	4	REPRINTED WITHOUT CHANGE
5	11 May 1990	5	REPRINTED WITHOUT CHANGE
6	----	6	11 May 1990
7	11 May 1990	7	REPRINTED WITHOUT CHANGE
8	----	8	11 May 1990
17A	----	---	-----

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-2199(SH) will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or canceled.

Preparing Activity:
Navy - SH
(Project 9330-N061)

AMSC N/A

FSC 9330

Distribution Statement A: Approval for public release, distribution unlimited.

1. SCOPE

1.1 **Scope.** This standard defines requirements for the materials to be used and provides detailed instructions for guidance on surface preparation, resin preparation, and application of fiberglass reinforced plastic coverings on waterborne propulsion shafting.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 **Specifications.** The following specifications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

P-D-680	Dry Cleaning and Degreasing Solvent

MILITARY

MIL-C-9084	Cloth, Glass, Finished, for Resin Laminates
MIL-R-17882	Repair Kits, Metallic Pipe and General Purpose, Damage Control
MIL-P-23236	Paint Coating Systems, Fuel and Saltwater Ballast; (Metric)
MIL-R-23461	Resin Compound, Thermosetting, Room Temperature Curing, For Metal Coating
DOD-C-24176	Cement, Epoxy, Metal Repair and Hull Smoothing; (Metric)

(Unless otherwise indicated, copies of federal and military specifications and standards are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 **Other Government drawing and publications.** The following other Government drawing and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DRAWING

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

NAVSHIPS 803-2145807 Shafting, Propulsion and Components

PUBLICATIONS

NAVSEA

090-LP-430-0012	NSTM Chapter 9430, Shafting, Bearings and Seals
0943-LP-017-1010	Submarine Propulsion Shafting Main Technical Repair Standard
0943-LP-017-2010	Propulsion Main Shafting for Surface Ships, Technical Repair Standard
S9086-VD-STM-000, Chapter 631	Preservation of Ship in Service (Surface Preparation and Painting)
S9086-VG-STM-000, Chapter 634	Deck Coverings

(Application for copies should be addressed to the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

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

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AMS 3824 Cloth, Glass Finished for Resin Laminates; (DOD adopted)

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 2583 Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor; (DOD adopted)

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

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

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Abrasive-blasting. Abrasive-blasting is a more all-inclusive term for the procedure known as sandblasting. Many abrasive materials other than sand are often used and are suitable for shaft surface preparation. In fact use of sand may not be permitted by some local environmental and safety regulations.

3.2 Accelerator (promoter). An additive for polyester resins which promotes curing of the resin at room temperature.

3.3 Air-inhibited (air-inhibited resin). A characteristic of some types of polyester resin which results in incomplete cure of the surface which is in contact with air; the surface remains tacky.

3.4 BARCOL (BARCOL hardness). A measure of surface hardness of a covering system and used to indicate the degree of cure. The method involves applying a hand-held impressor to the surface, following ASTM D 2583 for the procedures and the instrument.

3.5 Catalyst. An organic peroxide additive for polyester resin which initiates the curing of the resin and accelerator mixture at room temperature (see 5.3.2).

3.6 Cure (or Curing). The chemical reaction process by which epoxy and polyester resins change from a liquid to a solid mass having characteristic properties. Cure implies more than solidification alone. Cure continues for a period of time after initial solidification and results in the final physical and mechanical properties of the reacted resin.

3.7 **Fair.** The condition of a surface, either flat or curved, when it is smooth and free of irregularity, unevenness or abrupt change in curvature. It is the condition in which the ends of the glass reinforced plastic (GRP) covering blend smoothly into the shaft or sleeve without roughness, projection or abrupt change in thickness or curvature.

3.8 **Gel.** A step in the cure cycle in which the resin thickens to a semi-solid consistency. This thickening progresses to such a degree that the resin can no longer be applied effectively.

3.9 **Glass reinforced plastic (GRP).** Fiberglass reinforced epoxy or polyester resin.

3.10 **Hardener.** An additive component which for epoxy resin causes the curing of the resin.

3.11 **Infusible.** The condition in which the cured, solid resin-coating will not melt under application of heat.

3.12 **Insoluble.** The condition in which the cured, solid resin-coating will not dissolve or soften in a solvent (such as water).

3.13 **Milled glass fiber.** An additive, composed of short lengths of glass fiber (approximately 1.6 millimeters (mm) (1/16 inches), which thickens resin.

3.14 **Pot life (working life).** The length of time that the mixed resin is of the workable consistency required for proper application. It is the length of time after the catalyst or hardener has been added, to the point that gelling or thickening of the resin has progressed to the degree it can no longer be applied effectively to the shaft.

3.15 **Resin.** A liquid epoxy or polyester type of plastic which may be cured to an infusible, insoluble solid.

3.16 **Sleeve.** In most cases as used herein a (copper-nickel) cylindrical tube or band secured to the shaft by shrink-fit and used in way of bearings, coupling covers, and fairwaters.

3.17 **Tacky.** The condition of a coated surface which remains sticky to the touch.

3.18 **Thixotropic.** A characteristic of resins to which a finely divided silica (fumed silica) has been added, which thickens resin to the degree that it will not flow or move unless spread by hand or brush.

3.19 **Viscous.** A term describing the resistance of a liquid to flow. The thick, syrupy, consistency of resin would be a relatively high viscosity.

3.20 **Wet-out.** The ability of a resin to "wet" or saturate the reinforcing fibers. Good wet-out implies complete wetting. Also, the process of applying resin to reinforcement.

4. GENERAL REQUIREMENTS

4.1 **Personnel.** Before being assigned the task of applying a glass reinforced plastic propeller shaft covering, personnel shall have background and experience with regard to the following:

a. *Materials.* General knowledge of the characteristics of the particular resin system being used, determining the mass of proper proportions of resin, accelerator, catalyst or hardener, and mixing the components thoroughly without entrapping air.

b. *Shaft and sleeve preparation.* An understanding of the need for the proper shaft and sleeve surface preparation, including abrasive blasting and degreasing, for obtaining acceptable resin adhesive bond.

c. *Covering application.* The skill required for uniformly applying fiberglass tape and resin to the shaft, detecting and eliminating air entrapment, and thoroughly wetting-out the tape with resin.

d. *Quality control and inspection.* Experience in determining, by visual inspection and the tests specified herein, whether the covering has been properly applied, is void free, and has continuous adhesive bond to the shaft and sleeve.

4.2 **Facilities, tools, and equipment.** Facilities are required to provide a clean, dry environment and the temperature range required in 5.4.6.1 of both the shaft and surroundings. To ensure the safe and proper application of the shaft covering as described herein, equipment and tools shall be required to perform the tasks of abrasive grit blasting, mixing and applying the resin, and performing specified tests.

5. DETAILED REQUIREMENTS

5.1 **Basic materials.** The basic materials as specified in 5.1.1 and 5.1.2 shall be used.

5.1.1 **Resin.** Resin shall be in accordance with MIL-R-23461, type I or III, as applicable (see 5.3).

5.1.2 Glass reinforcement. Glass reinforcement shall be woven fiberglass tape with a flat salvage on both edges to prevent fraying, in accordance AMS 3824, style 7500 or MIL-C-9084, type XII A. The finish shall be compatible with the specific type of resin used (that is, for epoxy or polyester). The width of tape will depend on the diameter of the shaft. For shaft diameters greater than 20 centimeters (cm) (8 inches), the recommended width of tape is 15 cm (6 inches). Ten cm (4 inches) width tape is recommended for shaft diameter (see 5,6,2(f)(5) and wider tape may be used on larger diameter shafts if the skill and experience of the applicator permit. The point here is that there is no single width of tape that will only work on a certain size shaft. Rather, it depends on the skill of the applicator and finally, the quality of te completed covering that determines the suitable width.

5.2 **Auxiliary materials.** The materials specified in 5.2.1 through 5.2.3 may be required.

5.2.1 **Thixotropic filler (thickening agent).** The addition of a small amount (2 to 4 percent by mass) of a thixotropic filler to the basic resin may be necessary to minimize or eliminate resin drainage. The amount required depends on the ambient temperature and resin viscosity. More filler will be required in warm temperatures when the resin flows more freely. Some manufacturers will provide the basic resin with the filler previously added, if required.

5.2.2 **Fairing compound.** One of the following thickened or paste type resin materials shall be used:

a. Hull smoothing cement in accordance with DOD-C-24176

b. Repair kit paste resin in accordance with MIL-R-17882 (sometimes preferred due to its fast cure time)

c. Basic resin thickened with milled glass fibers (see 3.13) (recommended for use with polyester type resins).

5.2.3 **Coatings for flange coupling areas.** Coating for flange coupling areas shall be coal tar epoxy conforming to MIL-P-23236, class 2, or the basic resin thickened with milled glass fibers and thixotropic filler (see 5.4.3.2).

5.3 **Chemical types of resins.** The resins which are used in the GRP coverings are viscous liquids which can be cured at room temperature into hard, insoluble, and infusible plastics by incorporation of curing agents (accelerator and catalyst or hardener). The type and quantity of curing agents shall be in accordance with recommendations of the resin manufacturer. The resin used shall meet the performance requirements of MIL-R-23461 which specifies either of two different types of resin systems; epoxy or polyester. Working characteristics of the two types of resin are described in 5.3.1 and 5.3.2.

5.3.1 Epoxy resins. Epoxy resins have been most widely used for shaft coverings because of their superior adhesive characteristics and this type of resin system is recommended. Epoxy resins are cured by the addition of a specific amount and type of curing agent or hardener. The amount of hardener added shall be in accordance with the recommendations of the epoxy resin manufacturer and shall not be varied over a wide range for pot life control. Pot life of an epoxy resin and associate hardener depends on the ambient temperature (see 5.3.3).

5.3.2 Polyester resins. Isophtalic-type polyester resins are generally preferred because of their improved toughness. Polyesters are cured by the addition of an accelerator (promoter) and an organic peroxide catalyst (in liquid or paste form) as required in 5.3.2.1 and 5.3.2.2. Pot life of the mixed resin is affected by ambient temperature and may be varied within limits by adjusting proportions of the accelerator and catalyst in accordance with the resin manufacturers instructions.

5.3.2.1 Polyester resin curing. An accelerator shall be mixed into the polyester resin either by the user or pre-mixed by the resin manufacturer; the curing reaction can then be activated by mixing in a small amount of an organic peroxide catalyst. The type and amounts of these materials shall be in accordance with the recommendations of the resin manufacturer. Caution shall be taken to ensure that the accelerator and catalyst are not directly mixed together as this will result in a violent reaction. It is common practice and very desirable to acquire the resin premixed with the accelerator to avoid this dangerous possibility.

CAUTION

NEVER MIX ACCELERATOR AND CATALYST TOGETHER DIRECTLY!!

5.3.2.1.1 Peroxide catalyst, handling and storing. Care shall be taken in handling and storing the organic peroxide catalyst. It is flammable in nature and will decompose violently under certain conditions. It should not be exposed to heat such as direct sunlight, steam pipes, open flames, or sparks. Consult the manufacturer's data sheet for specific details on safe handling and storage conditions.

5.3.2.2 Polyester resin classification. Polyester resins may be classified as "air-inhibited" or "non-air-inhibited" (resins which cure tack free). Some air-inhibited resins frequently contain an additive such as wax which enables the resin to cure to a tack-free surface. This type of resin shall not be used since the wax additive interfere with adhesion between plies of reinforcement. The resin supplier shall furnish either a resin that is naturally non-air-inhibited or an additive (preferably non-wax) which can be added to the resin for the final tack-free layer coating application.

5.3.3 **Cure.** Once the hardener or catalyst has been added, the resin will remain liquid for a limited period of time after which it will begin to gel or thicken and become unworkable. The resin should cure at room temperature (or according to the manufacturer's instructions). However, optimum properties can be developed in a shorter time by post curing or heating at moderate elevated temperatures. Infrared lamps and strip heaters are convenient sources of heat. Post curing may be used to obtain optimum cure particularly for coverings applied in cold weather or coverings that must be put in service as soon as possible.

5.3.4 **Fillers.** Resin flow from the freshly applied covering shall be minimized or eliminated by assuring the proper viscosity, or if necessary, increasing the resin's viscosity by the addition of thixotropic filler material (see 5.2.1). This will probably be necessary if the shaft cannot be rotated continuously during application and cure. The addition of filler may have the disadvantage of obscuring visual inspection for voids and trapped air. Clear, unfilled resin shall be used on shafts which are rotated during application.

5.4 **Application procedures.**

5.4.1 **General description.** After proper shaft surface preparation, a coat of resin is applied uniformly to the shaft. The first ply of glass tape is then wound spirally on the shaft, butting the edges. After working out entrapped air and ensuring that the glass tape is wet-out properly, a coat of resin is applied over this ply. A second ply of glass tape is then wound on the shaft, reversing the direction of the spiral wrap. This process is continued until four plies of tape have been applied. Safety precautions (see 5.4.5) shall be observed in the handling and application of these materials.

5.4.2 **Preparation of shaft.** The shaft surface shall be prepared immediately prior to application of the covering in accordance with the following procedures to ensure a maximum degree of adhesion:

a. The existing covering on shafts and sleeves which have been in service shall be removed by mechanical means.

b. Remove any oil or grease from the surface of the shaft by washing with suitable solvents (for example, petroleum distillate type solvent in accordance with P-D-680, Type II, or other solvent that provides suitable cleaning and degreasing capability without leaving a residue. Solvents shall not be ozone depleting types and must be acceptable under local, State and Federal regulations, as required.

m. The application steps decribed above represent the basic method of application and the one most likely to produce good results under all conditions. Variations on this method are possible and permissible provided the end result is not degraded. For example, it has been reported that the covering layers can be aplied faster if two layers are applied at the same time, starting at opposite ends of the shaft.

There are some cautions that must be kept in mind. The second layer should not be applied over the first layer until the resin has had time to wet out the first layer. Otherwise there is a risk of trapping air bubbles in the underlayer. The amount of time the wet out requires depends on the particular resin system used and very much on the temperature of the shaft (and the air). If wraps are being applied from opposite ends, it may be necessary to end one wrap before the other approaches it, to allow sufficient time for wet out to occur before the one layer overlaps the other. When wet out has occurred the passing layer can proceed over the stopped layer and after wet out at the junction, the stopped layer can be continued over the passing layer. The junction of the stopped layer should be made with an overlap wrap as would be used when making a joint at the end of a roll of glass tape.

When two layers are applied at the same time, after they cross, additional resin will undoubtedly need to be applied to the bottom layer to provide wet out up through the next or passing layer. This is the same as if the layers were being applied one at a time. However, as noted above, the resin should not be applied to the under layer until wet out has occurred so as not to trap air bubbles in the underlayer. It is always better to have the resin wet its way up through the glass tape, pushing out the air, rather than to put the resin on the dry tape and have it wet down into the glass tape whereby the air has to work its way out through the resin.

Modifications to the basic method may be possible but it is the end product that counts. There must be no loss of quality in the finished covering.