Fred Barrett Yacht Design and Naval Architecture Pty Ltd

Design Consultancy specialising in Naval Architecture, Yacht Construction, Project Management and Engineering

CESR POLICY REVIEW.

Special Regulations Interpretation 6

Limitations on Stanchion Materials

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The Question:

The YA SR intends to only preclude structural dependency on carbon in stanchions, and not concern itself with cosmetic features, or, The YA SR intends to absolutely ban the use of carbon in stanchions.

Currently 3.12.7 states: Pulpits, stanchions, lifelines – limitations on materials for all Categories; "**Carbon Fibre shall not be used**"

CESR Response;

What constitutes as a "cosmetic" feature? Within the definition of this term the following is stated; "Decorative rather than functional"

The use of a single light weight carbon fibre laminate as a dedicated dress layer to present a "modern and or fashionable look" has been used within the marine industry and outside the marine industry for some period of time and can be seen as common place in many modern applications.

The risk assessment governing the question of carbon fibre cosmetic featuring at large could be argued for a multitude of yacht components, but it is the verification of what benefit if any the use of carbon as a cosmetic layer attracts.

A single 200gsm carbon fibre laminate may be deemed to provide a significant structural benefit only if the single laminate constitutes a significant percentage of the overall laminate stack incorporated within the manufacture of the part.

'C-Spar' supplied E-Glass/Epoxy stanchion.

I.D 23.6mm / O.D 31.7mm

As used on a large variety of the world's racing yachts and production multihulls.

EI value 1.44 - value for stiffness

Given a typical wall thickness of the above composite E-glass Stanchion is 4.05mm, the application of a single laminated of thickness 0.2mm constitutes a stack % of approximately 5%. We would consider this percentage of the overall laminate matrix not significant. Does this mean the carbon "cosmetic" layer won't crack, no, it means that it does not contribute significantly to the overall stiffness nor strength of the stanchion.

In terms of a stiffness increase with the application of a 200gsm carbon cloth, an EI increase of 1.44 to 1.46 has been determined. Note, this is geometry related and in this case presented as per the round C-Spar stanchion above. This represents an increase in stiffness of less than 2% and could be argued as presenting very little in additional structure to the original stanchion.

Composite Streamline Stanchion – standard E-Glass/Epoxy layup – no carbon fibre used cosmetically or otherwise.

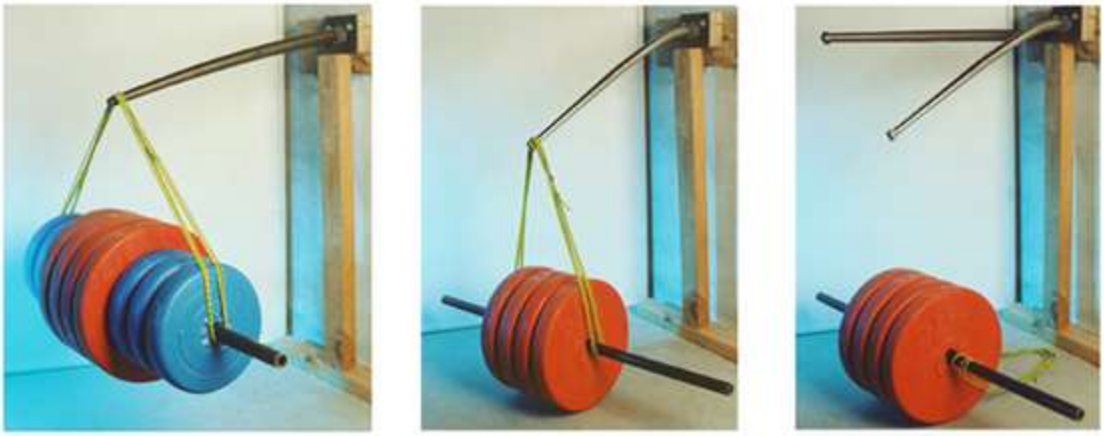
ISO 15085-2003 ‘Small Craft – Man Overboard Prevention & Recovery’ provide load and deflection standards irrespective of material type for the determination of satisfactory stanchions. The final engineering of a steel or composite stanchion for use within EU recreational craft must meet this standard.

The only other rationale thus far is to ensure the steel or composite stanchion is up to the job and suitable for the application. It would be recommended the ISO load cases shall be adhered to regardless of material type. Refer to Appendix A.

In the case of “Typical” E-Glass / Epoxy stanchions the strength, flexibility (stanchion stiffness) and robustness have been accounted for within the scope of manufacturers in-house testing.

Alternative pigmented E-Glass cloths are available to represent “Cosmetic” finishes and are used instead of ‘carbon fibre’ on a larger scale percentage of “composite” parts supplied around the globe.

C- Spar in New Zealand offers the following deflection testing. They do this to check their stiffness values (E.I) and strength and ultimately compare the effects of loading conditions on their composite stanchions in relation to a base setting, i.e. a Stainless Steel stanchion.



Composite stanchion 120kg load | **Stainless steel stanchion 40kg load** | **The result after load removed**

The potential to utilise the use of carbon fibre laminates outside the scope of a "cosmetic" layer within the construction of such parts as stanchions, pushpits and pulpits is at the heart of industry concerns.

The need to define a standard for the design and construction of composite stanchions may result from the acceptance of "carbon" being allowed into the construction of such parts.

A common misconception is that a carbon stanchion, or a carbon veneer' d E-glass stanchion is a performance advantage. It clearly is not. A light weight tapered carbon fibre stanchion would need to satisfy "suitable for the job" criteria by the manufacturer as no standards are available. Any manufacturer worth their salt would be hesitant in pushing the stanchion boundaries in the pursuit of a significant weight saving fearing failure and bad press. The result of a stanchion constructed from a significant amount of carbon fibre yields are very stiff element, with no plastic and little elastic properties, indeed this is where E-glass is superior, it has the mechanical ability to bend and return, up to the point of ultimate failure under load.

The performance misconception is clear, the crew wanting to hike harder can effectively hike further outboard with a stanchion undergoing a range of deflection as this allows the upper life line to move further outboard than the static 10° limitation imposed on stanchion orientation relative to the vertical.

The misconception is that an outer layer of carbon fibre plain weave (fashionable dress layer) will splinter, crack and provide the utmost danger to crew is over reactionary. Given a 200gsm laminate constitutes approximately 0.20 to 0.25mm in thickness this wafer thin fracture would in all reality be taped up by the crew. Again the emotional arguments that have been presented are reactionary and not necessarily based on any reality engineering or full size testing.

It should be noted if the amount of uni-directional fibres irrespective of material property within the stack constituting the construction of a stanchion is significant then two outcomes are;

1. The stanchion deflection will be limited to the quantity of uni-directional fibres contained within the laminate stack. The EI value will direct the deflection limitations.

2. The stanchion upon failure will present a dangerous failure region. The more uni-directional fibres, the more the quantity of sharp and spikey shards.

Whilst the above may be said in a general sense, not all failures may be the same each time.

The image shown to the left is the result of an E-Glass Spigot which was used to connect a stainless steel stanchion to a 52’ racing yacht.

The failure shown is the result of a M5 hole drilled through the spigot to mechanical fasten the stanchion to the ‘deck’.

Carbon fibre spigots are common place within the construction of carbon fibre yachts and have been accepted as an industry standard.

Other notable areas whereby carbon fibre is used and not necessarily regulated include;

Carbon Fibre wheels & tillers, Carbon Fibre grinding pedestals, Carbon fibre mast tubes, Carbon Fibre standing rigging, Carbon Fibre bunk tubes, carbon Fibre galley units, indeed anything carbon fibre ort combination thereof that a crew or multitude of crew may collide with resulting in damage both to human and component. The Volvo rule nominates stainless stanchions are required, ideally to limit the ultimate loss of lifelines in the result of a crash and given sails are commonly stacked to the weather rail. Broken carbon fibre wheels, pedestals, masts, bunk tubes and hulls, bulkheads, internal structural elements, and alike have all been broken within the world’s ultimate engineering test case, the Volvo Ocean race.

The image to the left shows the result of a stainless steel stanchion failure & stanchion socket foundation failure

Volvo 70 Movistar, Rio de Janerio, 2005

The yacht underwent a significant wipe-out in the southern ocean on her way to Rio during her delivery to Spain in 2005 for the 2005/06 Volvo Ocean race. Three stanchions broke on the port side after undergoing ultimate plastic deformation and then ultimate failure. Two stanchions that did not fracture applied enough load to ‘fracture’ the stanchion sockets within the deck laminate, resulting in ingress of water into the hull boundary.

Other carbon fibre elements that may be risky.

The picture below shows the result of running a hand up and down a carbon fibre standing rigging. The splintering was not seen prior to the action of the hand gliding its way up then down and the resulting puncture wound was quick and painful.

The result was micro surgery and a sore hand, some shock the incident occurred at all, and a great photo(s).

The above is the result of an element with a high percentage of uni-direction fibres with long chain behaviour splintering and acting as a long needle. Carbon standing rigging is not under question here, it is becoming more common and is not deemed illegal, but like anything on board a yacht, care must be taken.

Final Conclusion: - Special Regulations Interpretation 6

Within the bounds of the application of a light laminate of carbon fibre, so called, "cosmetic", over a structural member made predominantly not of carbon fibre, in the case of an E-Glass/Epoxy Composite based stanchion or indeed a stainless steel stanchion does not represent a clear and present danger and hence safety issue.

It must be noted however the following recommendations;

The application of any carbon fibre "cosmetic" laminate in the application of a yachts' stanchion must fall within an acceptable percentage of the overall laminate stack.

We have indicated a maximum allowance of 5% by thickness or weight would be in our opinion be satisfactory, i.e. one layer in twenty one by comparative fabric weight or thickness.

The carbon fibre cosmetic layer needs to be a plain weave of no greater than 200gsm, offered in the following orientations;

± 45° - i.e. off axis, which would result in a "laminate sock" being used.

0/90° - i.e. A wrap of plain weave cloth, applied, sanded & clear coated upon fitting.

Further;

The wording within ISAF needs to be clarified to bring it in line with today's modern world. The special regulations within ISAF were amended for yachts prior to 1987 and after 1987, this is some quarter of a century old.

3.14.7 Pulpits, Stanchions, Lifelines - Limitations on Materials TABLE 9 ** Earliest of Age or Series Date detail before January 1987 carbon fibre is not recommended in stanchions pulpits and lifelines. January 1987 and after stanchions, pulpits and lifelines shall not be made of carbon fibre.

Final Note;

The use of lightweight carbon fibre or hybrids in the application of "cosmetic" finishes on board yachts all over the world is becoming more prevalent, irrespective of any performance advantages that may be conceived. Other comparative materials such as black pigmented, red pigmented, yellow and blue pigmented E-glass "cosmetic" laminates are available. The basis I suspect behind carbon fibre being used in the cosmetic finishing of a particular stanchion at the centre of this, willingly or unwilling is clearly its availability, it's in the boat builder's shop. Clients want things to look "lightweight and carbon", again irrespective of actual weight savings or performance benefits.

The engineering of composites has advanced in the past twenty years significantly. Carbon fibre is used in other high performance sports, most notably F1 motor racing, where the usage of such materials is used to save the lives of those whom drive and crash these vehicles. Boat builders and composite component suppliers all need to engage in safe engineering practice and manufacture of parts that are suitable for their intended task, nothing less is unacceptable.

Appendix A

ISO 15085-2003: SMALL CRAFT – MAN OVERBOARD PREVENTION & RECOVERY

12.2 Requirements for stanchions or guard-line supports

12.2.1 Spacing

The spacing between stanchions or guard-line supports shall not be greater than 2.2m.

12.2.2 Strength

Stanchions or guard-line supports shall be capable of supporting, at their top, the following outboard forces applied perpendicular to the guard-line local direction, with the corresponding results.

- A horizontal force of 280 N with a deflection under load of the stanchion or support not greater than 50 mm at the force level. If there is a clearance between the stanchions and its base, this deflection shall be measured after the stanchion is inclined enough to have no residual play. with no permanent deformation of the stanchion or support after the force has been taken off;
- A horizontal force of 560 N without breaking.

When assessed for the above requirements, the stanchions shall be by themselves, with no lines on.

These requirements may be verified by calculation or test, for at least one sample of the device (stanchion or guard-line support, base, fixture system). In case of test, the deflection and strength need not be measured on the boat, and the stanchion and its support may be tested on a jig.

12.2.3 Fixture and disposition of stanchion and line supports

Stanchions/line supports shall be mechanically secured in their supports. The tension of the guard-lines is not considered to satisfy this requirement. Guard-lines shall be held vertically and horizontally by the stanchion/line support. Stanchions/line supports shall not be angled outboard more than 10° from the vertical, at any point above 50 mm from the deck.

LOAD NOTES:

280N represents a load of 28.54kg

560N represent a load of 57.08kg

Appendix B:

Definitions used or considered;

Strength:

A measure of the maximum load that can be placed on a material before it permanently deforms or breaks. Engineers often use this as yield stress, σ_y, as a measure of a material's strength.

Stiffness:

A measure of the amount of deflection that a load causes in a material. Engineers use a value called Young's modulus, E, for stiffness.

Stanchion stiffness:

The stiffness of a spar section (the EI value) is equal to the stiffness of the material itself (the E value) multiplied by the stiffness of the section shape (the I value).The stiffness of the material, E, is normally quoted in Giga Pascals (GPa) which is a unit of pressure.
The stiffness of the spar section, I, is entirely dependent on the size and shape of the section.