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VOLUME 3

COMMITTEE V.8

YACHT DESIGN

COMMITTEE MANDATE

Concern for the structural design of sailing and motor yachts and similar craft. Consideration shall be given to the material selection, fabrication techniques and design procedures for yacht hull, rig and appendages. Attention should be given to structural issues associated with special fittings as large openings, inner harbours, pools etc and with security requirements. The role of standards, safety and reliability in the design and production processes should be addressed.

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1 DISCUSSION

1.1 Official Discussion by Paolo Moretti

1.1.1 Introduction

I would like to thank the Standing Committee for inviting me to this congress and to review the report of the yacht design committee V.8 as the Official Discusser (OD).

Even if I am not a yacht designer, I feel confident that my contribution from a different point of view – in this case as a Classification Society representative and former yacht surveyor – could be appreciated.

1.1.2 Historical Background

Despite the fact that the yacht industry can take advantage of modern technologies (CAD, CAM, CFD), most probably old yacht designers and builders were able to have a better understanding of their professional tasks. Rules were simpler, level of craftsmanship was higher and the yachting standards were based on a professional top level of quality. Yachting was at that time defined as "the king of sports and the sport of kings". Royal yachts were built using the best materials, rigorous procedures and up to date know-how. In many cases these luxury vessels were designed, built and crewed in accordance with contemporary naval standards. Being also a naval architect by training, a yacht designer was involved in the design and building of warships, cargo sailing ships or steamers, and high speed craft such as steam destroyers or fast motor torpedo boats.

In the first half of the nineteenth century the last objection to steam yachts was removed by the Royal Yacht Squadron rescinding all of the rules which had prohibited these craft being owned by members of the club. It had been decreed in 1827 that any man who owned a steam yacht should automatically disqualify himself from the membership. In 1844 the following minute was approved: "*No steamer of less than 100 horse/power shall be qualified for admission into, or entitled to the privilege of the Squadron*". Although a condition had been imposed, the steam yacht was now acknowledged. In 1873 George Lennox Watson founded the world's first yacht design office. Watson's most famous design, "HMY Britannia", was commissioned by Edward Prince of Wales, subsequently King Edward VII. Among his work in yacht designs Watson designed extensively for the Royal National Lifeboat Institution (RNLI) with his boats becoming renowned for their seaworthiness and durable qualities. High speed steam boats were designed and built by legendary names, such as Herreshoff's yard, working at the same time on luxury yachts and early naval torpedo boats.

By 1900 the gasoline engine was taking place of the steam engine in the smaller launches and the so called "automobile boat" was coming into use. A few years later (starting form WWI) fast motor torpedo boats have been built by the following yacht builders too:

- Elco and Higgings in the United States;
- Thornycroft and Vosper in Great Britain;
- Lürssen and Abeking & Rasmussen in Germany;
- Baglietto and Picchiotti in Italy.

Recently new boat-builders have been created from nothing and, in many cases, this lack of tradition and skill has been marketed as "new concept" proposals in order to attract new potential customers. Lack of professional skills may lead, sometimes, to projects that are either unfeasible or very far from real seaworthiness.

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1.1.3 Motor Yacht Basic Design and Typologies

The term "yacht" has been used in a very broad sense, ranging from a rowing kayak to a three masts sailing ship. In order to have a better understanding of the subject, a more detailed classification (depending on yacht size) could be useful and the authors have managed to provide a comprehensive view of the terminology currently in force to categorise pleasure vessels.

Even if there is no firm lower-end cut-off for the size of a yacht, it can generally be said that a vessel or conveyance used on the water for pleasure, under approximately 30-34 feet (9–10 meters) in overall length is not a yacht but a "pleasure boat" or "recreational boat". Insurance companies define "yachts" as vessels of 27' or more in length, while "boats" are 26' or less (yacht and boat insurance policies are quite different).

According to a common perception a yacht is technically any recreational vessel greater than 20' with an enclosed cabin. The European Directive text considers:

- boats shorter than 24 m as "recreational craft";
- Yachts exceeding 24 m are classified (according to many Flag Administrations) as "large yachts";
- Yachts exceeding 30 m are usually defined as "super-yachts"
- Yachts exceeding 45 – 50 m are usually categorized as "mega-yachts"
- Yachts exceeding 100 m are commonly referred to as "giga-yachts".

1.1.4 Rules and Regulations

The authors made a very accurate analysis of the standards currently applicable to pleasure vessels. Class rules are not harmonized through common IACS (International Association of the Classification Societies) requirements. Statutory regulations may vary depending on which flag the yacht is flying, the intended service (private or commercial) and the dimensions (length and gross tonnage), as per the following examples.

Private Yachts

The mandatory requirements are very light; for the vast majority of Flags a registration survey and a tonnage measurement, carried out by an authorised surveyor, are the applicable standards. The only mandatory international conventions are those relevant to the marine environment (such as the MARPOL Annexes).

Commercial Yachts

Nearly all major Flag Administrations require commercial yachts to be certified in accordance with a specific large yacht safety code. The most popular of these safety codes and the first to be developed is, without any doubts, the MCA Large Commercial Yacht Code (LY2) that has replaced the former Code of Practice for the Safety of Large Commercial Sailing and Motor Vessels (LY1) published in 1997. This Code is applied by the Red Ensign Group Flags (UK, Cayman Islands, Isle of Man, Bermuda, Gibraltar, BVI, etc.) and it is recognised as a reference standard for all the yachting industry. Other Flags have developed similar codes: Luxembourg, Italy, Marshall Islands, Malta, Belize and Holland are some examples. While introducing a stricter set of rules and regulations, if compared to private yachts, the commercial registration is offering to yacht owners the possibility of making profits from the chartering activity of their boats and to take advantage of all the other benefits coming from a commercial operation (in particular VAT exemption on the purchase, sale, bunkering, provisions,

Table 1: Gross Tonnage and mandatory certification

CERTIFICATE	Over 24 m any GT	300 ≤ GT< 400	400 ≤ GT < 500	≥ 500GT
LARGE YACHT SAFETY CODE	X	X	X	X
SAFETY CONSTRUCTION				X
SAFETY EQUIPMENT				X
SAFETY RADIO		X	X	X
LOADLINE	X	X	X	X
TONNAGE	X	X	X	X
MARPOL 73/78			X	X
CLASS CERTIFICATE	X	X	X	X
ISM (Safety Management)				X
ISPS (Security)				X

dry-docking and others). The number and type of the mandatory certificates depends on the size of the vessel; those reported in Table 1 is an indicative list.

Main technical features of the commercial yacht codes:

- new ships are usually obliged to strictly adhere to the provisions of the Code;
- existing boats can be granted with dispensations or equivalencies;
- the severity of the safety requirements decreases in case of reduced navigation and imposed operational limitations;
- the safety requirements increase when the yacht has a gross tonnage equal or exceeding 500 GT (corresponding to a full displacement motor yacht of $45-50\,m$ in length);
- the safety codes apply to vessel who are 24 meters or over in load line length;
- yachts are certified to carry on board a maximum number of 12 passengers.

Passenger Yachts

Since the average size of the yachts has dramatically increased over the last five years, it appears evident how limiting the "12 passenger"' upper threshold is. For this reason the MCA and all the Red Ensign Group has recently adopted a new code, the so called "Passenger Yacht Code", which allows yachts to transport up to 36 passengers. In accordance with the provision of this Code, the yacht shall have a class certificate as passenger ship (hull, machinery and electrical parts) and a statutory document in line with the requirements of the SOLAS passenger ship with less than 36 passengers, which implies stricter requirements on fire load, means of escape, lifesaving and damage stability.

Recreational Crafts

This category includes all boats having a length below 24 m. The main reference standards are:

- European Directive 94/25/EC as amended by the 2003/44/EC: mandatory regulations, applicable to recreational crafts and components that are intended to be commercialized within the EU, based on ISO standards relevant to hull construction, fire protection, electrical, bilge, stability, etc.

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- American Boat and Yacht Council (ABYC), voluntary standards for boats intended to be used within the USA national waters.

The above mentioned standards have similarities and in this respect it is to be highlighted the commitment of ICOMIA (International Council of the Marine Industry Associations) in establishing an international working group with the mandate of publishing "Global Conformity Guidelines" with the aim of assisting the boat-builders to comply with either ISO or ABYC.

1.1.5 Vibration and Noise

Vibration and noise are crucial topics in the motor-yacht design and the authors have carried out a very accurate comparative study of the comfort class rules published by the major classification societies. Comfort on board of motor yachts is usually associated only with noise and vibration levels. Both these parameters can be predicted, measured and – if needed – reduced taking advantage of several engineering methods. Last but not least, it is possible to assess and certify a "comfort merit factor" based on purpose made class society surveys. Comfort class notation, if not mandatory, can even add resale value to luxury yachts, or it can be used as a reference standard in the contractual specification.

Sea-keeping, intended as the capability to operate in severe weather conditions seems to be an almost forgotten factor within a yacht's basic design. Due to the fact that on fast motor yachts, maximum speed is still considered as a key selling point, many yacht designers adopt very small deadrise angles to gain a few knots, keeping the same power/weight ratios.

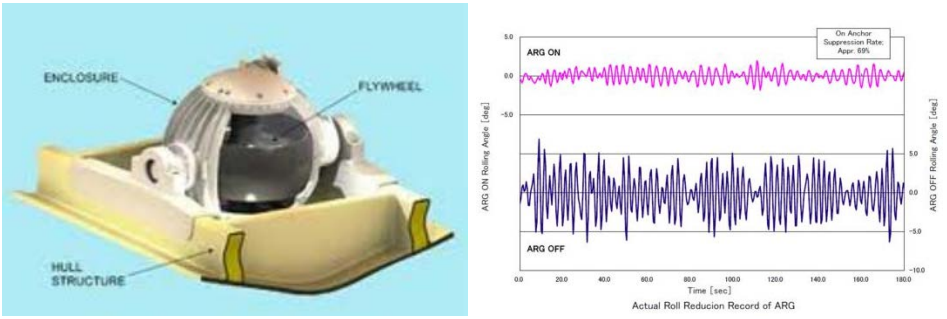

Figure 1: Anti rolling gyro (ARG) stabilizer; Roll reduction records with and without ARG system.

Unfortunately small deadrise angles, even if very efficient from a propulsion point of view, lead to unbearable vertical accelerations and slamming pressures when weather conditions are not perfect. Taking into account the fact that sea-keeping is usually higher on the priority list of professional small craft, these kinds of boats use deep-V hulls, shifting the focus from speed to seaworthiness. Roll stabilization seems to be the only sea-keeping parameter that is currently being considered on board luxury yachts. Uncomfortable roll angles can be effectively reduced using anti rolling gyro (ARG) stabilizers (Figure 1) or through active stabilising fins.

1.1.6 Structural Arrangements and Production Methods

The authors have correctly identified the main technical aspects related to the different type of construction:

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- wood;
- steel;
- aluminium;
- composite material.

Wood

This type of construction is mainly limited to Italy (North Tirrenic and Northern Adriatic areas) and Turkey (in particular in Bodrum and Marmaris). While in Italy there are at least five builders of top class wooden motor yachts, the Turkish tradition is more focused on the traditional schooners built with lamellar wood hulls. Class rules usually have specific structural requirements for wooden vessels up to $40\,m$; over this size a direct calculation approach is to be adopted.

Steel

This material of construction is commonly used for yachts over $50\,m$, always in conjunction with aluminium built superstructures. Limited niches of smaller size steel built full displacement motor yachts are still "en vogue" in Holland. The structural criteria set by the class rules are almost the same of the merchant ships of similar size. FEM calculations are often required for the large side openings enclosing garages and other recesses and global strength verification mandatory for all yachts having a length over $50\,m$. It is to be highlighted how small is the influence of the hull construction on the build of very large yachts, due to the fact that:

- the construction process lasts at least 36 months for a $60 - 65\,m$ yacht, the large majority being spent in the outfitting and finishing activities;
- the direct cost of the steel hull production is very low compared to the overall cost of the yacht;
- a "sub standard" welding and assembling process is, at a later stage, covered by filler and paint.

Aluminium

Aluminium construction is still considered as a valid option for fast planing hulls in the range between 35 and $50\,m$. Also for this kind of material it is imperative to remain within the $500\,GT$, otherwise the entire hull and superstructure should be insulated to a "steel equivalent" fire rating, compromising the weight reduction effect and the efficiency and speed of the hull construction process. Aluminium boats represents a very good compromise between high performance and production costs (the mould construction investment being avoided).

Fibre Reinforced Plastic (FRP)

FRP construction is by far the most used in the yachting market, in particular for serial production. Due to the fact that moulds are quite expensive, boat-builders are oriented to spread this fixed cost on as large number of hulls as possible in order to improve the process cost effectiveness. Modern use of large moulds leads to the following effects:

- yacht models lives can be "extended" taking advantage of re-styled superstructures using old hull moulds;
- hull lines, and – in turn – mould shapes, are engineered in a modular way to enable building of longer, wider or deeper hulls inserting only small additional mould removable parts;

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- if needed, yacht moulds can be used to laminate workboats, small passenger ships, or patrol boats;
- owner's freedom to choose a customized project is reduced, and yacht builders are now offering "semi custom" yachts where buyers can request specific interiors based on a basic standard hull layout;
- some boat-builders are now starting to produce yachts of around $50\,m$, made with FRP hulls and aluminium superstructures, in order to combine the serial production advantage of a standard hull mould construction with the greater flexibility and cost savings induced by a customisable superstructure built in aluminium alloy.

Composite materials on large yachts are now used for hulls up to a maximum of 165-170' ($48-50\,m$), the upper threshold being determined not only by the market request but also by the statutory regulations which prescribe that a pleasure vessel engaged in charter activities and over $500\,GT$ should comply with the SOLAS requirements and therefore being built with a "steel equivalent" hull.

The use of new lamination techniques under vacuum, the so called infusion, is granting a significant reduction of the weight and a more controlled and environmental friendly production process.

Yacht Structural Failures

As already mentioned, pleasure vessels are not covered by IACS requirements and furthermore class is not always maintained through the operational life of the yacht, not being a mandatory safety standard: this issue, associated with an almost total absence of Port State Control inspections on yachts, implies a certain lack of databases containing casualties and accidents reports related to the boating industry. Anyway class reports, insurance statistics, legal claims and other institutional sources such as the U.S. Department of Transportation's statistical database on marine accidents, indicates that swamping, fire and explosion, collision, and drowning are the principal causes of casualties within the yachting community.

In the entire history of the Office of Boating Safety, the USCG has imposed a recall for reasons of structural inadequacy on only two boat companies. It seems that there is no significant pattern of hull failures or hazard to human life deriving from an inadequate construction process of recreational crafts or large yachts. Most structural problems seem to be limited to gel-coat cracking and de-lamination of frames in GRP boats. Total structural failure in pleasure craft is rare, because fibreglass hulls give plenty of warning before failing catastrophically. . . ..or may be because boats are almost never used under severe weather conditions.

1.1.7 Outfitting

As clearly identified by the authors, this is the most crucial topic for a large yacht construction, also due to the fact that very important and basic areas of the outfitting are built and surveyed without having in place well defined international standards. Apart from the structural challenges, the two areas of major concern, from the class perspective, are the fire integrity and the stability requirements.

For commercial yachts having a gross tonnage of less than $500\,GT$:

- structural fire protection: machinery spaces, decks and boundaries are to be properly insulated in order to reach A-30 standard in unrestricted service and B-15 standard in short range navigation.

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- fixed fire detection systems should be fitted in machinery spaces, control stations, service and accommodation spaces (smoke detectors and manual call points);
- upholstery composites and suspended textile materials used through the vessel shall be certified non combustible in accordance with IMO FTP Code. As an alternative a sprinkler system or equivalent should be installed on board;
- two separate means of escape for each machinery space or accommodation spaces are mandatory.

For commercial yachts with a gross tonnage equal or over $500\,GT$:

- structural fire protection: the requirements are derived from the SOLAS passenger ship rules applicable to ships carrying less than 36 passengers; this apply to the subdivision in main fire vertical and horizontal zones, fire integrity of bulkheads and decks;
- fixed fire detection systems should be fitted in machinery spaces, control stations, service and accommodation spaces (smoke detectors and manual call points);
- automatic sprinkler system is always fitted;
- two separate means of escape for each machinery space or accommodation spaces;
- restricted use of combustible materials for the interiors.

All yachts shall comply with intact stability requirements and, if commercial yachts in unrestricted navigation, shall meet the damaged stability criteria and being subdivided in watertight compartments bounded by watertight divisions without any openings except for type-approved watertight doors.

In addition to those areas covered by class rules and statutory regulations (hull, machinery, electrical, automation, lifesaving, etc.), even if not harmonized, there is a huge gap of standards related to very important aspects in the contractual specification of a pleasure vessel such as:

- coatings;
- interior quality and finishing;
- large windows;
- innovative composite materials and production technologies;
- gangways, ladders, balconies , cranes and other deck equipment;
- security equipment.

Boat-builders and refit shipyards have recently developed international associations, like the SyBass (Superyachts Builder Association), with the mandate of cooperating in identifying and developing new standards applicable to the yachting industry, in particular in those areas not covered or vaguely addressed by the international and national regulations currently in force. One of the most important project, in this respect, is being done through the ISO/TC8/SC 12 – Large Yachts, that has the mandate to develop international standards on:

- hull coatings – measurement and analysis of the visual appearance (already published);
- strength, security and water-tightness requirements of windows and port-lights in large yachts (currently under review);
- structural standards for deck cranes and gangways (currently under review);
- other work projects such as noise & vibration, steering and control systems, anchoring equipment and new fire protection standards on large GRP yachts.

Another important trend of the yachting industry is represented by the so called “environmental challenge”. Whilst the mandatory international and local environmental

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regulations apply to yachts in the same way as they do to cargo ships, some owners are prepared to invest in the most innovative green technologies to ensure their yachts achieve the highest levels of efficiency and the lowest possible environmental impact, going beyond the compulsory requirements and introducing innovative technologies.

This is where the voluntary based certification comes in. Some Classification Societies have recently developed internal standards to certify the environmental sustainability of ships and yachts, some of these being prescriptive rules while other goal-based standards. The key criteria of the "goal-based" standards, are that a yacht should reflect a significant investment in design solutions, on-board equipment and operational procedures aimed at contributing to an environmental performance above the minimum levels required by the regulations, covering, as far as possible, all the different ship pollution sources concerning emissions into the sea and into the air: oil from machinery spaces, sewage, grey water, ballast water, garbage, ozone-depleting substances, greenhouse gases, NOx, SOx, CO2, particulates, building materials and recyclability.

1.1.8 Sailing Yachts

The authors' contribution on this topic is an interesting upgrading of the V.8 ISSC Committee on Sailing Yacht Design (2009). It is to be once more highlighted how Classification Societies have always excluded mast and rigging from the scope of class, Germanischer Lloyd being the only institution involved in this plan approval activity. In parallel, the new edition of the MCA-LY2 code (the so called MCA-LY3), coming into force in 2013 is expressly requiring the classification society in charge of the approval of the hull structures to take also the responsibility of reviewing the mast and rigging calculation in accordance with an international recognised standard.

1.1.9 Conclusions

The authors have evidenced the singularity of super-yachts: a very special and unique marine product falling outside the common criteria of conventional ships, due to their high intrinsic value. The main areas of interest and research trends of the yachting industry have been correctly identified and addressed:

- ship weight reduction through lighter structures;
- on board comfort (noise and vibration);
- performance;
- innovative construction materials and production techniques;
- outfitting design and production methods.

1.1.10 Final Remarks by the Official Discusser

This report gives a very complete description of the yacht design and the authors are to be congratulated. Through this reports some criticalities have emerged such as:

- errors in the basic design project due to a relatively poor knowledge of rules and regulations, which are often very complex and not harmonized;
- aesthetical aspects often in contrast with technical and functional requirements: designers versus naval architects.

These issues should be addressed and dealt with by the yachting community through:

- harmonization of class rules and statutory regulations. In particular it should be adopted a common approach to the structural scantling, based on the material of the hull, the speed and the operational profile;
- involvement of notified bodies and Class Societies at the very early stage of basic design;

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- minimum mandatory qualification skills for builders and designers;
- dissemination of guidelines for the correct interpretation of the mandatory regulations, such as the ISO rules for the compliance to the European Directive.

There are a growing number of professionals coming from other industry sectors (such as automotive, fashion, civil architecture) into the yachting industry, bringing with them new concepts and ideas that in some cases do not match the complexity of a marine product, thus causing delays and additional costs for the boat-builders.

1.1.11 References

Despite the lack of availability of specific papers about yacht structures, the authors succeeded in collecting a wide number of related articles very useful for designers and researchers.

1.2 Floor and written discussion

1.2.1 Simon Benson

My comment relates to the continued growth in the size of the new generation of mega-yachts. At various points in the report and presentation, reference was made to the similarities to commercial ship design. Although it is stated that a mega-yacht is a very special structure which falls outside conventional design, it is also emphasised that design principles are not so different to commercial vessels such as passenger ships. In certain respects I disagree with this statement.

Mega-yachts are highly specialist ships from a structural design point of view and in many aspects are closer to naval vessel design than a commercial ship. There is a huge quantity of research, experience and history in naval ship design. Could the Committee comment on how this experience may be important for the mega-yacht industry and how this may influence and improve motor yacht design?

1.2.2 Andrea Ivaldi

How is the trend in the Classification Societies in order to tune the requirements of the market in the mega-yachts world (to have yachts classified as passenger vessels) with the actual status of the rules that are suited to commercial vessels like passengers and cargo ships?

Moreover, I suggest to keep the committee alive also for next editions of ISSC.

1.2.3 Jerolim Andrić

1. At page 362 of the report you referenced using an expansion joint to control level of hull girder stresses at decks of naval vessel. From my knowledge it is not design practice to use expansion joints in very large yachts ($> 80\,m$) design. Can you comment this issue?

2. What are methods (besides the FEM) to calculate natural frequency of decks (grillage) and superstructure in the early design stage, especially if structural optimisation is performed?

2 REPLY BY THE COMMITTEE

2.1 Reply to the Official Discussion

2.1.1 Introduction

On behalf of all Committee Members, first I wish to thank Mr. Paolo Moretti for his kind availability to be the Official Discusser of the Yacht Design Committee. His

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experience in the field of pleasure boats and super-yachts, gathered in many years of activity as surveyour and manager of the Italian Classification Society, makes the Official Discussion a valid and precious completion of this Report, especially from the Regulations point of view, which is a fundamental hinge of the whole design procedure of super-yachts.

An example of this formulation is the contribution given by Mr. Moretti on the historical background of the motor boat and motor yacht development from the first steam machines in the early 1800, up to the introduction of gasoline engines, at the beginning of 1900.

2.1.2 Motor Yacht Basic Design and Typologies

Even if the interest of the Yacht Design Committee has been mainly devoted to large yachts (length over 24 metres), being this category more subject to structural problems, smaller yachts and pleasure boats have been considered as well for some aspects, given their great diffusion and importance from the commercial point of view. Nevertheless, as stated in the Report, we have not subdivided motor yachts into commercial categories such as "mega-yachts", "giga-yachts" or "dream-yachts" because these terms have not an official acknowledgement by any technical institution. So we classified motor yachts exclusively according to the MCA-LY2 definition: yachts with freeboard length below/over 24 metres.

2.1.3 Rules and Regulations

For what the Rules and Regulations is concerned the Official Discusser added many specific and useful information about classification and certification, gathered from his long experience in this field. Particularly appreciated is the reference to the American Boat and Yacht Council (ABYC) and to the International Council of the Marine Industry Associations work (more well known as ICOMIA) in establishing an international working group with the mandate of harmonizing the present Rules for the design and construction of recreational boats.

2.1.4 Vibration and Noise

About noise and vibration, the "comfort merit factor" quoted by the OD, is released by the Classification Society as a function of the noise and vibration level measured on board and compared with those "suggested" by their rules. In the Report, at page 363, 364 and 365, three synthetic, comparative tables are presented with vibration and noise maximum levels extracted from the Classification Society rules.

A short account in the Report is also provided on seakeeping problem, quoting some important papers on this subject by Dallinga and Van Wieringen (1996), Van Wieringen *et al.* (2000) and Stevens and Parsons (2002).

2.1.5 Structural Arrangements and Production Methods

The OD agrees with the general planning of this section and its content and provides a comprehensive set of information about materials and outfitting from the Classification Society point of view, dividing the yacht fleet into vessels with less than $500\,GT$ and more than $500\,GT$. Some points have been assessed in the Report as well, but just from the structural point of view.

A final remark is devoted to yacht structural failures where he asserts that this is not, fortunately, a recurring concern. Structural failures have not been covered by the authors because of the lack of available data. Classification Societies obviously consider this kind of information very confidential and the shipyards, even more obviously, don't

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like to spread them. As a matter of fact no important examples of structural failures exist in the yacht field other than those due to fires and groundings.

2.1.6 Outfitting

While the analysis made by the Committee of this subject covered mainly all those aspects which have a direct influence on yacht structures, Mr. Moretti focused the attention on fire integrity and stability requirements, giving additional information about the main requirements super-yachts should comply with. The fleet has been divided into two main classes, that is yachts below $500\,GT$ and yachts exceeding $500\,GT$. Other important aspects quoted by the OD in the "Outfitting" chapter are the Superyacht Builder Association (SyBass) and the "environmental challenge", better known as "green technologies", by which the owner and the shipyards aim at ensuring their yachts achieve the highest levels of efficiency and the lowest possible environmental impact.

2.1.7 Sailing Yachts

This chapter, particularly loved by all members of the Committee, doesn't have the space it deserves. Owing to space limitation in the Report, it has been assessed only from the point of view of an updating of the previous V.8 ISSC 2009 edition. Nevertheless the authors have been able to include as much new information as possible, integrated by Mr. Moretti observations.

2.1.8 Conclusions and Final Remarks

The Official Discusser concludes his review with some final considerations, the Committee fully agrees with, especially in the following two cases:

- harmonization of yacht rules and regulations relative to structural scantlings (because a large part of the design is based on them);
- better understanding between designers and naval architects (often in contrast each other).

Moreover the Committee finds very important a larger participation of yacht shipyards and technical offices in research and dissemination programs (including ISSC) not finalised only to commercial purposes.

2.2 Reply to the Floor and Written Discussions

2.2.1 Simon Benson

In some sections of our Report we assimilate super-yachts to "conventional ships", and not to "commercial ships", given that by this term we consider a large category of vessel in which both merchant and military ships are included. This statement finds its main justification if we refer to the previous V.8 ISSC Committee on "Sailing Yacht Design", where the described design and construction procedures are specifically developed for and applied to sailing yachts, however not excluding that, also in this case, many common aspects exist with conventional ships.

The common aspects between super-yachts and ships ranges from their characteristics in terms of dimensions, speed and construction materials, up to the design approach ("first principle" approach and/or Classification Societies Rules approach), loads (both typologies and calculation procedures), and instruments utilised for structural and seakeeping analysis (FEM and CFD). Other super-yacht issues are assessed with the same philosophy of ships, such as fatigue and reliability, even if they have not critical aspects like in case of ships.

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The Committee agrees with Dr. Benson about the importance of the research on naval vessels and its relationship with yacht industry; many characteristics of some yacht typologies derive from military vessels: an example above all is represented by the planing, hard chine hulls, lent by fast patrol vessels to all kinds of fast motor yachts. Many other elements coming from naval vessels have been adopted on motor yachts such as high resistance materials, low noise propellers, silenced electric generators and, as ultimate application, security instruments.

2.2.2 Andrea Vivaldi

First of all we acknowledge Mr. Vivaldi for his comment to maintain this Committee also for the next ISSC edition but, unfortunately, this does not depend on the Committee members. About his question, Classification Societies behave differently about super-yachts; some of them have specific rules, others prefer to apply conventional ship rules. In any case it is to be highlighted the good work done by MCA which adapted the most important International Conventions developed for ships to yachts, allowing the latter to maintain their particular identity.

2.2.3 Jerolim Andrić

The reference quoted in the Report is relative to a naval vessel with higher performances and the capability to face rougher sea conditions with respect a motor yacht of similar dimensions. In addition superstructures on naval vessels are particularly extended in length and width. The insertion of expansion joints is the only solution in this case to avoid critical stresses in the higher superstructure decks. In case of motor yachts superstructures have a reduced length with respect to the hull. In addition the lower speed and wider breadth of the hull makes superstructures from one side less stressed and, from the other one, stronger. This does not exclude the utilisation of expansion joints also on yachts, even though of very large dimensions.

Given the complex hull structure of modern super-yachts, the FEM approach remains the best tool to perform preliminary vibration calculation. Anyway other theoretical or analytical methods can be used in a preliminary assessment of natural frequencies of a deck with a regular geometry. One of these is the Raileigh method, an application of which is reported by A. Laakso *et al.* in a paper presented at MarStruct 2013 Congress in Aalto (Finland), entitled “An Analytical Method for Cabin Deck Fundamental Frequency”.