Carbon Fibre in Pulpits and Stanchions

Public Comment

&

Final Recommendations

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Abstract

The use of carbon fibre in stanchions, pulpits, pushpits and lifeline systems has been banned in the ISAF Offshore Special Regulations (OSR) since as early as 1987. The ban is purportedly due to the risks of injury to crew members if the pulpit or stanchion fails.

Investigations found that an International Standard for stanchions, ISO 15085 Small Craft - Man-Overboard Prevention and Recovery, has since been developed by an International Standards Organisation (ISO) Technical Committee and it does not preclude the use of carbon fibre. The investigations also confirmed that the use of carbon fibre on board yachts had become prolific in almost every design or feature.

With the advancement of composite materials and engineering, design practices, and the prevalence of carbon fibre onboard racing yachts, the currency of the regulation was scrutinised.

The recommendation to delete OSR 3.14.7 to reflect the improvement in modern design and composite engineering practices.

Table of Contents

Background

Yachting Australia (YA) recently considered the use of carbon fibre in stanchions and whether the limitations on its use in OSR 3.14.7 was applicable in the context of cosmetic or decorative uses.

Boat owners and clubs were advised that Interpretation 6, which initially allowed for this, was withdrawn[1] and until such time as the OSR are amended, carbon fibre shall not be used in pulpits, stanchions and lifelines.

The issue however, highlighted that there has been significant advancement in composite engineering and carbon fibre applications over the past 20 years. Carbon fibre is now used extensively on boats including in hulls, spars, rigging, sails, steering wheels, pedestals, tiller extensions and galley sinks. The only restrictions are either sound design practices, or the requirements of a relevant Standard.

Investigations found that ISO 15085 Small Craft - Man-Overboard Prevention and Recovery does not restrict materials in the construction of stanchions and it does not preclude the use of carbon fibre. The ISO 15085 does however provide deflection and ultimate failure loads for stanchions, defining the performance outcomes required of the equipment.

YA considered amending the wording of its own SR 3.12.7 to update the limitation on the use of carbon fibre by making it conditional on compliance with ISO 15085. The detailed proposal[2], incorporating subject matter expert opinion from Fred Barrett Yacht Design[3], was developed in accordance with YA's Risk Management Policies and was released on its website for public comment. Subsequent to this process YA conducted further internal investigations into the use and failure of carbon fibre, and commissioned destruction tests to be conducted by Van Munster Boats.

The public comments received and results of its own investigations have been considered by YA, and its findings published in this report. The recommendation reflects these findings accordingly; the limitations on carbon fibre should be deleted and that a submission to ISAF be made accordingly.

[1] See Appendix E - Interpretation 6
[2] See Appendix D - Clarification of Existing Special Regulation
[3] http://www.yachting.org.au/site/yachting/ayf/downloads/StanchionsFBYDreport.pdf

Summary of Public Comment

Six items of public comment[4] were received presenting views that varied from objections to the proposal, to endorsement of it. It was found that the key objections were focused on the dangers of failed carbon fibre. The endorsements were centred on the successful application of carbon fibre in other high profile sports and its prevalence in modern yacht and dinghy racing, or other Occupational Health and Safety (OHS) uses such as in composite guard rails.

The public comment submissions received may be summarised as follows:

1. YA should not be a leader of regulatory development in this matter
2. Suitably specified and manufactured [carbon fibre stanchions] should be appropriate. Composite stanchions, glass or carbon, can be designed to provide the requisite level of safety
3. Comparisons were drawn to Formula 1 (F1) racing cars using carbon fibre and their crashes as evidence of its suitability
4. The financial resources in F1 racing enable that sport to develop composite engineering and materials in a way that would not be possible in yachting
5. Comparisons were drawn to *Macquarie Innovation* world speed record holder who elected to use plywood rather than carbon fibre for their pod, and the VOR70 boats that restrict stanchions to stainless steel indicating it's unsuitability, both cases ostensibly being due to safety concerns
6. Comparison to Australian OHS applications indicating its suitability
7. The fact that carbon fibre is already used prolifically elsewhere on racing yachts is irrelevant as these applications are not safety equipment
8. Stainless steel lifelines and carbon fibre stanchions would be incompatible. Metal ferrules must be required to mitigate possible damage
9. Sharp shards and razor sharp ends could easily cause injury if crew falls on it, and there is greater risk to crew if a stanchion fails. Broken carbon fibre is dangerous[5]. Serious impaling/puncturing is not addressed
10. The stanchion should not be subject to loads to the extent that it pulls a hole in the hull at the sheer line before the stanchion breaks. The stanchion should be the weak link in sheerline design
11. The premise of the SR is to provide measurable levels of performance of a yacht's key safety features
12. There is no quality control of boat parts made in Australia, or anywhere else
13. The crew taping up dangerous shards is brushing away a safety issue. Tape (such as might be used for taping up a failed carbon fibre stanchion) is not required by the SR
14. Compliance with an ISO cannot be checked by a club safety auditor. Certification of ISO compliance must be required
15. ISO 15085 is for cruising boats and is not appropriate. It does not concern itself with the consequences of failure or collateral damage of failed features
16. ISO 15085 does not define 'break'

[4] See Appendix C - Public Comment
[5] The parties making submissions relating to the dangers of broken carbon fibre were invited to provide references to the source of information demonstrating or supporting the risks being claimed.

Tests Conducted and Photographic Evidence

YA commissioned Van Munster Boats to conduct destructive tests[6] on commonly available stainless steel stanchions, and composite stanchions manufactured by Excel Composites. The tests were conducted as follows:

1. The following types of stanchions should be broken by fixing the base and applying a sideways force to the point of ultimate failure
    a. Stainless steel
    b. E-glass
    c. Carbon fibre / E-glass
2. Document the weight/force at which each type ultimately failed
3. Provide the laminate schedule for the E-glass and carbon fibre stanchions
4. Provide detailed photos of the failed stanchions
5. Film the failures using a digital video camera
6. Provide the failed stanchions to YA

Concurrent to the destruction tests, management investigated carbon fibre tubes used in other sports or applications and procured photographic examples[7] of failures. These were mainly from cycling and pole vaulting. Investigations were also made into the Volvo Open 70 Class (VOR70) Rules and their limitations on materials in stanchions[8] and *Macquarie Innovation*, the 2010 World Speed Record holder.

[6] See Appendix A - Tests Conducted
[7] See Appendix B - Photographs
[8] Included in Appendix C - Public Comment Received

Conclusions

The importance of a proper laminating schedule in the fabrication of carbon fibre and E-glass stanchions is noted. The laminating schedule will dictate how carbon fibre or E-glass will splinter or fracture when broken. The ISO 15085 provides performance outcomes and it would be up to the designer and builder to determine an appropriate laminating schedule to achieve the appropriate strengths in a stanchion or pulpit that could be considered fit for purpose, and compliant with the ISO.

The same concern is applicable to the use of stainless steel, E-Glass, or any other material in stanchions. Neither the OSR nor SR regulates the grade of material to be used in currently compliant stanchions. There is a responsibility on the designer to determine the best grade of material for the intended purpose.

The compatibility between carbon fibre tubes and stainless steel wires is acceptable as observation of almost any modern racing yacht with a carbon fibre spar and stainless steel rigging shows effective integration. Again, it is the responsibility of the designer and builder to determine the best way of integrating stainless steel wires into the stanchions and pulpits, in a manner that is fit for purpose, and compliant with the ISO.

Comparisons to other sports were of interest and investigated. When the much stronger carbon fibre replaced aluminium as the material of choice for chassis construction in the F1, there was not a single driver fatality at a race meeting for the rest of that decade[9]. Aside to F1 motor racing, carbon fibre is common place in many sports such as golf, tennis, rowing, canoeing, skiing, archery, motorcycle helmets, and more.

Of particular interest were cycling and pole vaulting where equipment failures are well known. These equipment failures result in a participant, who is under considerable momentum, being in close proximity with the failed carbon fibre tubing at the moment of its failure. It is noted that these other sports have not banned the use of carbon fibre.

The immense resource understood to be available to the commercial development of composite materials and engineering in fields such as the aeronautical industry or F1 motor racing is noted. It is also recognised that the yachting industry may not have the same amount of resources to underwrite similar developments independently. Designers and engineers in yachting are able to draw on public exchange of knowledge in journals, texts, online or at conferences. This resource sharing disseminates through to education in the given profession or industry, and practices in the field. Whilst yachting may not have the resource available to sports such as F1, the flow of information occurs, and an enquiring engineer that looks at one can apply it to another.

This evolution is happening gradually and can be evidenced through the fact that a carbon rudder stock today is much better than one that may have been used in 1987. Standards such as those developed by the ISO that address composites have been around for a decade or more. A qualified engineer performing a job of design will produce a good result so long as the engineer practices within his/her expertise and constraints of the materials. It is

[9] "All Formula One Deaths" F1complete http://www.f1complete.com/content/view/228/383/. Retrieved 11 July 2011

anticipated that an experienced manufacturer will put that design together in an equally satisfactory manner.

The significant focus of the public comment is on the risks of impalement on a failed carbon fibre stanchion. However, it may be argued that the primary risk of a failed lifeline system may be its inability to perform its intended purpose and prevent man-overboard incidents.

Interestingly this matter has received little acknowledgement in any submission of public comment. This primary risk, man-overboard, would be the case for any failed lifeline system regardless of the materials used in its manufacture. It would require the person in charge to determine how to affect repairs to reduce any danger to the crew, and make a decision as to whether to continue racing.

The focus on the impalement risks of a failed carbon fibre stanchion does however indicate a possible inherent risk in any use of carbon fibre or polyepoxide (epoxy), regardless of its application. The apparent proposition deemed valid in 1987, that the shards and edges of failed carbon fibre such as those in a broken stanchion or pulpit, may be made redundant by the prevalence of carbon fibre and epoxy in almost every other feature on a racing yacht. The risks associated with failed carbon fibre will be present regardless of what the broken piece of equipment or feature is on a yacht or dinghy; it is not limited to carbon fibre stanchions or to Category 1 to 4 offshore yachts.

Taking guidance from conservative examples within the sport can be both helpful and misleading. A public comment submission[10] drew attention to *Macquarie Innovation* who, the submission stated, elected to build its crew pod out of ply wood rather than carbon fibre, as it was considered that the use of carbon fibre too hazardous to the crew in the event of a high speed crash. It was found on its website that it was because of designing deliberate early failure into the crew pod. The crew pod was constructed using lightweight marine plywood as a safety feature of the design so that in the event of an accident, the crew could be thrown clear of the wreckage with minimal impedance to their path out of the craft[11].

It was understood that the VOR70's requirement that stanchions be made of stainless steel was, "…imposed due to safety concerns[12]". Investigations found that the VOR70s originally specified stainless steel for the, "…1997-98 race with the Whitbread 60s as an attempt to control costs and prevent using titanium". It was also found that the requirement was maintained for the current Volvo Ocean Race as they "wanted to avoid expensive solutions and all agreed that this [stainless steel] was a good material for the job[13]". The decision was made to restrict costs and not in response to any risks of using carbon fibre as initially believed. The discussions regarding the VOR70s were nonetheless helpful as it highlighted the need to ensure that the design of stanchions is done in consideration of the deck and sheerline laminate design. There is a responsibility on the designer to determine the appropriate sheerline or deck laminate composition, and work the stanchions into this in a sound and appropriate manner.

[10] See Appendix C - Public Comment Received, Yachting Victoria submission
[11] See Structural Design at http://www.macquarie.com.au/mgl/au/speedsailing/design
[12] See Appendix C - Public Comment Received, Yachting Victoria submission
[13] See Appendix C - Public Comment Received, James Dadd email

Other examples within the sport include the Moth, 18 Foot Skiff and F18 Catamaran classes. These classes are less conservative and have embraced the use of carbon fibre regardless of the great speeds and, for some crews, regular crashes and gear failures experienced.

The destruction tests and the photographs of failed carbon fibre demonstrate splintering or shattering that may cause injury if fallen upon, but not necessarily any worse injury than what may be caused by falling onto other torn stainless steel, aluminium, or broken composite features on a racing yacht. The loads needed to break a carbon fibre stanchion were also significantly greater than those for stainless steel[14], demonstrating a lesser likelihood of incurring a broken stanchion in the first place. Using the tests conducted it may be argued that composite stanchions are a superior safety feature to common commercially available stainless steel stanchions, as they may maintain the integrity of the lifeline system far longer.

The ISO 15085 does not preclude fast or racing boats, or limit itself to cruising boats. It does provide measurable performance outcomes that can be certified by the designer or builder. Guardrails related to OHS requirements have similar outcomes based requirements. The standard AS 1657:1992 which provides for platforms, stairways and ladders, prescribes test methods for guard rail posts; requiring approximately 55kg to be applied horizontally at the top of the post[15]. This is similar to ISO 15085.

Certification of a stanchion's design and manufacture was raised in public comment[16]. It was argued that, "…if a standard is introduced then there must be some form of manufacturer's/builder's certification that the pulpits and/or stanchions comply with the standard." To require this would be consistent with how the SR treat any other safety features and equipment that are required to be compliant with a Standard, and should be included in the regulation if amended.

It is considered impractical and unreasonable to ban the use of carbon fibre in all applications because of the perceived splintering and impalement risks associated with its failure. It is also considered inconsistent and illogical to ban it one application, but allow it in all others.

The use of carbon fibre in stanchions is a simple engineering matter and can be considered at an evidence based level. There is no evidence that carbon fibre in its currently allowable applications on yachts, or as a properly designed and manufactured lifeline system, presents any significant risk that would be a precursor to a continuing ban on its use in pulpits, stanchions and lifelines.

The existing limitations on carbon fibre in OSR 3.14.7 as ban might be considered redundant.

To delete OSR 3.14.7 and its limitation on carbon fibre may be considered a change of an administrative nature that does not impact safety; it is maintaining currency with modern composite engineering practices and applicable Standards.

[14] See Appendix A - Tests Conducted
[15] See Appendix C - Public Comment Received, Shaun Ritson email
[16] See Appendix C - Public Comment Received, YNSW submission

Recommendations

It is recommended that:

1. YA SR 3.12.7 is deleted.
2. A submission is made to ISAF recommending that the ISAF OSR 3.14.7 is deleted.

Appendix A - Tests Conducted

Videos of the tests can be viewed as follows:
In a standard Microsoft/Windows format: https://www.box.com/s/7749db7b7dca1345dc7c
In the Quicktime/iTunes/Apple format: https://www.box.com/s/1a98b213dac3e67320af

The tests conducted by Van Munster Boats demonstrated:

Material	Yield Point
Stainless Steel	60kg
E-Glass	208kg
Carbon Fibre / E-glass	178kg

The video shows tests in the following order:

Stanchion Type	Comments
1. Stainless steel #1	The first test shows the importance of the integrity of the entire lifeline system, this is the reason it is included. The E-glass spigot broke before the stainless steel stanchion deformed.
2. Stainless steel #2	The second test shows that the standard production stainless steel stanchion fails at approximately 60kg of lateral load. This is about the same requirement of the ISO 15085; it would have complied. It folds and results in two hard points at the fold. There is evidence of tearing of the stainless steel on the inside of the fold indicating that it is close to breaking off.
3. E-Glass	The third test shows that the E-glass stanchion breaks at around 205kg of lateral load. A click or ping can be heard as the epoxy and fibres first crack, and a corresponding drop in weight is seen on the load cell as the stanchion 'gives'. It then breaks and completely fails under the load. The broken stanchion did not separate completely in the test, but the stanchion does show signs that if separated there would be rough tearing. It is theorised that the E-glass stanchion has the greatest breaking strength as it has the greatest elasticity. The E-glass stanchion is 2mm (8 wraps) of unidirectional glass wrapped first. Approx. 2mm (8 wraps) of standard GEP 224 glass is added. Then a further 1mm (4 wraps) of GEP 224 is added for about 580mm along the butt. The standard glass is a "satin weave" pattern. The fibres are interwoven in such a way to lock it all together. The fibres run similar to 75% longitudinal and 25% latitudinal.
4. Carbon fibre	The fourth test is the carbon fibre stanchion. At around 178kg of lateral load a click or ping can be heard as the epoxy and fibres first crack, and a corresponding drop in load is seen on the load cell as the stanchion 'gives'. It then breaks off at around 168kg of load. The broken stanchion shows rough tears, but no 'razor sharp' shards or edges. The carbon fibre stanchion was made identically to the E-glass model. It was GEP224 on the inside, with a woven carbon similar to the GEP224 pattern on the outside. The build-up at the base was woven carbon.

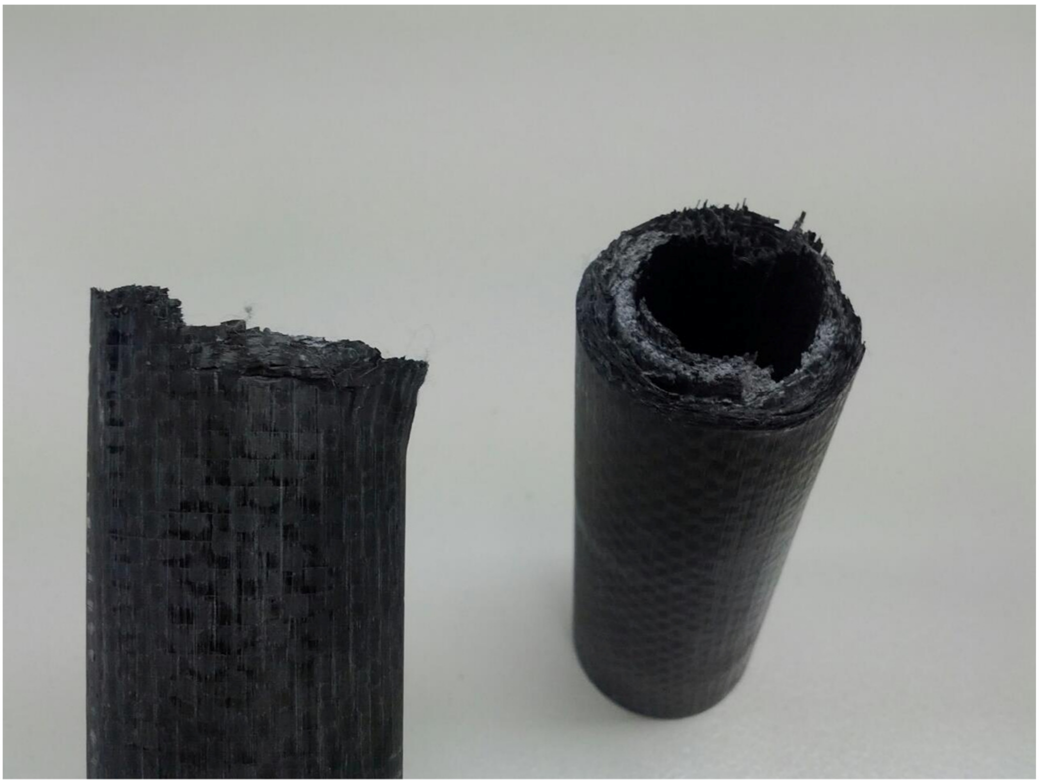
Stainless Steel. The tear can be seen in the middle of the fold. Straightening the stanchion risks breaking the stanchion in half.

Stainless Steel. The stainless steel has deformed significantly.

E-glass. Rough tears can be seen where the break has occurred. This is evident on the full circumference of the stanchion.

E-glass. Closer viewing shows velar vertical splits in the E-glass.

Carbon fibre/E-glass. Rough tears can be seen where the break has occurred. This is evident on the full circumference of the stanchion.



Carbon fibre/E-glass. Closer inspection shows the rough edges.

Appendix B - Photographs

Cycling – Carbon fibre seat post

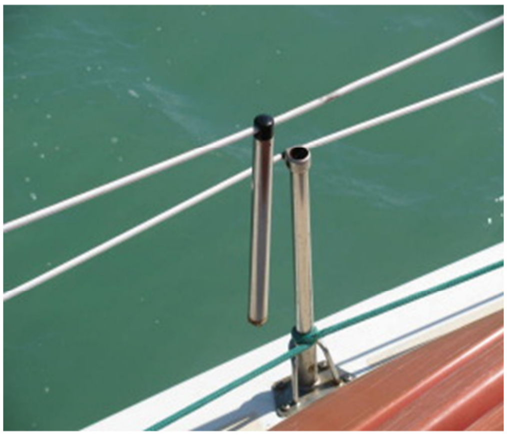
Cycling – Carbon fibre seat post

Cycling – Carbon fibre frame

Cycling – Carbon fibre frame

Yachting – Carbon fibre boom

Yachting – Aluminium Boom



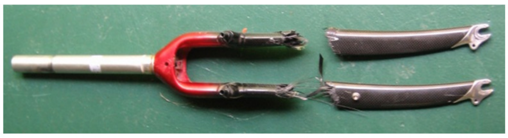
Yachting – Stainless steel stanchion

Cycling – Carbon fibre seat post

Unknown – Carbon fibre post

Motorcycling – Carbon fibre wheel

Unknown – Carbon fibre tube



Cycling – Carbon fibre forks

Appendix C - Public Comment Received

Yachting New South Wales

PROPOSED AMENDMENT 11 to YA SPECIAL REGULATIONS
Comments on CESR No. 2
1. Proposal
That YA SR 3.12.7
—Pulpits, stanchions and lifelines œ limitations on materials Carbon fibre shall not be used"
be replaced with a new 3.12.7
—Pulpits, stanchions and lifelines œ limitations on materials
—Where carbon fibre is used, pulpits stanchions and lifelines shall comply with ISO 15085".

2. Comment
2.1 YNSW submits that the CESR is inappropriate for the following reasons:
A CESR is to be used for the Clarification of an Existing Special Regulation. What has been presented is not a clarification but a substantial change. Rather it should be a Change Management Procedure analysis in accordance with COM(1).11.2010 as this policy states in 2.1 Policy Statement
—material changes or actions that impact safety follow a formal Change Management Procedure process (refer to the CMP procedure)".
In the CESR under the Heading Step 1(a). Establish the Context there is the note
—(What is the existing Special Regulation Wording that is ambiguous or unclear)"
YA SR 3.12.7 was made ambiguous by YA Interpretation No.6 but as that Interpretation has been withdrawn the Regulation is now quite clear and unambiguous, namely, —carbon fibre shall not be used". Furthermore, it is mandatory by virtue of YA SR 1.03.2. Therefore a pulpit and/or stanchion or lifeline that contains, ie uses, carbon fibre does not meet the requirements of YA SR 3.12.7.
2.2 The proposal introduces a standard which is not related to materials per se but instead the mechanical properties that the pulpit/stanchion must meet. The ISO permits any material including carbon fibre which meets the mechanical standards. It is not known but assumed that ISO 15085 defines the strength of pulpits and pushpits. YNSW submits that the introduction of a standard for pulpits and/or stanchions or lifelines only containing carbon fibre is inappropriate. As ISO 15085 provides load and deflection standards for pulpits and/or stanchions, these criteria should be applied to all new pulpits and/or stanchions irrespective of material used. A boat complying with the RCD will have pulpits and/or stanchions complying with this standard.
2.3 S/S wire lifelines and carbon fibre stanchions are incompatible materials. The mechanical abrasion of wire through the carbon fibre stanchion may not be addressed in the Standard. There is no proposal to replace S/S wire for lifelines. If carbon fibre is permitted in stanchions, modifications to include metal ferrules must be addressed to prevent damage to the stanchion and production of carbon fibre dust particles in close proximity of crew.

2.4 It is not known whether that ISO standard also refers to lifelines.
YNSW submits the proposal must not include lifelines as proposed.
For lifelines, the standard and deflection tests are already stated in regulation 3.12.6 and to introduce a second standard for lifelines ie, ISO 15085 is to produce ambiguity and uncertainty eg, 3.12.6(a) which requires lifelines to be of stainless steel wire. Therefore, the heading of regulation 3.12.7 must be changed by deleting the reference to "Lifelines', if the

use of carbon fibre is introduced.

2.5 YNSW supports the introduction of a standard for pulpits and/or stanchions with proviso, but not for lifelines as the requirements for lifelines are defined in existing YA SR 3.12.6.

2.6 YNSW submits that the introduction of a standard without clear and widespread knowledge of what the standard is to govern is meaningless. The proposal is devoid as to what is required of pulpits and/or stanchions to meet ISO 15085. None of owners, auditors or organising authorities have access to ISO 15085. The proposal should incorporate the basic desired elements of ISO 15085 relating to pulpits and/or stanchions such as load & deflection characteristics as the regulations currently include for lifelines.

2.7 YNSW submits that if carbon fibre is to be permitted then specifications must incorporate a maximum limit of how much carbon fibre is to be used, and prescribe the type of fibre eg woven fabric, double bias or unidirectional fibres that are permitted as well as the maximum number of plies in the laminate and the maximum thickness of the laminate, so as to reduce the likelihood of damage to crew by splinters. Further the specification should require carbon fibre as an outer layer only. It is further noted that ISO 15085 permits any material which meets the mechanical tests set out in the Standard. Any YA regulation must be clear as to whether the standard applies to all materials for stanchions/pulpits or only carbon fibre.

2.8 YNSW submits that if a standard is introduced then there must be some form of manufacturer‘s/builder‘s certification that the pulpits and/or stanchions comply with the standard. Merely looking at the stanchion will not reveal the extent to which carbon fibre has been used in the stanchion. Thickness of laminates can vary significantly depending on the method of construction ie use of autoclave or vacuum pressure will be significantly thinner than a standard wet layup laminate. Consequently auditors will sign off audits in ignorance of whether or not the stanchion complies with the standard.

2.9 YNSW submits that the issue of serious impaling/puncturing injury has not been adequately addressed.

Other parts of boats may use carbon fibre, such as grinding pedestals, pipe cots or engine housings. However, these are for defined mechanical or cosmetic uses and are not designed or intended to be used specifically for anything related to safety purposes. Lifelines pulpits and stanchions sole use is for safety and should not be assessed in the same context as other components.

2.10 NSW submits that the FBYD report poses its own slant on the meaning of —Carbon fibre shall not be used“ by posing —The Question“ in assuming that —the YA SR intends to only preclude structural dependency on carbon in stanchions(sic lifelines and pulpits?) and not concern itself with cosmetic features.“YA SR 1.03.2 states '“shall“ and —must“ are mandatory, —should“ and —may“ are permissive.

—Carbon fibre shall not be used“ does not have any connotations about cosmetics or structural dependency on a particular type of material. It quite clearly excludes the use of carbon fibre whether cosmetic or structural in such use.

The English is simple, unequivocal and unambiguous.

In short the report whilst informative and interesting, does little to show that —carbon fibre shall not be used“ permits carbon fibre to be used, whether or not the carbon fibre is used for cosmetic, structural, or both, reasons. It also does nothing in respect of other materials which are permitted under ISO 15085 which meet the Standard‘s tests.

2.11 What the report does do is make a clear case for need of some form of standard to apply to the strength of pulpits and/or stanchions. This is clearly illustrated by photographs which show either permanent deformation but not failure or complete failure of metal stanchions. All this section of the report does is to show that the particular steel stanchions were not a strong as the composite ones, thus reinforcing the need for a strength standard and not the permissive use of carbon fibre or other non metallic materials as a cosmetic - whatever that means œ finishing treatment.

From: Rob Cook [mailto:recook@ozemail.com.au]
Glen,
I note the recent request for comment on use of carbon fibre for stanchions and pulpits. The supporting documents are well researched but miss the important factor that originally caused ISAF and YA to prohibit the usage of this material in these components. It is not the strength that is in question, otherwise e-glass and similar would have been subject to the ban also.

The original concern, and I have not seen any repudiation that would give cause for change, is in the fracture nature of carbon fibre wherein it can result in shards and sharp ends that could easily cause serious injury to a crew member falling on it.

Whilst a simple analysis will show that the ISO standard numbers will be sufficient for normal crew impacts, it appears to ignore the effects of docking impacts and of crew members swinging from a stanchion to access the boat from a marina. Given that we are talking about racing crews of significant size and robustness frequently applying loads to stanchions and pulpits etc. it is quite possible for there to be long-term damage that eventually fails, possibly at sea and leaving a dangerous sharp point just when it is most risky. We have all experienced similar failures of stainless steel stanchion bases but these neither leave the crew unprotected nor at risk of penetration injury.

It would be almost impossible, given the wide range of loading cases, to develop an acceptable test for carbon fibre stanchions and pulpits.

The NSC needs to clearly identify the situation applying to the racing situation and not hide behind the ISO or ISAF in this matter, to adopt a standard intended for cruising boats is not a way out.
Rob Cook

From: Glen Stanaway [mailto:glen.stanaway@yachting.org.au]
Hi Rob,
Your comments below mention the shards and sharp ends, or dangerous sharp points that can result from the failure of carbon fibre. Are you able to provide any references to the source of this, or provide any photographs demonstrating the problem? We're looking into this ourselves, but as you've mentioned it you may already have the information we need.

Kind regards,
Glen Stanaway Sport Services Manager
Yachting Australia
Direct Dial Phone: +61 (0)2 8424 7408 Skype: glenstanaway

From: Rob Cook
Glen,
Regretfully I don't any longer have any of the material on which the original regulation was based.

I doubt that there is a way of overcoming the problems inherent in carbon fibre construction of stanchions and pulpits that could be assessed by the marine industry component makers in an economical way.
Attached is a pic of a failed bicycle head, you can readily see the dangers. The failure mode has been progressive and left the sharp ends after a subsequent impact (analogous to crew regularly swinging, leaning etc on the stanchion and then someone falling against it).
Can we as controllers of the safety of competitors take a chance on such failures on racing yachts?
Various processes/formulations are available to mitigate the failures but the problem for sailing is as how to validate what a part is made from. Also advances in the field are so fast that the regulators would be constantly besieged by vendors of the latest great thing for rule changes.
For interest at how carbon fibre can be modified look at http://www.kraiburg-composites.com/content/index.cfm/fuseaction/37,dsp,0,1,0,0,2,0,-fracture-behaviour.html

this is not directly related to stanchions but does show the range of product modifications that can be made. There is some interesting new work with nanotubes that could produce safer stanchions but again the difficulty is how does the club level inspector assure themselves that what they are looking at is "good" carbon fibre (for that task).

If you watch the Grand Prix telecasts you will see the problems they experience with broken carbon fibre body parts puncturing tyres and that in a sport with tight controls and plenty of money. If anyone could regulate material specification to eliminate sharp edge failure it is F1.
Maybe a further comment on the ISAF "not recommended" versus a prohibition. I would suggest that in the Australian legal liability situation it would be exceedingly difficult to defend a negligence claim if the basis was "he went against our recommendation". If there is evidence to show there may be a danger then it should not be permitted. The Euros have the luxury of a different legal system and, in any case, ISAF can hide behind its words that say that it is the responsibility of any MNA adopting its regulations to modify them to suit "local conditions". Interestingly RORC have applied this and rejected the application of textile lifelines, recently approved by ISAF, and continue to require stainless steel and have evidence to demonstrate the justification. It was not just a luddite act.
Rob Cook

From: jwarnock
Hi Glen,
I am in favour of moving forward to use Carbon fibre in these applications subject to appropriate regulation. These are two applications where the weight saving should improve the performance of all yachts. Will it be sufficiently strong and tough? Suitably specified and manufactured with quality, I think so.
Why? You may have recently seen a clip of that terrifying, high speed crash of an F1 car into the safety barriers at Monaco this year. Once again, after crashing at over 200 kph, the driver walked away. Amazing; the carbon fibre reinforced tub of these cars seems to be sufficient to protect drivers and the same material in appropriate thicknesses and formulations would seem sufficient for the yachting applications envisaged. After all, we already use it for most of the critical applications on a yacht including hulls, foils, spars and standing rigging and now sails.
If it is another case of the Reg's. being updated to conform with technology, we should get on with it, objectively and prudently, but get on with it just the same.

Cheers,
John S Warnock

Yachting Victoria

Dear Glen,

Thank-you for the opportunity of reviewing and commenting on YA's CESR Limitation on Use of Carbon in Stanchions dated 3 May 2012. This document has been placed on the YV website with copies issued to the Ocean Racing Club of Victoria, The YV Keel Boat Committee and the Risk Management and Safety Committee who have each carefully considered the matter and combined to contribute toward this letter.

YV recommends against the approval of this CESR as the use and potential failure of carbon fibre in a yacht's safety feature as stanchion greatly increases the risk of further injury to the crew and rescue personnel if the stanchion fails. This CESR disregards the policy of both the current YA Special Regulations (SRs) and those of the ISAF Offshore Special Regulations of banning the use of carbon fibre for safety reasons.

Our response to the CESR is based on the premise of maintaining the known and internationally accepted measures of safety in the sport of sailing. Safety equipment is a vital part of any yachts basic gear and must be effective when called upon to perform and not present further dangers to the vessel or its crew. Changes in technology are readily acknowledged by YV and are acceptable provided they maintain or enhance safety rather than diminish that of a yacht's crew.

In regards to the CESR itself, I draw your attention to the following –
Step 1(a) – The reference to carbon fibre being used for hulls, spars, rigging, sails, steering wheels and pedestals is irrelevant to the debate as these parts of a yacht do not constitute a measurable form of a yacht's safety equipment per the SRs. Similarly the reference to ISO15085 as this Standard is not concerned with the consequence of failure.

Step 1(b) – The use of carbon fibre in any amount or form in a stanchion may increase its stiffness by increasing the Young's Modulus of the section. The raison d'etre of the SRs is to provide known, measurable levels of performance of a yacht's key safety features and so do not concern themselves with costs, looks, stiffness or strength on such elements as masts, rigging, steering pedestals, bunk frames, etc.

YA claim in the CESR, that "carbon fibre coating improves stanchion strength, estimated as 10-20%, while increasing stiffness". This is not the case as the addition of a carbon fibre layer only increases the initial stiffness up to the point when the carbon fibre skin shatters, but then the e-glass core will take the load, deflect and eventually fail at the same loads as a stanchion without the carbon coating. Thus this statement should read "carbon fibre coating has no effect on the stanchion strength, but improves initial stiffness by an estimated as 10-20%." In any case, our concern and those of the SRs are of safety in the event of failure and not of strength or stiffness.

Reference is made in an attachment to the CESR that after failure of a carbon fibre stanchion and production of these sharp and dangerous shards, they can be "taped up by the crew".

This seems to brush away the safety issue by assuming the crew will swing into action to address the broken stanchion ahead of the issue that caused the stanchion to fail in the first instance. We are also unaware that the SR specifies “tape” as a mandatory item of equipment to be carried and applied if carbon fibre stanchions fail.

Clause 3.14 of the SRs state "Carbon fibre shall not be used". This is a clear statement of intent to prohibit the use of carbon fibre. Although the intent of this clause is not stated in the SR’s, YV agrees with YA’s earlier statement that the prime reason for banning carbon fibre stanchions was one of crew safety. The sharp shards and razor sharp edges produced at the time of failure of carbon fibres increases the danger and risk of further injury to those on board. Adding further risks to the safety of personnel either on-board or others assisting a damaged vessel, should not be introduced at a time when an item of safety equipment has failed. In most instances, the presence of this danger only becomes evident when a further injury occurs to the crew.

It is noted that ISAF SRs state that “after January 1987 stanchions, pulpits and lifelines shall not be made of carbon fibre”, again another clear and unambiguous statement of intent.

In regards to ISO15085, defines only structural requirements of stanchions and is completely silent on the dangers associated with using composite materials such as carbon fibre. The standard defines two structural requirements for stanchions as follows:
1. Shall deflect less than 50mm when a horizontal load of 280N is applied.
2. Shall not break under a load of 580N.

Requirement 1 is a straightforward test, but requirement 2 is less clear as the term “break” is not defined. It is suggested that “break” be replaced with “failure of structural integrity”, as it is very unlikely that a stanchion will “break” into separate pieces.

ISO15085 does not concern itself with the consequences of failure or collateral damage when its’ design criteria has been exceeded. As ISO15085 is silent on construction techniques, under this standard alone, stanchions could be made with 100% longitudinal carbon fibres (such as carbon fibre battens) and thus present a very serious danger to a yacht’s crew.

Stainless steel stanchions will permanently deform (cylinder collapse), whilst composite stanchions may delaminate and create the sharp shards and splinters.

It is of significance to note that part of the design brief current Volvo Round the World yachts, specified that stainless steel must be used for stanchions. This is noteworthy in the light of the extensive use of carbon fibre through-out these yachts for nearly all other items in the boat structure. This requirement was imposed because of safety considerations.

In 2010 Macquarie Innovation broke the World Water Speed Sailing Record, being the first craft to exceed 50 kts. Macquarie Innovation was built of carbon fibre with the exception of the crew pod which was constructed from plywood. The reason being the designer considered the use of carbon fibre too hazardous to the crew in the event of a high speed crash. Thus carbon fibre was again not used for reasons of safety should failure occur.

As an aside to the use of carbon fibre in stanchions, YV does not object in principle to YA introducing stiffness and strength requirements for these items of safety equipment (such as ISO15085), but it must be qualified by the continued banning of carbon fibre. Consideration also needs to be given to compliance with ISO15085 of current on-market cantilevered type stanchions.

Regards
Steve Walker
Chief Executive Officer

Yachting WA

Glen Stanaway
Yachting Australia

Dear Glen,

Re CARBON IB STANCHIONS

I have discussed this matter with all members of the YWA Safety Committee today – some had already read the papers when previously sent. They are all of the following opinion.

1. Yachting Australia should not be the first to allow the use of carbon in stanchions. We should wait until ISAF allows its use. If YA feels strongly then it should lobby ISAF to change but should not lead in this matter.

Further, the following points were made:

2. While stanchions designed and manufactured to ISO 15085 in a controlled factory environment will be sound there is no guarantee they all will be, as anyone can claim to have done so. As we know carbon must be manufactured in controlled conditions if it is to reach its designed strength.

3. The diagram at the top of page 5 of Fred Barrett's well written paper clearly indicates the problem of what can happen if unforeseen holes are drilled in any structure or other actions for which it was not designed are allowed, thus weakening it. Broken carbon is dangerous to crew.

4. There is no quality control of boat parts made in Australia (or ? anywhere else). While some are produced to a very high standard, some shipwrights and DIY "boat builders" make and fit items as they see fit, often based on limited personal experience. Broken carbon is dangerous.

5. The argument that F1 cars are made of carbon is fallacious in our environment where testing is limited by available research funds. Until carbon stanchions are manufactured and tested to a standard and these are the only ones that are acceptable we cannot be sure the product is going to be reliable. As an example PFDs and Safety Harnesses are products that we do not accept unless tested to accepted standards. Carbon stanchions need to be the same. Broken carbon is dangerous.

6. Because some imported or visiting boat(s) has carbon in their stanchions is no reason for Australia to adopt it just to placate some importer / owner. We have seen no evidence on the ISAF website that ISAF has changed the restriction on the use of carbon in stanchions and nor should we until ISAF sees fit to do so.

Apologies for the lateness of this submission, regrettably it had been overlooked amongst our other work.

Best Regards
Bill Burbidge
Chairman, YWA Safety Committee

From: **Shaun Ritson** [mailto:shaun.ritson@nmsolutions.com.au]

Sent: Wednesday, 13 June 2012 3:07 PM
To: Glen Stanaway
Subject: RE: Stainless Steel Stanchions

Glen

It's an interesting question.

There are arguments for and against. Obviously when the subject is something as fundamental as safety then the tendency is to err on the side of caution.

There have been significant advancements made in the area of safety over the years. Inflatable lifejackets immediately come to mind. It could be argued that they are less safe because they may not inflate but that has been addressed with appropriate standards and quality assurance.

Composite handrails are available commercially. If they are acceptable in a work environment (i.e. an oil rig) then why not accept them in a leisure environment also.

AS1657:1992 requires roughly 55kg to be applied horizontally at the top of a stanchion. If we apply this to a say 34mm OD tube with a 2mm wall that is 600mm high then you get a stress of around 220MPa which for stainless is approaching yield. So for a Volvo stanchion AS1657:1992 may not be an unreasonable standard to apply. Interestingly, in the video the steel stanchion yielded at 60kg.

I'm not sure what work has been done as part of the project but perhaps a risk assessment should be carried out on what happens after a stanchion yields. Is a bent steel stanchion safer than a failed composite one? Is there practically any difference between a totally collapsed steel stanchion vs a broken composite one?

My personal opinion is that composite stanchions, be they glass or carbon, can be designed to provide the requisite level of safety. A suitable standard just needs to be identified or developed and applied.

Regards

Shaun Ritson
Naval Architect

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James Dadd

From: Glen Stanaway [mailto:glen.stanaway@yachting.org.au]
To: James Dadd, RORC Rating Office
Cc: shaun.ritson@nmsolutions.com.au
Subject: Stainless Steel Stanchions

James,
All is well I hope. We're looking at stanchions here at the moment, a thrilling topic. In our investigations, I've noted in the Volvo 70 rule http://www.volvooceanrace.com/static/assets/content/media/files/m3082_volvo-open-70-rule-v3-including-amendment-3.pdf, in 4.7.1 a requirement that pulpits and stanchions shall be 31.75mm nominal or larger outside diameter 316 stainless steel round tube with a minimum wall thickness of 2.0 mm. If you are able, would you be able to help with a couple of questions I have? I had phoned Shaun to ask him, but he was going to redirect to you anyway!
1. Can you check your records and see how long the specific requirement for stainless steel stanchions has been in the Volvo 60 or 70 rules?
2. Can you also tell me the engineering rationale behind this current requirement for stainless steel stanchions?

I'd look forward to hearing back from you.
Kind regards,
Glen Stanaway Sport Services Manager

From: James Dadd, RORC Rating Office
To: Glen Stanaway
Cc: shaun.ritson@nmsolutions.com.au
Subject: RE: Stainless Steel Stanchions
Date: Thursday, 7 June 2012 5:33:40 PM

Glen,
Good to hear from you.
1. The stainless steel rule has been there since the 1997-98 race with the Whitbread 60s as an attempt to control costs and prevent using titanium. the diameter was introduced for the 2001-2002 race with the Volvo 60s as teams were starting to play with aerofoil stanchions. A minimum gauge was introduced for the 2005-2006 race with the first version of the Volvo 70 rule, but there was inconsistency around the world as to what wall thickness this produced. Teams were pushing to get weight down so went to the US (I think) for stanchion tubes as the gauge that gave the thinnest wall possible. The current wall thickness was introduced for the 2008-2009 race.
2. The reason for stainless was that we wanted to avoid expensive solutions and all agreed that this was a good material for the job, and as such we should take the simple approach and specify that. The wall thickness has gradually increased to the 2008-09 race as prior to that teams were replacing pulpits and stanchions after virtually every long or hard leg as they bent them, often with the simple water pressure on the code zero foot being pushed against the pulpit. The current rules seem pretty bullet proof, but the structure has to be engineered to make sure they still bend before ripping a hole in the deck. the current rule seems to work pretty well.

I am currently working with Volvo on the future of the race and I am 99% sure we will apply

the same rules to what ever comes next.
Hope that answers it, and the answer 1 is from memory before 2005 race, so I might be a bit out there.
James

From: James Dadd, RORC Rating Office [mailto:james@rorcrating.com]
Sent: Friday, 8 June 2012 7:34 PM
To: Glen Stanaway
Cc: shaun.ritson@nmsolutions.com.au
Subject: RE: Stainless Steel Stanchions

Glen,

Thanks for this. That actually demonstrates why we use stainless steel. We want the stanchion to bend before it breaks, and we don't want it to be possible to load it to the extent that it pulls a hole in the hull at the sheer line. the stanchion should be the weak link, and it should yield long before it breaks. A bent stanchion is still a stanchion. A snapped one is not, and even worse, a super strong stanchion that rips a hole in the sheerline is a very dangerous consideration.

James

Appendix D - Clarification of Existing Special Regulation

Change No. 2 (CESR) register No.	Limitations on the use of carbon in stanchions	Initiator YA	Date 3 May 2012

Step 1(a). Establish the context
(*What is the existing Special Regulation wording that is ambiguous or unclear?)*

SR 3.12.7 places certain limitations on materials used with lifelines, pulpits and stanchions. The SR states that "Carbon fibre shall not be used".

The initial limitation on stanchion material in the YA SR was in the 1997-2000 Blue Book which provided through 33.11.i that pulpits, stanchions, and stanchion bases must be metal.

The 2001-2004 Blue Book's SR 3.11.i removed the requirement that stanchions be metal, and introduced the restriction that carbon fibre shall not be used.

Subsequent SR publications have, other than minor renumbering changes, remained unchanged.

The ISAF OSR has placed a less stringent limitation on carbon fibre. OSR 3.14.7 for Boats with an Earliest of Age or Series Date before January 1987 states "carbon fibre is not recommended in stanchions pulpits and lifelines' and after January 1987 'stanchions, pulpits and lifelines shall not be made of carbon fibre'. OSR 3.14.3 m also adds 'it is strongly recommended that designs also comply with ISO 15085'. The ISO 15085 is titled Small craft – Man-overboard protection and recovery.

There has been significant advancement of composite engineering and carbon fibre applications in the past 10 years. Carbon fibre is now used very extensively on boats as hulls, spars, rigging, sails, steering wheels, pedestals, tiller extensions and galley sinks – without any restrictions.

The ISO 15085 does not restrict materials in the construction of stanchions and in doing so does not preclude the use of carbon fibre. The ISO 15085 does provide load and deflection standards for stanchions.

Step 1(b). Scope
(*What is the context of the existing rule? E.g. Class, Piece of equipment, Geographic location, entire fleet etc.)*

The existing SR applies to stanchions installed on yachts racing in Australia in Category 1, 2, 3 and 4 races.

The issue does have a broader international implication and any change to the SR should also be recommended to ISAF for inclusion in the OSR.

The use of carbon fibre in a stanchion would produce a stronger, stiffer and possibly lighter stanchion that may or may not be an advantage on a boat. A stanchion constructed from a significant amount of carbon fibre yields a very stiff element, with elastic (i.e. non-plastic) behaviour. E-glass also behaves in this respect as it also has the mechanical ability to bend and return up to the point of ultimate failure under load although its lower value of E-modulus compared to carbon means it will deflect further for the same load.

Step 1(c). Explain the need for Clarification
(*Why is the existing Special Regulation wording ambiguous or unclear? Does this introduce an unnecessary safety risk?)*

A boat has been presented to an Organising Authority with a carbon fibre coating on its stanchions and entered a Category 4 event. The boat was unable to gain a Category 4 Certificate because its stanchions were considered not to comply with SR 3.12.7.

The boat claimed that the application of a thin layer of carbon fibre was decorative and only cosmetic. The clear coat outer layer of the stanchion was made out of 200gr/m2 woven carbon fibre – the carbon wafer would be 0.20mm to 0.25mm in thickness (less than the thickness of a business card). The boat applied to YA for an Interpretation of the SR and questioned whether the application of a cosmetic carbon fibre veneer on stanchions was subject to the limitations of SR 3.12.7.

Following as detailed an investigation as was possible in the limited time available; the YA National Safety Committee (NSC) ruled that the limitations of SR 3.12.7 did not apply to the cosmetic application of carbon fibre (Interpretation 6). The NSC also commissioned a more detailed review of the matter and a report from Fred Barrett Yacht Design and Naval Architecture Pty Ltd (FBYD). Comments were also sought from the MYAs.

Inputs were received from Yachting Victoria, Yachting WA and some discussion was held with Yachting NSW. In addition to the FYBD report (http://www.yachting.org.au/site/yachting/ayf/downloads/Technical/RRSandSR/Amendment%2011%20-%20Stanchions%20FBYD%20Report.pdf) inputs were received from two other naval architects; David Lyons a member of the NSC and Don Jones through the Yachting Victoria's submission.

The review reiterated the requirements of YA SR 13.12.7, ISAF OSR 3.14.7 and ISO 15085 and revealed:

- carbon fibre coating improves stanchion strength, estimated as 10-20%, while increasing stiffness
- carbon layers (with higher Young's Modulus – E Factor) will shatter before glass fibre point of failure and leave the surface coated with carbon splinters
- the danger presented by these splinters will depend upon the type of carbon fibre construction with a woven carbon fibre overlay presenting less of a risk than a uni-directional carbon fibre construction
- a failure of a thin woven carbon fibre overlay could be easily rendered safe through the simple application of a wrapping tape
- the risk presented by carbon fibre in stanchions is no greater than the permissible use of the same material in other parts of a boat and its equipment

The NSC met on 3 May 2012 and further considered the matter and the findings of its more detailed review. The committee decided the initial interpretation (Interpretation 6) was unsound in that cosmetic is not defined and the application of a carbon fibre overlay does have a material effect on the properties of the stanchion. Interpretation 6 is to be withdrawn.

Notwithstanding, the NSC considered the absolute ban of carbon fibre in the construction of stanchions was outdated by the developments in its application and general use in boat design and construction. The committee considered there is a clear need to amend the SR and rely upon the outcomes based prescription contained within ISO 15085.

The NSC further resolved to make a recommendation to ISAF for a similar amendment to the OSR.

Step 1 (d). Insert Recommended Wording

SR 3.12.7 Pulpits, stanchions, lifelines – limitations on materials.

Where carbon fibre is used, pulpits, stanchions and lifelines shall comply with ISO 15085.

Step 2. MYA or Class Association Review and Approval Not necessary as initiated by YA. All MYAs were consulted and provided an opportunity to comment. These comments have been considere		
Reviewed by (MYA Safety Officer)	*Name: N/A*	*Date: N/A*
Approved by (MYA Safety Chair)	*Name; N/A*	*Date: N/A*

Steps 3 and 4. YA Review and Approval		
Reviewed by (YA Safety Officer)	*Name: Glen Stanaway*	*Date: 3 May 2012*
Approved by (YA Safety Chair)	*Name; National Safety Committee*	*Date:3 May 2012*

Appendix E - Interpretation 6

Special Regulations Interpretation 6

Limitations on Stanchion Materials

7 May 2012

Interpretation 6 issued on 9 March 2012 is withdrawn.

For Category 1, 2, 3 and 4 races, carbon fibre shall not be used in pulpits, stanchions and lifelines as stipulated in SR 3.12.7.

Special Regulations Interpretation 6

Limitations on Stanchion Materials

Issued 9 March 2012

Question:
Is the application of a cosmetic carbon veneer on stanchions subject to the limitations of SR 3.12.7?

Answer:
No.

Issue:
YA SR 3.12.7 places limitations on pulpits, stanchions and lifelines. It states that carbon fibre shall not be used.

Background:

It is important that stanchions are built out of materials that provide strength for the performance of their intended job, and do not unnecessarily increase risks in case of damage to the stanchion.

The intention of SR 3.12.7 is that stanchions should not be made out of carbon fibre as this material can shatter and splinter when damaged.

A yacht has presented stanchions that are built out of e-glass and epoxy resin, with clear coat outer layer made out of 200gr/m2 woven carbon fibre. The outer layer is for cosmetic purposes only.

The cosmetic veneer does not constitute construction of carbon fibre. Stanchions entirely or substantially made of carbon fibre remain noncompliant with the Special Regulations.

Therefore, the limitations of SR 3.12.7 do not apply to the cosmetic application of carbon fibre.