MSC Guidelines for Review of Structural Plans for Fiberglass Reinforced Plastic (FRP) Vessels

Procedure Number: H1-12 Revision Date: 4/13/00

References

a. Title 46 CFR Subchapter R, Subpart 167.20 - Hull Requirements, Construction and Arrangement of Nautical School Ships, Subpart 168.05 - General Requirements, Subpart 169.300 - Construction and Arrangement
b. Title 46 CFR Subchapter T, Subpart C - Hull Structure
c. Navigation and Vessel Inspection Circular No. 8-87: Notes on Design, Construction, Inspection and Repair of Fiber Reinforced Plastic Vessels
d. 1997 ABS Guide for Building and Classing High-Speed Craft
e. 1986 ABS Guide for Building and Classing Offshore Racing Yachts
f. 1978 ABS Rules for Building and Classing Reinforced Plastic Vessels
g. Lloyd's Register Rules and Regulations for the Classification of Special Service Craft
h. Lloyd's Register Rules and Regulations for the Classification of Yachts and Small Craft
i. Design Guide for Marine Applications of Composites, Ship Structure Committee Report No. 403, November 1997

Disclaimer

These guidelines were developed by the Marine Safety Center staff as an aid in the preparation and review of vessel plans and submissions. They were developed to supplement existing guidance. They are not intended to substitute or replace laws, regulations, or other official Coast Guard policy documents. The responsibility to demonstrate compliance with all applicable laws and regulations still rests with the plan submitter. The Coast Guard and the U. S. Department of Homeland Security expressly disclaim liability resulting from the use of this document.

Contact Information

If you have any questions or comments concerning this document, please contact the Marine Safety Center by email or phone. Please refer to the Procedure Number: **H1-12**.

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Structural Standards

Subchapter T

In general, all vessels must be built to one of the structural design standards referenced here within. However, the MSC may also accept either a systematic analysis based on engineering principles or an applicable design standard of another classification society as sufficient evidence that the vessel's structures have adequate safety and strength (§177.340).

Subchapter R

Public nautical school ships are prohibited from being constructed of FRP (§167.20-1).

Civilian nautical school ships must be built to the same structural requirements as similar sized passenger vessels (§168.05-1).

Sailing school vessels must be built to the structural design standards established by a recognized classification society (§169.309). Sailing school vessels that carry more than 100 persons or have overnight accommodations for more than 49 persons are prohibited from being constructed of FRP (§169.311).

Classification Society Review

Vessels Reviewed for Classification

The MSC considers the structural plan approval by a recognized classification society for the purpose of classification as sufficient demonstration of compliance with the regulations. Any plans of a vessel classed by a recognized classification society and submitted to the MSC will be returned without action stating this policy.

Vessels Reviewed for Load Line Assignment

The MSC considers the structural plan approval by an assigning authority for the purpose of load line assignment as sufficient demonstration of compliance with the regulations. Any plans reviewed by an assigning authority for this purpose and submitted to the MSC will be returned without action stating this policy. Please note that a load line review is much less extensive than a classification review. In a load line review, the assigning authority reviews only the major external strength members and ignores many structural components such as internal bulkheads that are reviewed if a vessel is seeking classification.

Plans of structural members not reviewed by the assigning authority must be submitted to the MSC for review and approval.

Vessels Reviewed By Class Societies for Other Purposes

The MSC considers the structural plan approval by a recognized classification society as sufficient demonstration that the vessel's structures have adequate safety and strength in accordance with Title 46 CFR 177.340.

Documentation

Check that the following items are included in the submittal package:

- A detailed list of all plans noting what action is desired (approval, information only, etc.)
- A general description of the vessel and its functions such as: length overall, length between perpendiculars, breadth, depth, block coefficient, estimated lightship and draft, load line draft, vessel speed, wave height vs. speed relationship (if applicable), service limitations, identification of novel designs and/or connection details requiring direct analyses, anticipated route, and types of cargo and number of passengers to be carried.
- If the vessel is classed: Ensure that the MSC and the cognizant Officer in Charge, Marine Inspection (OCMI) receive copies of the classification society's approval letter(s). The OCMI must also receive copies of the classification society's approved drawings for their use in the inspection and certification process.
- If the vessel is load-lined: Ensure that the MSC receives a copy of all structural plans not being reviewed by the classification society. In addition, ensure that MSC and the OCMI receive copies of the approval letter(s) for the plans reviewed by the classification society. The OCMI must also receive copies of the classification society's approved drawings for their use in the inspection and certification process.
- If the vessel is not classed or load-lined but the hull structure has been reviewed and approved by a classification society for other reasons: Ensure

that the MSC receives the class society's approval letter and approved drawings.

Materials

Check that the following information is included in the submittal package if applicable:

- **Resins:** Specifications that include the types (general purpose or fire retardant) and cured mechanical properties of all resins and gel coats used, as well as the type and amounts of catalyst, accelerators, hardeners and other additives.
- **Reinforcements:** Specifications that include the fiber type and form, weave, fiber orientation, weight, physical data, and mechanical properties of all reinforcing materials used.
- **Core Materials:** Specifications that include the material type, density , and mechanical properties of all cores used.
- **Plywood and Timber Members:** Specifications that include the type, density, grade, and mechanical properties of all plywood and timber members used.
- **Laminates:** A laminate schedule for each laminate used in the design that includes the layup procedure, the type, orientation of reinforcements, sequence of plies, and the assumed or calculated mechanical properties. This information should be indicated on the drawings.

Testing

Contact the cognizant OCMI to determine the amount and frequency of laminate material testing required.

Plan approval should be completed prior to beginning the vessel's construction . This means that MSC approval of the vessel's plans is based on structural calculations using assumed or calculated material properties for each laminate. Since the strength and reliability of a laminate is entirely in the hands of the fabricator and may vary greatly from one boat to the next, it is essential that the design properties are verified prior to the Coast Guard issuing the vessel a Certificate of Inspection. Preferably test panels are either laid up as qualification test samples at the time of boat lay-up, or they are taken from hull cut-outs or plugs or hull laminate extension tabs. If test results determine that the laminates'

properties are less than those used in the design, the plans and/or calculations must be appropriately updated and resubmitted to the MSC for approval.

The tests associated with the laminate properties determine the laminates' specific gravity, glass content, tensile strength and modulus, flexural strength and modulus, shear strength, and where glass content is 40% or more, interlaminar shear strength. The specific tests are as follows:

Single skin	Flexural strength and modulus	ASTM D790 or D790M or ISO 178
Single skin	Shear strength, perpendicular and parallel to warp	FTMS 406 1041 or ASTM D732 85
Single skin and sandwich	Glass content and ply-by-ply analysis	ASTM D2584 or ISO 1172
Single skin and sandwich (both skins)	Compressive strength and modulus	ASTM D695 or D695M or ISO 604
Single skin and sandwich (both skins)	Tensile strength and modulus	ASTM D3039 or D638 or D638M or ISO 3268
Single skin and sandwich (both skins)	Interlaminar shear strength	ASTM D3846
Sandwich: Core to skin bondline	Flatwise tensile test	ASTM C297
Sandwich: Core material	Shear strength and modulus	ASTM C273

Plans

Check that the following plans are included in the submittal package if applicable to the vessel (in triplicate). Representative sections must be submitted when scantling plans are not available.

- Bottom construction, floors, girders, inner bottom plating, etc.
- Deck plans
- Framing plan
- Midship section - Identifying all cutouts, longitudinal stiffeners/girders that are not considered effective, and all local loadings (i.e. wheel loads, foundation loads, concentrated or distributed loads).

- Pillars and girders
- Scantling profile and decks
- Shell expansion
- Superstructure and deckhouses
- Watertight and deep-tank bulkheads
- Miscellaneous non-tight bulkheads which are used as structural supports
- Watertight doors and framing
- Window and framing details
- Structural details of engine foundations, deck fittings, deck to hull joints, interior joints, shell details such as chine and transom, through hull penetrations, boundary angles, flanges or tapes, mechanical fasteners, panel stiffeners, brackets, openings in girders, structural intersections, tripping brackets, stanchion supports, stiffener endings, snipes, bulkhead penetrations, and cutouts
- Typical sections for areas of unusual structure
- General arrangement (for reference only)

Calculations

Ensure that the structural standard used to demonstrate compliance is:

(1) a standard permitted by the vessel's specific subchapter, and
(2) applicable to the vessel.

Check that the following structural calculations are included in the submittal package (in triplicate) If the standard chosen does not address some of the calculations, then calculations are not required for that particular aspect of the vessel's design:

- Keels, stems, and shaft struts
- Bottom shell plating and attached stiffeners
- Side shell plating and attached stiffeners
- Strength deck plating and attached stiffeners
- Longitudinal hull girder strength
- Hull transverse, torsional, and shear strength (multi-hull only)
- Watertight bulkheads and attached stiffeners
- Deep-tank bulkhead plating and attached stiffeners
- Non-tight structural bulkheads/tank boundaries and attached stiffeners
- Superstructure and deckhouse plating and attached stiffeners
- Other deck plating and attached stiffeners
- Stanchions
- Windows and framing

- Rudders
- Unusual structure requiring direct analysis (novel designs and/or connection details, hydrofoil appendages, etc.)
- Racking load calculations (large multi-level superstructures with few transverse bulkheads and/or supporting stanchions)

Calculations

If longitudinally framed, check to ensure the following:

- Bulkheads, partial bulkheads or web frames are arranged to provide effective transverse rigidity and to support the ends of the superstructure or deckhouse.
- Longitudinal frames are supported by effective transverse structure.
- In general, longitudinals are continuous in way of transverse supporting members, except at transverse bulkheads where they may be intercostal provided continuity of strength and end fixity are maintained. If longitudinals are not continuous, ensure that they are not used in the longitudinal hull girder section modulus calculations.

If transversely framed, check to ensure the following:

- Deck and bottom girders are provided. Girders may be intercostal at transverse bulkheads provided continuity of strength and end fixity are maintained.
- Transverses are arranged as continuous web rings and girders are aligned with stiffeners at bulkheads. Alternatives will be specifically considered.

For all vessels, check to ensure the following:

- Where changes in thickness or structural section occur, they are gradual to prevent notches, hard spots and other discontinuities, and that the ends of all internal structural members provide end-fixity and load transmission to the supporting members.
- The webs of all members are effectively attached to the shell, deck or bulkhead plating, to their supporting members, and to face bars.
- Openings in structural internal members are clear of concentrated loads and areas of high stresses.
- Openings in decks are framed to provide sufficient support and attachment for the ends of deck beams.
- Portlights below the main weather deck are of substantial construction and capable of being closed and secured watertight.

- Engines are supported and secured by substantial girders, suitably stiffened, supported against tripping and supported at bulkheads.

Structural Fire Protection

Ensure that the resin used is fire retardant and meets MIL-R-21607 as required by §177.410(b). A listing of fire retardant resins that meet MIL-R-21607 is provided in an attachment to these Guidelines.

If the resin does not appear in the attachment and does not meet MIL-R-21607, it may be accepted as fire retardant if it has an ASTM E-84 flame spread rating of not more than 100 when tested in laminate form. The requirements for testing a resin system are listed in §177.410(b). The test results must be submitted for MSC review. Specific laminate schedules regardless of resin type may be considered fire retardant if testing determines that the schedule has an ASTM E-84 flame spread rating of not more than 100.

If the resin used is general purpose, check to ensure the following:

- The additional requirements of §177.410(c) concerning cooking and heating appliances, sources of ignition, fire detection and extinguishing systems, machinery space boundaries, and furnishings are met:
- The vessel does not have overnight passenger accommodations for more than 12 persons.
- The vessel is not powered by gasoline, unless powered by outboard engines with portable fuel tanks stored in an open area aft that does not produce an unreasonable hazard as determined by the OCMI.
- The vessel does not carry hazardous combustible or flammable cargo.

Attachments

1. List of Accepted Fire Retardant Polyester Laminating Resins

MSC Guidelines for Review of Structural Plans for Fiberglass Reinforced Plastic (FRP) Vessels

Attachment 1

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ACCEPTED FIRE RETARDANT POLYESTER LAMINATING RESINS

The resins below meet Mil-R-21607. This list was compiled by Commandant (G-MSE-4) on November 17, 1997.

Company	Resin(s)
Advance Coatings Company, Depot Road, Westminster, MA 01473	Advaco #3510
Ashland Chemical Company, Resins and Plastics Divisions, P.O. Box 2219, Columbus, OH 43216	Hetron 92, Hetron 355, Hetron 24370, Hetron 27196, Hetron 28429
Koppers Company, Inc., Organic Materials Group, Pittsburgh, PA 15219	Dion 6395, Dion 6395T, Dion 6431, Dion 6692, Dion 6692T, Dion 6692TSD, Dion 601, Koplac 3403
McWhorter Technologies, Inc., 400 East Cottage Pl., Carpentersville, IL 60110	752-448(-) series
Reichold AS (formerly Jotun Polymer A/S), Box 2061, N-3202 Sandefjord, Norway	NORPOL 842-842 (formerly PX-7342), NORPOL 850 series
Reichold Chemicals, Inc., RCI Building, White Plains, NY 10602	Polylite 33-440, Polylite 33-441, Polylite 33-442, Polylite 94-179 (var. of 33-441)
Scott Bader Company Limited, Wollaston, Wellingborough, Northamptonshire NN8 7R1, England	Crystic 302
Silmar Division, Vestron Corporation, 12335 South Van Ness Avenue, Hawthorne, CA 90250	Silmar S-517, Silmar S-517A, Silmar S-517B
USS Chemicals Div. Of United States Steel, Polyester Unit, 1605 Elizabeth Avenue West, Linden, NJ 07036	Laminac EPX-187, MR 357, MR 12165
ICI Americas, C.R.P., Wilmington, DE 19897	ALTAC 792
Interplastic Corp., 2015 N.E. Broadway, Minneapolis, MN 55413	CoRezyn 105-58