MSC Guidelines for Review of Rigging Systems for Sailing Vessels

Procedure Number: H1-15 Revision Date: 04/14/16

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References

a. Navigation and Vessel Inspection Circular (NVIC) No. 02-16, Inspection Guidance for Sail Rigging and Masts on Inspected Sailing Vessels
b. Federal Register, Volume 59, No. 9, January 13, 1994
c. 2015 Lloyd's Register Rules and Regulations, Special Service Craft
d. Kinney, Francis S. Skene's Elements of Yacht Design. New York: Dodd, Mead & Company, 1981.
e. Larsson, Lars and Eliasson, Rolf E. Principles of Yacht Design. New York: McGraw Hill, 2007.
f. NVIC No. 8-87 Change 1: Notes on Design, Construction, Inspection and Repair of Fiber Reinforced Plastic (FRP) Vessels
g. 1978 American Bureau of Shipping Rules for Building and Classing Reinforced Plastic Vessels
h. 1997 Germanischer Lloyd Rules for Classification and Construction, Tall Ship Rigs
i. 2009 Germanischer Lloyd Rules for Classification and Construction, Guidelines for Design and Construction of Large Modern Yacht Rigs

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Contact Information

If you have any questions or comments concerning this document, please contact the Marine Safety Center (MSC) by e-mail or phone, referring to Procedure Number: H1-15.

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Applicability

This Plan Review Guideline explains MSC procedures for review of sailing vessel rigging plans submitted for under the provisions of 46 CFR 116.202(b)(14), 116.330, 169.309 (b), (c), and (e), 177.202(b)(12), and 177.330.

46 CFR does not include specific Coast Guard requirements or regulatory standards for sailing vessel rigging systems. Consequently, while we encourage vessel owners to have their sail rigging systems designed and stamped by a Professional Engineer, we are unable to provide expedited review of such plans under the provisions of NVIC 10-92.

General Guidance

When required by the Officer in Charge, Marine Inspection (OCMI) per 46 CFR 177.330, the vessel owner must submit plans and calculations to MSC for review of the design, materials, and construction of the rigging system.

A rigging system includes, but is not limited to masts, yards, booms, bowsprits, standing rigging, mast steps, rigging anchoring points, and hull structure in way of rigging anchoring points.

Rigging system plan submission and review is typically conducted during new construction or initial certification. However, the OCMI may require submission of plans and calculations from the owner or request technical guidance from the MSC on existing rigs, especially following a repair or modification.

Plan review cannot effectively evaluate every potential condition a vessel may experience during operation. In addition, the effects of fatigue and the state of the rigging system tuning may be difficult to capture during plan review. The owner(s), master, and crew of a vessel have responsibility for monitoring the condition of the vessel to maintain the safety of passengers and crew and avoid structural failure of the rigging system (or failure at the attachment points to the vessel).

Reference (a) provides guidance that is specific to sail rigging equipment for inspected sailing vessels. The goal of reference (a) is to ensure critical components of the sail rigging are replaced on a routine schedule in accordance with manufacturer recommendations, and when necessary due to normal wear and tear. This is typically accomplished through a Preventative Maintenance Plan (PMP) that chronicles a vessel's sail rigging system components and inspection intervals.

Methodology

Per reference (b), there are no approved standards or "rule sets" for rigging systems and the submitter must provide a detailed explanation of the methodology used in designing and sizing the rigging system. References (c) through (i) are examples of common industry methodologies for the design of sailing vessel rigging systems. These methodologies often rely on empirical data and assumptions regarding vessel type and service. For example, reference (d) is typically suitable for small simplistic rigs, whereas reference (h) is intended for much larger traditionally-built tallships. Alternatively, rigging systems may be evaluated using a detailed first principals engineering approach.

Every submission should summarize the rigging system loads (compression, tension, shear, torsion) for all components and all points of sail, including downwind, beam winds, and upwind. The methodology should fully support decisions to use a particular rigging design and include engineering methods used to size the spars (masts, booms, spreaders, gaffs, bowsprits), standing rigging (shrouds, stays), running rigging (sheets, halyards, vangs), mast steps, rigging anchoring points (chain plates, stem fittings, mast fittings, link plates, etc), and hull structure at rigging anchoring points. Assumptions should be clearly stated.

If there are questions or concerns regarding the suitability of a methodology, contact the MSC, Hull Division, Small Passenger Vessel Branch.

Stability and Rigging System:

A vessel's stability characteristics are critical factors when determining rigging system loads. Vessel characteristics, including displacement, trim, and sail areas must be consistent throughout the USCG plan review process (i.e., hull structure, stability, rigging systems, etc.).

- Monohulls: The rigging system analysis should account for the maximum righting moment of any loading condition.

- Multi-hulls: The rigging system analysis should account for either (1) the maximum righting moment of any loading condition, or (2) the maximum heeling moment associated with a conservative apparent wind speed. See below for further discussion on wind speeds.

Hull Structure and Rigging System:

The scantlings of the vessel, such as the hull and deck structure, should be adequately sized to support the rigging loads. In particular, the designer should provide calculations demonstrating the structural adequacy of the following items:

- Cross beams for multi-hulls
- Head stay bridle links (typically on multi-hulls)
- Reinforcement in way of rigging anchoring points, including bolt shear strength and the potential for the deformation / crushing of the structure (hull, spar, etc) at the anchoring point.

True vs. Apparent Wind:

True wind speed is the wind speed measured when stationary.

The apparent wind speed is the wind speed experienced while making way. Rigging reviews should utilize a conservative apparent wind speed that is typically comprised of (1) true wind speed that is appropriate for the region, intended service and route; and (2) the vessel's maximum speed and leeway angle.

True wind speeds generally should be assumed to be no less than those implied in 46 CFR 171.055 for stability route and Z factor. The conversion from Z factor to wind speed is as follows:

46 CFR 171.055	Factor	P (ton/ft^2)	P (lb/ft^2)	Wind Speed (knots)
Exposed	Z = 1.9	0.0019	4.256	31.4
Partially Protected/Protected	Z = 1.25	0.0013	2.800	25.5

The vessel's assumed maximum speed should be assumed to be no less than the hull speed.

Materials:

All materials and coatings used for the rigging system shall be suitable for marine service. Consideration should be given to separating/isolating dissimilar metals. Material and strength specifications for masts, yards, booms, bowsprits, standing rigging, mast steps, and rigging anchoring points should be included in submissions to the MSC.

Deck Step vs. Keel Step Masts:

Masts steps are primarily configured with one of two different methods: deck stepped masts terminate at deck level, whereas keel stepped masts terminate within the hull. For all mast configurations, the designer should consider the transfer of compressive, transverse, and longitudinal loads from the mast(s) to the vessel's hull and deck. For deck stepped masts, analyses should consider the strength and alignment of compression posts and beams.

Safety Factors:

Common industry methodologies do not always explicitly state safety factors, but instead they are often included as coefficients within the formulas. Therefore, rigging system components designed with a suitable industry methodology do not typically require the application of additional safety factors. However, all first principal engineering analyses require the justification and application of suitable safety factors. When determining appropriate safety factors, the engineer should take into consideration:

- Spar penetrations, alignment of attachment points with associated rigging (lead to load), and redundancy
- Worst-case loads from all reasonable operating conditions (i.e., downwind vs. upwind, reefed vs. full sail, etc.), wind and wave conditions, and passenger loading and distributions.
- Yield vs. Breaking strength (see table on following page)

Evidence of satisfactory service of rigging systems on existing vessels may be taken into consideration by MSC.

The following minimum safety factors are generally acceptable.

Component	Analysis	Minimum Safety Factor	Notes
Spars	Bending, buckling	2	• Based on yield strength
Rigging Anchoring Points (chain plates, stem fittings, etc)	Tension, bending	1.33	• Based on yield strength • Based on breaking strength of attached rigging
Rigging, Anchoring Point, Bolts / Fasteners	Shear, tension	2	
Stays, Shrouds, Rigging		2	• Based on breaking strength

Computational Analyses:

Submissions for rigging systems designed with computational analyses should include all inputs, assumptions, methodology, and loads. Generally, single sheet (or similar) "Black Box" summaries do not provide adequate detail for MSC acceptance.

Required Plans & Calculations

Plans:

All plans should be to scale and include material specifications, dimensions, angles, titles, and revision dates.

- ❑ Spar plans (masts, booms, spreaders, gaffs, bowsprits, yards), including section modulus and moment of inertia details
- ❑ Unique details or components, such as cross trees, tabernacles, etc.
- ❑ Rigging plans, including location and attachment points for all shrouds, stays, runners, and other rigging components (both standing and running)
- ❑ Rigging anchoring points
- ❑ Sail plans (including reefed configurations)
- ❑ Mast step(s)
- ❑ Hull in way of rigging anchoring points

Calculations:

Units should be clearly indicated and consistent, and all documents should include titles and revision dates.

- Maximum loads and safety factors for all spars
- Maximum loads and safety factors for all standing rigging
- Topping lifts, boom topping lifts, quarter lifts, lazy jacks *
- Rigging anchoring point configurations and sizing
- Hull structure in way of rigging anchoring points
- Mast steps and mast compression pathways
- Calculations should also consider loads when the sailing rig is reefed**

*Certain rigs utilize the spar suspension systems to secure both the sail and boom (i.e., topping lift dependent). Calculations should consider all associated loads with such an arrangement.
**Reefed sail plans, as compared to the full sail plan, may induce greater loads on the rigging system.

Replacements, Repairs, & Modifications

Any replacements, repairs, or modifications performed to the vessel's rigging system should be documented by the vessel owner, preferably in a Preventative Maintenance Plan (PMP), and reported to the OCMI. As discussed below, submissions to the MSC may be required to verify the adequacy of the rigging system.

In-Kind Replacements

In general, plans and calculations for one-for-one replacements of rigging components due to manufacturer recommendations, wear and tear from normal service and at normal intervals, and purely cosmetic reasons need not be submitted to the MSC for review. However, if questioned by the OCMI, plans and calculations may be required to be submitted for evaluation.

Repairs

Repairs made necessary by normal wear and tear and that do not change the configuration of the rigging system do not typically require the submission of plans and calculations to the MSC (see "In-Kind Replacements" above).

Repairs following the failure of a rigging component during service, especially if associated with a reportable marine casualty, may necessitate, if required by the OCMI, the submission of plans and calculations to the MSC. The submission should demonstrate adequacy of the repair through calculations. While repair proposals may not consider the entire rigging system, conservative assumptions and clear methodology are necessary for MSC acceptance.

Modifications

Modifications (even those that appear minor) may have substantial impacts on the loads experienced by the rigging system. Any modifications that changes the angle of a rigging component, modifies the sail area or distribution (centers of effort), changes attachments for running or standing rigging, or otherwise modifies the original design in any way should be documented and submitted to the OCMI for review. Many modifications will also require the submission of plans and calculations to the MSC for the modified components and / or the entire rigging system. The OCMI and MSC will communicate and make determinations in instances where it is unclear if the modifications necessitate the submission of calculations to the MSC.

Disclaimer

This guidance is not a substitute for applicable legal requirements, nor is it itself a rule. It is not intended to nor does it impose legally-binding requirements on any party. It represents the Coast Guard's current thinking on this topic and may assist industry, mariners, the general public, and the Coast Guard, as well as other federal and state regulators, in applying statutory and regulatory requirements. You can use an alternative approach for complying with these requirements if the approach satisfies the requirements of the applicable statutes and regulations. If you want to discuss an alternative, you may contact the Marine Safety Center, the unit responsible for implementing this guidance.