

Summary of timings and search areas covered by SAR assets during the first search period

Identification	Description	Type	Time Start search track	Time End search track	Percentage of search track complete	Track length searches (nm)	Total Area Searched (nm ²)
CGR2004	Untitled search pattern	VS	16 May 1030	16 May 1049	100	90	314
CGR2004	Untitled search pattern	VS	16 May 1100	16 May 1119	100	45	79
CGR2004	Untitled search pattern	VS	16 May 1130	16 May 1149	100	108	452
<i>Georgia Highway</i>	Untitled Search Pattern	TS	16 May 1400	16 May 1559	100	50	51
<i>Georgia Highway</i>	Untitled Search Pattern	TS	16 May 1700	16 May 1959	100	32	33
Rescue 333	Visual	PS	16 May 1730	16 May 1859	100	190	191
Rescue 333	Visual	PS	16 May 1915	16 May 2034	100	177	178
CGR 2006	Visual	PS	16 May 2115	16 May 2306	100	163	164
CGR 2006	Visual	CS	16 May 2307	17 May 0006	100	142	157
R332	NVG	PS	17 May 0300	17 May 0529	100	381	420
R332	NVG	PS	17 May 0530	17 May 0659	100	382	421
2004	Visual	PS	17 May 1113	17 May 1344	100	306	306
AFR5727	Visual	PS	17 May 1900	17 May 2232	100	611	1319
<i>Teesta Spirit</i>	Untitled Search Pattern	PS	17 May 0700	17 May 1059	100	14	15

<i>Teesta Spirit</i>	Untitled Search Pattern	TS	17 May 0700	17 May 1100	100	7	8
Teesta Spirit	Untitled Search Pattern	TS	17 May 0600	17 May 0659	100	7	8
<i>Maersk Kure</i>	Untitled Search Pattern	VS	17 May 1400	17 May 1559	100	27	28
<i>Maersk Kure</i>	Untitled Search Pattern	VS	18 May 0000	18 May 0259	100	27	28
<i>Maersk Kure</i>	Untitled Search Pattern	TS	17 May 2200	18 May 0359	100	21	22
<i>Maersk Kure</i>	Untitled Search Pattern	TS	18 May 0400	18 May 0759	100	35	36
<i>Maersk Kure</i>	Untitled Search Pattern	TS	18 May 0800	18 May 0959	100	12	13
Total						2 826	4 243

Glossary of abbreviations

CS - Creeping line search
 NVG - Night vision goggles
 PS - Parallel track search
 TS - Track line search
 VS - Sector search

Summary of timings and search areas covered by SAR assets during the second search period

Identification	Description	Type	Time Start search track	Time End search track	Percentage of search track complete	Track length searches (nm)	Total Area Searched (nm ²)
ZH 873	Visual	PS	21 May 1130	21 May 1332	100	842	1081
AFR 5727	Visual	PS	21 May 1100	21 May 1959	100	1531	1683
Rescue 333	Visual	PS	21 May 1725	21 May 2129	100	612	918
307	Visual	PS	21 May 2155	22 May 0315	1	4	10
2002	Visual	PS	21 May 1930	21 May 2119	100	457	780
R307	Untitled Search Pattern	VS	22 May 0300	22 May 0308	100	54	113
R336	Visual	PS	22 May 0941	22 May 1105	50	152	306
AFR 5727	Visual	PS	22 May 1300	22 May 1559	100	304	612
CGR 2002	Visual	PS	22 May 1410	22 May 1648	100	458	918
AFR 5727	Visual	PS	22 May 1855	22 May 2159	70	535	1070
UK ZH873	Visual	PS	22 May 1808	22 May 1944	60	275	552
<i>British Robin</i>	Untitled Search Pattern	TS	22 May 0010	22 May 1009	100	120	624

R307	Untitled Search Pattern	VS	22 May 0309	22 May 0317	100	54	113
<i>HS Bruckner</i>	Untitled Search Pattern	TS	22 May 0838	22 May 1229	100	62	333
<i>Rio Malleco</i>	Untitled Search Pattern	TS	22 May 0011	22 May 1010	100	72	386
5727	Visual	PS	22 May 1855	22 May 2159	100	458	919
710	Visual	PS	22 May 1930	22 May 2229	100	228	460
ZH873	Visual	PS	23 May 0200	23 May 0459	100	458	917
710	NVG	PS	22 May 2330	23 May 0229	100	227	689
<i>DDG79</i>	Visual	PS	23 May 0500	23 May 0759	100	28	78
<i>Laurentia</i>	Untitled Search Pattern	TS	22 May 2000	23 May 0032	100	35	75
R307	Untitled Search Pattern	VS	22 May 0318	22 May 0326	100	54	113
<i>Chem Venus</i>	Untitled Search Pattern	TS	20 May 2300	21 May 0650	100	68	290
<i>Bow Flora</i>	Untitled Search Pattern	TS	20 May 1830	21 May 0059	100	45	94
<i>AM Hamburg</i>	Untitled Search Pattern	TS	21 May 0712	21 May 1330	100	70	377
<i>Amapola</i>	Untitled Search	TS	20 May	20 May	100	45	93

	Pattern		1830	2200			
<i>DO Brasil</i>	Untitled Search Pattern	TS	21 May 0724	21 May 1515	100	90	377
<i>DO Brasil</i>	Untitled Search Pattern	TS	21 May 1730	22 May 0144	100	163	841
<i>Laurentia</i>	Untitled Search Pattern	TS	22 May 2037	22 May 2259	100	19	41
<i>Vigorous</i>	Visual	CS	23 May 1100	23 May 2259	80	102	584
2002	Visual	CS	23 May 1900	23 May 2029	100	318	734
47	Visual	PS	23 May 1430	23 May 1729	100	458	918
710	Visual	PS	23 May 1400	23 May 1659	100	228	275
710	Visual	CS	23 May 1330	23 May 1529	60	137	180
710	Visual	PS	23 May 1500	23 May 1759	100	227	597
79	Visual	PS	23 May 0500	23 May 2259	100	109	348
Total						13 664	25 620

Glossary of abbreviations

- CS - Creeping line search
- PS - Parallel track search
- TS - Track line search
- VS - Sector search

Wolfson Unit report following its assessment of the keel structure of the Beneteau First 40.7 yacht
Cheeki Rafiki

Report No. 2542

October 2014

Marine Accident Investigation Branch (MAIB)

Assessment of the Keel Structure of the Beneteau 40.7 Yacht – Cheeki Rafiki

1 INTRODUCTION

The following report describes an assessment of the keel structure of the sailing yacht “Cheeki Rafiki”, a Beneteau 40.7, which suffered a catastrophic keel failure, resulting in the yacht capsizing and the loss of all crew on board. The work was commissioned by the Marine Accident Investigation Branch (MAIB) and is broadly in accordance with the Wolfson Unit M.T.I.A. proposal 4177_rjp.

2 BACKGROUND AND SCOPE OF THE REVIEW

The Wolfson Unit have reviewed drawings, pictures and the related design data of the Beneteau 40.7 yacht “Cheeki Rafiki” to assess whether the keel structure of the yacht meets the latest structural design standards available.

The Beneteau 40.7 was designed in 1997 by Farr Yacht Design. At the time of design, the most commonly used standard for the structural design of this type of yacht was the American Bureau of Shipping (ABS) Guide for Building and Classing Offshore Racing Yachts¹. Since then, the ISO standard 12215 has been developed, and is now the recognised way for builders and designers to show that they have complied with the EU Recreational Craft Directive. The ISO 12215 standard incorporates many similar aspects to the ABS Guide, but it has also been updated in certain areas to provide more specific guidance than was given in the ABS Guide (e.g. keel bolt washer plates).

It was requested that this keel structure be analysed using the latest relevant standard ISO 12215-9². Photographs provided by the US Coastguard of the capsized yacht suggest potentially significant corrosion to the aft most keel bolt. To assess the potential effect of this keel bolt having failed, the calculations were also run with this bolt missing.

3 YACHT CONSTRUCTION

Figure 1 shows a schematic representation of the internal keel structure of the Beneteau 40.7 Yacht. The hull is constructed of a solid hull laminate, with a separate stiffening structure which is laminated and then bonded to the hull. Figure 1 shows only the structure surrounding the keel.

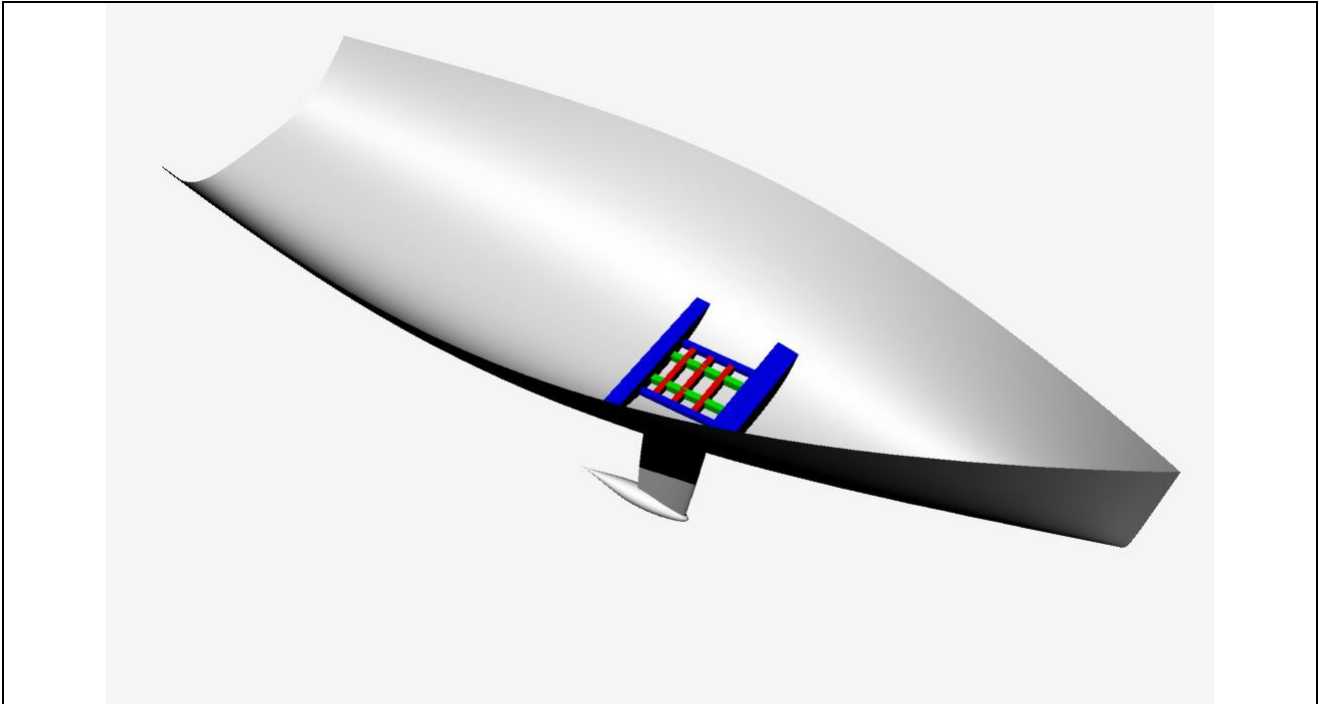


Figure 1: Schematic diagram of yacht internal keel structure.

The elements coloured blue are the significant stiffeners in the hull, and are the parts of the structure at which the boundary conditions of the structural analysis are applied. The keel floors are coloured red and the keel longitudinal girders are coloured green. This form of construction is common within the mass produced yacht sector. The floors and girders provide stiffness to the surrounding area of hull laminate, and the keel is attached to the hull via 9 x 24mm and 1 x 14 mm through bolts.

The hull laminate and stiffening structures are made from glass fibre combinations of uni-directional, woven fibre and chopped strand mat in various amounts and distributions throughout the hull. The drawings supplied are shown in Table 1 below.

Drawing/Document Title	File Number
Keel Construction Details	18390P11 Sections Coque.pdf
Overall Hull and structure documentation	043292 Structure Coque.pdf
Email Description	044294 Quille GTE.pdf

Table 1: Drawing List.

The stainless steel keel bolts are cast into the solid lead keel during the manufacturing process. There is a significant length of bolt within the keel and pairs of bolts are connected together, so as to firmly fix them within the lead. The paragraph below is taken from ISO 12215-9 and the manner in which the bolts are cast into the lead is in keeping with the standard.

Lead or lead alloys have very low mechanical properties. Therefore thin deep fins made from this usually need a steel framing and top flange to allow both sufficient bending strength and connection. If this framing is not fitted, regular tightening of bolts is generally required, due to lead creeping, in which case instructions for keel bolt checking and re-tightening shall be included in the owner's manual.

The keel is specified as being made from a Lead Alloy with 4% Antimony, which when added to the lead has the effect of more than doubling the tensile strength of the lead from 17MPa to 39MPa.

4 ISO 12215-9 LOAD CASES AND STRUCTURAL ELEMENTS CONSIDERED

The ISO standard covers the appendages of many types of sailing craft, and specifies load cases with criteria which the keel structure has to meet. The relevant load cases for the keel structure in this investigation are:

- Load Case 1: Fixed keel with the boat heeled at 90 degrees
- Load Case 3: Keelboat vertical impact
- Load Case 4: Keelboat longitudinal impact

These load cases represent extreme, but not unexpected loadings that a yacht may encounter within its lifetime and are similar to those that were included in the ABS Guide. Load case 1 represents a knockdown whilst sailing, and load cases 3 and 4 represent a likely load due to grounding.

The following elements of the keel structure were analysed in each of the above load cases:

- Floor and Girder properties
- Bolt Strength
- Backing plate sizes
- Laminate in way of keel bolts.
- Keel Section Modulus

The ISO 12215-9 standard has for different elements and materials formulae which allow the calculation of a compliance factor (CF). Except where specifically stated, it is generally considered that a CF of 1.0 meets the standards requirements, and a CF of less than one does not. It is not the intention of the standard that designs be designed down to 1.0, and equally compliance factors greater than 1.0 are no guarantees of the engineering soundness of a design over its lifetime of operation.

A fatigue analysis was not conducted as the ISO 12215-9 standard only requires a fatigue analysis to be conducted if the keel is welded. No other hull structure was analysed in this study.

5 ASSESSMENT OF AS DESIGNED STRUCTURE

The structural drawings for the Beneteau 40.7 were provided by the MAIB, and the information from these was assessed against ISO 12215-9. The program used to check for compliance with the standard was the Keel Checker program, written by Dr. Robin Loscombe, who had a great deal of involvement in developing the standard. The table below summarises the results of assessing the structure.

Structural Item	Load Case 1 CF	Load Case 3 CF	Load Case 4 CF	Summary
Floor 1	4.35	7.96	2.87	Complies
Floor 2	1.06	7.76	25.66	Complies
Floor 3	1.74	7.96	3.24	Complies
Girder	n/a	n/a	2.54	Complies
Keel Bolts	1.05	n/a	1.06	Complies

Table 2: Table of compliance for structural elements.

The minimum thickness requirement for laminate in way of the keel bolts is 9.1mm, the bare hull laminate is 7.7mm thick and the additional stiffening structure laminate is 10.5mm thick, making a total of 18.2mm, therefore the hull laminate complies.

The keel bolt washer plates as designed do not meet the standard, both in terms of area and thickness. An additional 3mm thickness (to be 11mm thick plate) and 3mm to the width of the plates would be a sufficient increase to be compliant.

The keel section modulus has been checked and this has a CF of 2.24.

By removing the aft most bolt from the analysis, in terms of the standard, does not change the loading on the composite structure, but the keel bolts do vary. The compliance factors for the keel bolts in load case 1 come down from 1.05 to be at 0.95, meaning the remaining bolts are no longer compliant. They remain compliant in load case 4.

Within the standard, the loads applied to the composite structure are distributed according to their relative stiffness, the stiffest element being apportioned the most load. It was investigated whether if only certain elements of the keel structure to be repaired and not all, they would attract sufficient load, so as to make them non-compliant to the standard. A variety of repair methods were used, and it was found that if using the same materials as used originally (i.e. glass fibre), the amount of material required to sufficiently change the stiffness of an element, was more than would realistically be used in effecting a repair.

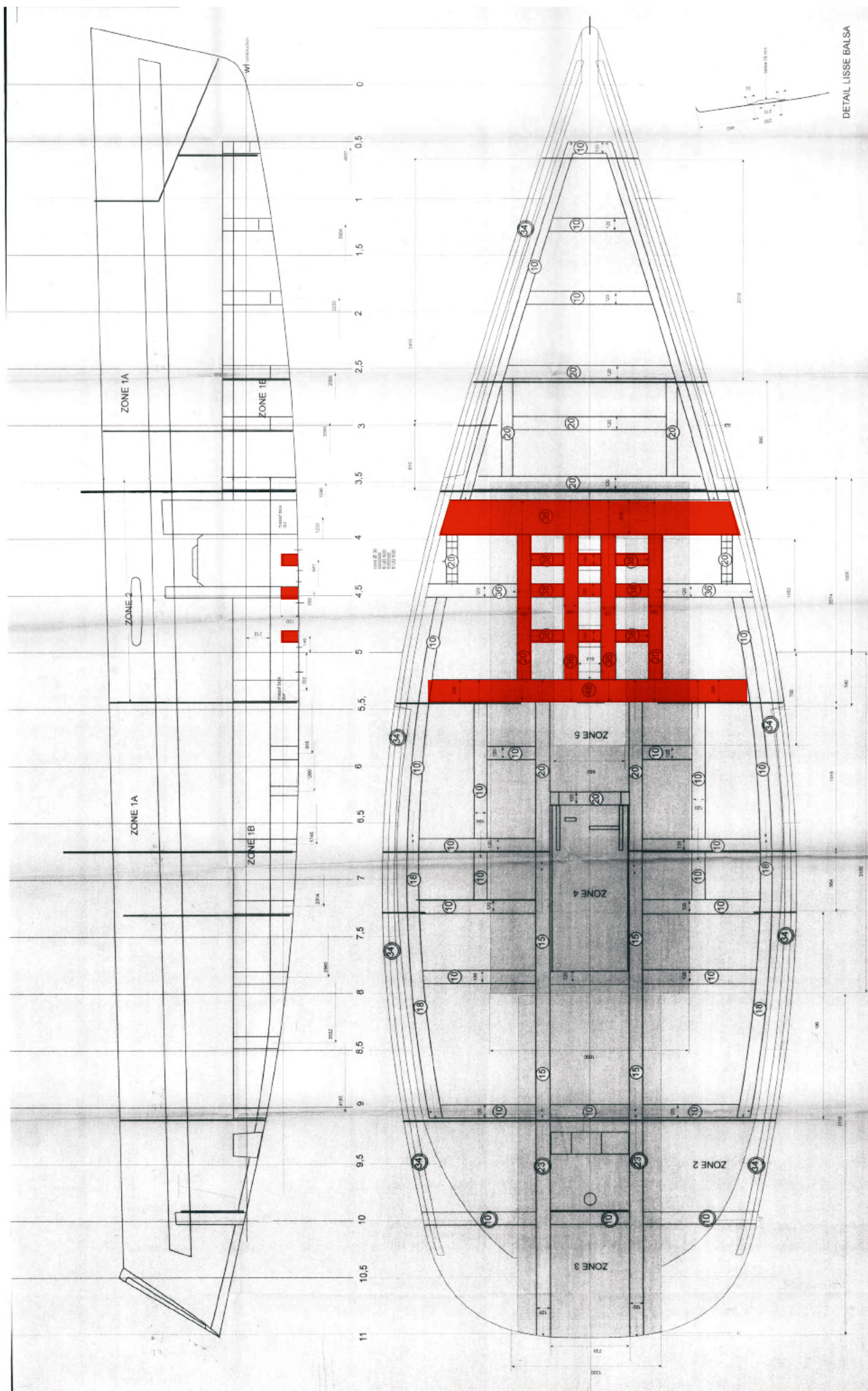
6 CONCLUSIONS

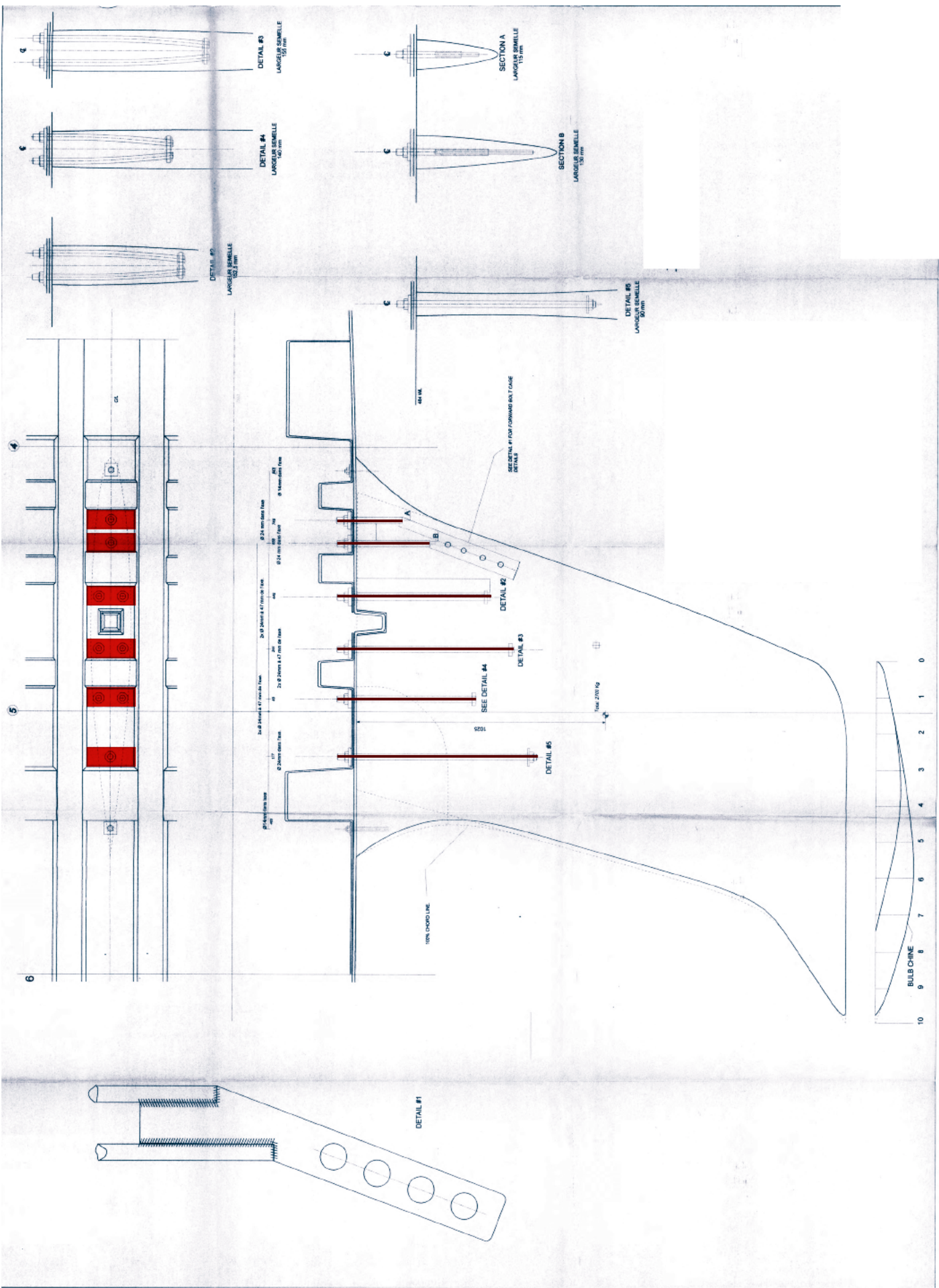
- In the as designed condition, the vast majority of the structure meets the requirements of the ISO 12215-9 Standard.
- The keel bolt washer plates do not meet the requirements of the standard. At the time of design, the ABS Guide required that these be “substantial” but offered no formula for calculation. The increase in size required to comply is not great, and the plates would have been viewed as being sufficient for the ABS standard at the time of design.
- With the aft most 24mm diameter bolt removed, the remaining keel bolts do not meet the ISO Standard in the 90 degree knockdown case.

7 REFERENCES:

1. ABS Guide for Building and Classing Offshore Racing Yachts, 1994.
2. ISO Standard. Small craft - Hull construction and scantlings: Sailing craft appendages ISO 12215-9:2012
3. Keel Checker 12215 Version 1.0 Software Manual, Robin Loscombe, 2010.

Drawings of the Beneteau First 40.7 internal structure and keel attachment detail





Extracts from Beneteau First 40.7 Owner's Manual



OWNER'S MANUAL

FIRST 40.7

SUMMARY:

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EXPLANATION OF THE TYPOGRAPHY USED:

DANGER

WARNING

TAKE CARE

VI) FRESHWATER AND BLACK WATER TANKS

REF	DESCRIPTION
1	Water Tank 150 l
2	Water Tank 150 l
3	Filler - Fresh Water Tank
4	Filler - Fresh Water Tank
5	Vent Hole – Fresh Water Tank
6	Collector Fresh Water System
7	Filter – Fresh Water System
8	Water Pump
9	Foot Pump for Fresh Water (Optional Extra)
10	Boiler (capacity : 22 l)
13	Galley Sink
14	Washbasin/Shower
15	Icebox – capacity : 100 l
16	Fridge
17	Black water rigid tank 110L

Characteristics

- These capacities cannot be totally used depending on the trim, loading and the position of filling point(s) and / or eventual emptying point(s).
- Do not discharge the toilets close to shore.
- Inform yourself about local environmental protection regulations, and the respect of codes of good practice.
- Respect international regulations against pollution of the marine environment (Marpol).

Operating the black water holding system

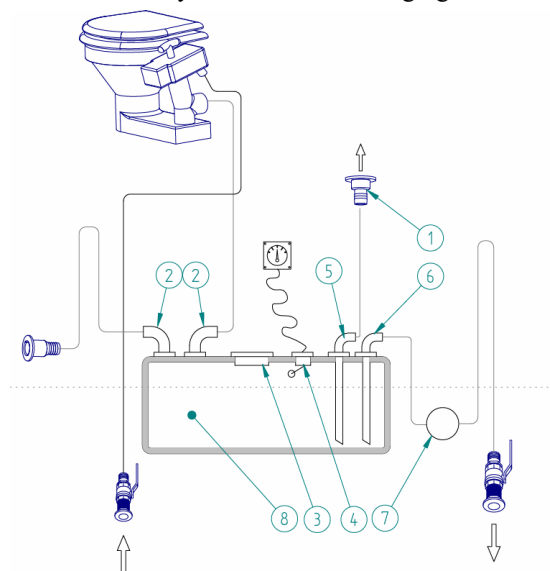
The operating principle for the system is described in the attached schematic diagram.

- After each use, rinse the system: fill the bowl with fresh or sea water then empty.
- Products to use for cleaning should be domestic cleaning products.
- The system should be empty during immobilisation of the ship in negative temperatures.

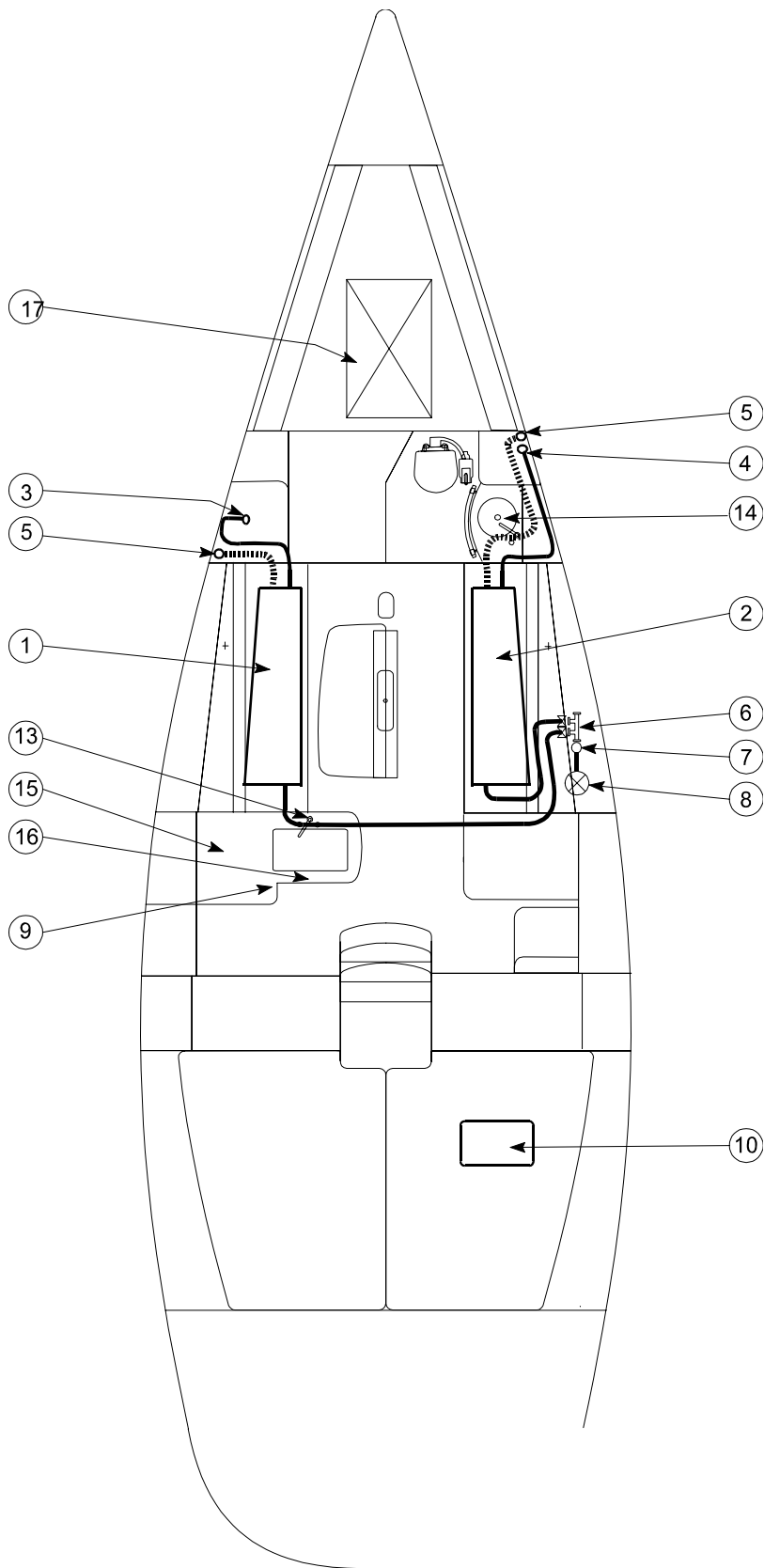
For the respect of the environment:

- Do not discharge the contents of the holding tanks close to the shore; use the pumping systems of ports or marinas for emptying the holding tanks before leaving port.
- Make sure that the holding tank discharge cock is closed in order to avoid any inadvertent discharging.

REP	Description
1	filler
2	skin fittings
3	trap
4	gauge
5	plunger
6	plunger
7	Electric pump
8	black water rigid sump tank



LAY OUT



VII) BILGE PUMP SYSTEM

REF	DESCRIPTION
1	Electric Bilge Pump 17 l/mn
2	Filter of the Electric Bilge Pump
3	Sump
4	Manual Bilge Pump 0.75 l/each time
5	Electric Bilge Pump Intake
6	Manual Bilge Pump Intake
7	Delivery of Electric Pumps
8	Manual Bilge Pump Delivery
9	Shower Intake
10	Filter of the Electric Shower Pump
11	Electric Shower Pump 17 l/mn

Make sure the bilge pump system is in good working order before you put out to sea.

Make yourself acquainted with the way the bilge pump system of your boat works :

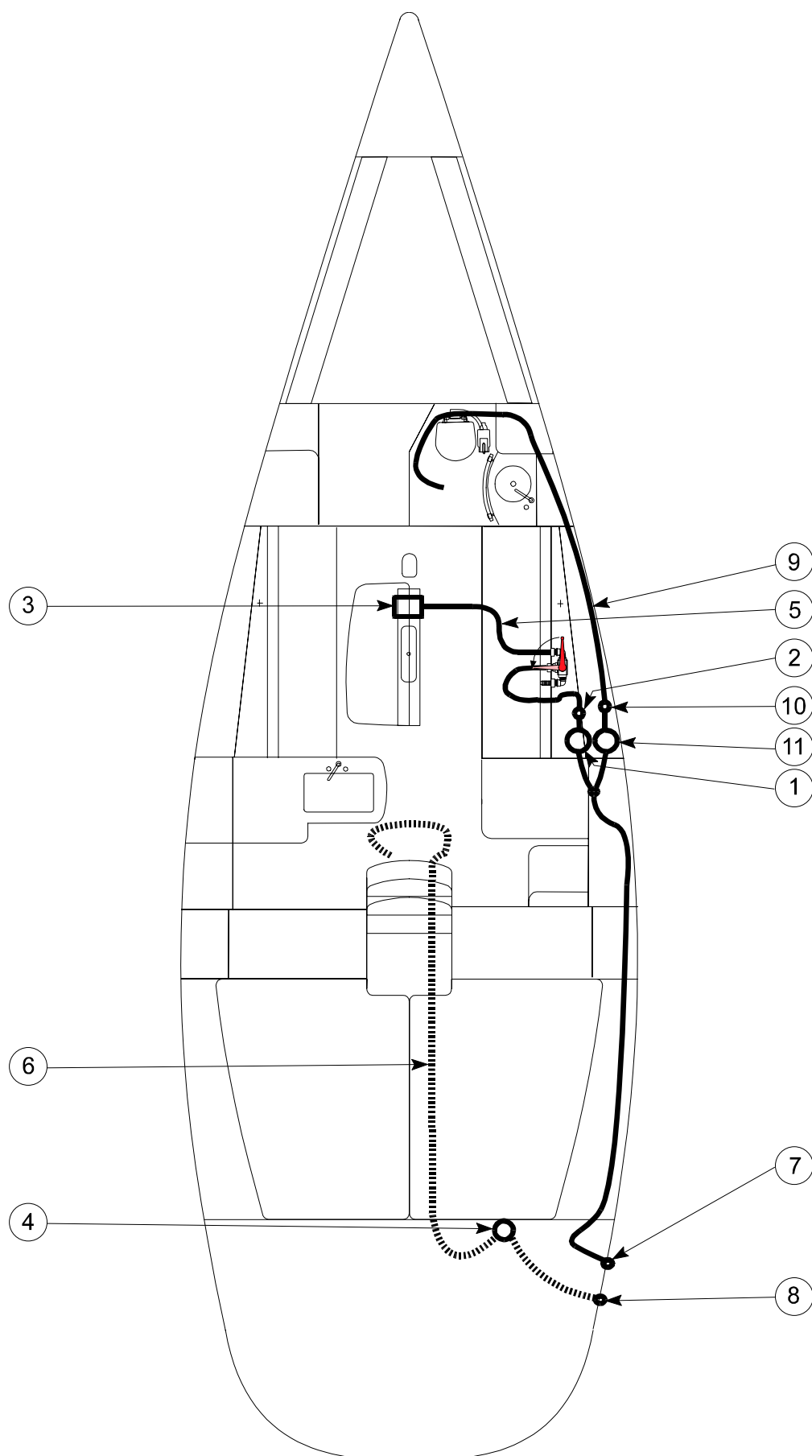
- **Locate the manual bilge pump and the handle which enables you to make it work.**
- **Locate the on switch of the electric bilge pump and get to know how the seacocks work**

(for the boats fitted with an electric bilge pump).

(See the lay out drawing of the system in the owner's handbook)

Make sure that the bilge pump intake strum box is not blocked with dirt.

Regularly clean the intake strum box on the sump and the filter of the system in case of an electric pump.

LAY OUT OF THE BILGE PUMP SYSTEM

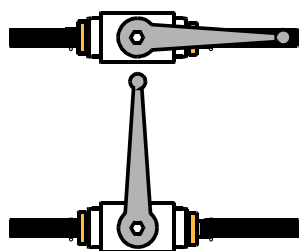
VIII) SEACOCKS AND SKIN FITTINGS

Close all the seacocks when you leave the boat.

The flushing toilets may be situated below the waterline ; get into the habit of systematically closing the seacocks after each use.

Make sure that all the seacocks which are not used are closed before you put out to sea. (in the owner's manual, see the drawing where the lay out of the skin fittings is shown).

Opening and closing of the seacocks

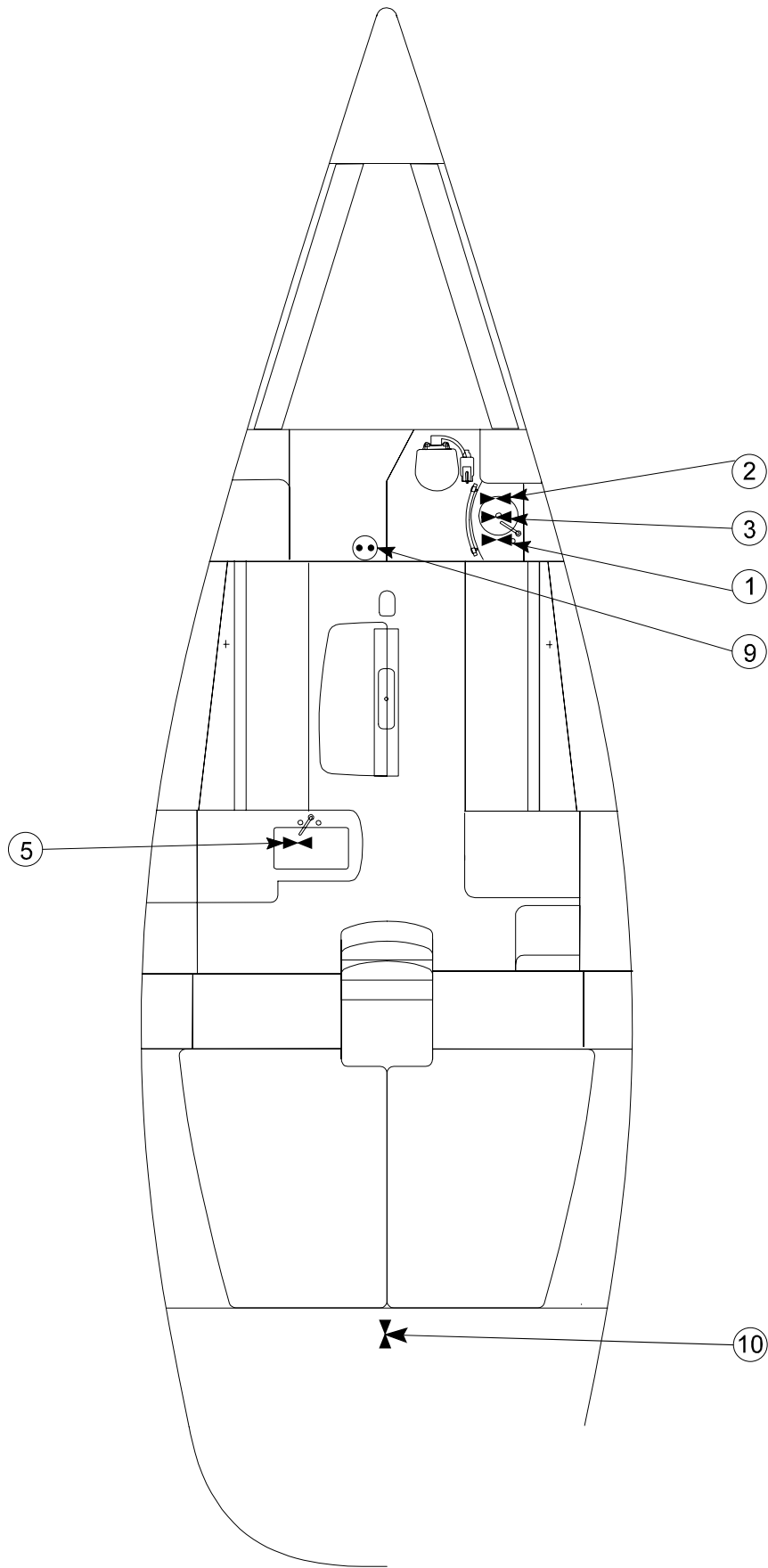


Open

Closed

REF	DESCRIPTION
1	Heads Outlet
2	Heads Intake
3	Washbasin Outlet
5	Sink Outlet
9	Log / Sounder Skin Fitting
10	Outlet of the Steering Wheel Pit

SEACOCK AND SKIN FITTING LAY OUT



XIV) MAINTENANCE

Because you have chosen to invest your money in a recreational item that spends its life in a harsh environment, it is very important to ensure that your boat is well and regularly maintained. Furthermore, a fair number of accidents are due to negligence and the lack of maintenance. These two reasons (the protection of your property and safety) must make you become aware of the importance of a regular and thorough maintenance of your boat.

The advice you will find hereafter and your PERSONAL NOTES will help you.

1) THE HULL

It is in laminated GRP. It is made with high quality products. However it would be wrong to assert that it will keep its original condition for life if you do not give over to it a minimum care.

The gel coat is fragile and the knocks and scratches it might have when you manoeuvre might leave marks on it. Have always a member of your crew ready to put a fender at the right place.

It will be useful to hose off the hull and deck with fresh water, as often as you can.

Hull Preparation

Beforehand, you may apply on the gel coat an epoxy paint ; it will protect the bottom (the careen) of your boat against the natural attacks of the sea environment.

Moreover, the bottom shall be covered with a protective antifouling paint which will prevent the adhesion of the sea vegetation.

When you apply the antifouling paint, be careful : do not paint the anodes, the heads of the electronic instruments and do not obstruct the strainers of the water intakes, in particular the strainers of the engine-cooling system.

In all events, remove the grease from the bottom and slightly hand rub down with at least # 400 grit sand paper and water.

Maintenance

In order to keep the good looking gel coat of your boat, a preventive and regular maintenance of it is necessary. For this, do not hesitate to ask your dealer who will give you advice about the methods to follow and the most appropriate products to use.

2) THE DECK

Regularly rinse the deck and deck fittings with fresh water.

Regularly scrub the deck with a mild detergent liquid.

Deck Fitting :

Regularly lubricate the blocks, sheaves, turnbuckles, winches, windlass, rails, travellers, and so on with grease or light oil.

Polish with an appropriate polish paste the stainless steels which may have small pits or superficial oxidation pits.

The Outside Teak Woodworks :

Scrub the woodworks using water.

The teak woodworks do not need any particular protection. If you just rub them down with fine sandpaper, it will renovate the look of the teak.

The Rudder :

Every year have the whole steering system overhauled.

3) INSIDE

Whenever the weather makes it possible, air and ventilate regularly your boat, take off the floorboards, the berth spreads and put them vertically when you leave the boat.

Protect the inside of your boat as often as you can with the fitted curtains.

Make sure that the bilges are clean and dry.

The internal woodworks are varnished in most of our boats ; therefore you have to rinse them with fresh water and a liquid detergent, then polish them with a chamois leather.

The cleaning of the fabrics, cushions or lining of your boat depends on the materials used. Therefore you must contact a skilled specialist before you do anything.

Fresh Water System

It is possible to sterilize the tanks with Clonazone tablets (Dygerma in UK, or a product sold in your country and containing the equivalent molecule, i.e. Tosylchloramid) which are available at the Chemist's.

If the boat is not used for a long period of time, rinse the tanks and pipes with water and vinegar.

Engine

Have the whole drive system overhauled and maintained by a skilled mechanic and refer to the instructions by the engine manufacturer , These instructions are supplied with your boat.

Keep the fuel tank as full as you possibly can in order to avoid condensation.

4) RIGGING

You must examine once a year the running and standing rigging. Take advantage of this examination to maintain them.

Carefully rinse the running rigging with fresh water at the end of each season.

5) SAILS

Whenever it is possible, rinse the sails with fresh water and let them dry.

The sails cannot stand the sun and water ; therefore, unrig them whenever you can or at least protect them, using appropriate covers.

6) WINTER STORAGE

LAYING UP

Remove from the boat all the documents of the boat, the lines which are not useful to moor the boat, the supplies, the clothes, the safety equipment, the batteries, the gas cylinder, and so on...

Have your safety equipment overhauled.

During this laying up period, draw up a complete inventory of the equipment on your boat.

PROTECTION AND MAINTENANCE

a) Inside:

Drain the fresh water pipes and rinse them with water and vinegar.

Close the water intake seacocks (except if your boat is dried out), rinse and drain the toilets pans and pumps.

Store the sounder and speedometer heads.

Carefully drain and dry all the bilges.

Put the floorboards, the cushions and berth spreads vertically in order to favour the airing of the compartments.

b) Outside :

Rinse with plenty of water the hull, the deck, the deck fittings, lubricate all the mechanical and mobile parts.

Protect your boat with fenders and make sure that the mooring lines are taut

Fix the rudder so that it may not move

c) Engine :

Only a skilled mechanic can do the winter laying up of the engine. It will not be the same if the boat remains afloat or ashore.

ALL THESE RECOMMENDATIONS DO NOT MAKE UP AN EXHAUSTIVE CHECK LIST. YOUR DEALER WILL GIVE YOU THE ADVICE YOU NEED AND WILL CARRY OUT THE TECHNICAL MAINTENANCE OF YOUR BOAT

Definition of 'pleasure vessel' from The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998

1998 No. 2771 (extract of)

MERCHANT SHIPPING

SAFETY

The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998.

11th November 1998

Laid before Parliament

20th November 1998

Coming into force

16th December 1998

The Secretary of State of the Environment, Transport and the Regions, after consulting the persons referred to in section 86(4) of the Merchant Shipping Act 1995[1], in exercise of the powers conferred by section 85(1)(a) and (b), (3) and (5) to (7) and section 86(1) of that Act, and of all other powers enabling him in that behalf, hereby makes the following Regulations:

1. - (1) These Regulations may be cited as the Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998 and shall come into force on 16th December 1998.

...

Interpretation

2. - (1) In these Regulations-

...

"pleasure vessel" means-

(a) any vessel which at the time it is being used is:

(i)

(aa) in the case of a vessel wholly owned by an individual or individuals, used only for the sport or pleasure of the owner or the immediate family or friends of the owner; or

(bb) in the case of a vessel owned by a body corporate, used only for sport or pleasure and on which the persons on board are employees or officers of the body corporate, or their immediate family or friends; and

(ii) on a voyage or excursion which is one for which the owner does not receive money for or in connection with operating the vessel or carrying any person, other than as a contribution to the direct expenses of the operation of the vessel incurred during the voyage or excursion; or

(b) any vessel wholly owned by or on behalf of a members' club formed for the purpose of sport or pleasure which, at the time it is being used, is used only for the sport or pleasure of members of that club or their immediate family, and for the use of which any charges levied are paid into club funds and applied for the general use of the club; and

(c) in the case of any vessel referred to in paragraphs (a) or (b) above no other payments are made by or on behalf of users of the vessel, other than by the owner.

In this definition "immediate family" means-

In relation to an individual, the spouse or civil partner of the individual, and a relative of the individual or the individual's spouse or civil partner; and "relative" means brother, sister, ancestor or line of descendant.

Chapter 2 of the RCD Guidelines – Conformity Assessment

Chapter 2: Conformity assessment

Article 8: Modular choice

Article 8

Before producing and placing on the market products referred to in Article 1(1), the manufacturer or his authorised representative established in the Community shall apply the following procedures for boat design categories A, B, C and D as referred to in section 1 of Annex I.

1. For categories A and B:

- *for boats of less than 12 m hull length: the internal production control plus tests (module Aa) referred to in Annex VI,*
- *for boats from 12 m to 24 m hull length: the EC type-examination (module B) referred to in Annex VII supplemented by module C (type conformity) referred to in Annex VIII, or any of the following modules: B + D, or B + F, or G or H.*

2. For category C:

- (a) *for boats from 2.5 m to 12 m hull length:*
 - *where the harmonised standards relating to sections 3.2 and 3.3 of Annex I are complied with: the internal production control (module A), referred to in Annex V,*
 - *where the harmonised standards relating [to] sections 3.2 and 3.3 of Annex I are not complied with: the internal production control plus tests (module Aa) referred to in Annex VI.*
- (b) *for boats from 12 m to 24 m hull length: the EC type-examination (module B) referred to in Annex VII followed by module C (type conformity) referred to in Annex VIII, or any of the following modules: B + D, or B + F, or G or H.*

3. For category D:

For boats from 2.5 m to 24 m hull length: the internal production control (module A) referred to in Annex V.

4. For components referred to in Annex II: any of the following modules: B + C, or B + D, or B + F, or G or H.

The choice of the modules was the subject of difficult negotiation between the Member States and the outcome is a compromise. The modular framework does not permit a manufacturer the freedom to choose another module other than A or Aa, where these are specified, thus involving a notified body, and still remain in the regulatory modular system.

The conformity assessment procedures according to the required module and, in particular, the affixing of the CE marking must take place prior to placing on the market.

As the scope of the modules is defined in Annexes V to XII to the directive, the following is a reminder of the characteristics of the modules.

If a manufacturer chooses for commercial reasons additional assessment or certification following, for example, the procedures laid down in another module than that required, such a decision lies in the voluntary domain. The certification body involved may then undertake certification under its own name and not under an EC certification heading.

Until such time as the choice of modules available within the directive may be amended, the modular choice for manufacturers, within the regulatory sector, remains that shown on the following page.

<i>Design category</i>	<i>Available modular choice</i>	
	<i>2.5 m ≤ hull length < 12 m</i>	<i>12 m ≤ hull length ≤ 24 m</i>
A 'Ocean'	Aa	B + C, or B + D, or B + F, or G or H
B 'Offshore'		
C 'Inshore'	If harmonised standards for stability and buoyancy are complied with	A
	If harmonised standards for stability and buoyancy are not complied with	Aa
D 'Sheltered waters'	A	
'Components'	B + C, or B + D, or B + F, or G or H	

<i>Module</i>	<i>Title</i>	<i>Description</i>
A	Internal production control	Internal conformity assessment and production control by the manufacturer himself who draws up a written declaration of conformity containing the information given in Annex XV.
Aa	Internal production control plus tests	This is module A, plus tests of stability and buoyancy carried out on the responsibility of the notified body, which issues an examination report.
B	EC type-examination	Covers EC type-examination; the notified body issues an EC type-examination certificate for a representative production sample which it has assessed in accordance with the essential safety requirements. This module applies only to the design phase and must be followed up by the manufacturer applying a module providing for assessment in the production phase.
C	Conformity to type	Covers the manufacturer's declaration on the basis of conformity to type, approved by the notified body (module B above).
D	Production quality assurance	Generally supplements module B. Derives from quality assurance standard EN ISO 9002 with the notified body responsible for approving and controlling the quality system set up by the manufacturer.
F	Product verification	Supplements module B. Covers product verification at the production phase, with the involvement of a notified body, which controls conformity to type and issues the certificate of conformity.
G	Unit verification	Covers unit verification of the design and production of each product controlled by a notified body, which issues a certificate of conformity.
H	Full quality assurance	Derives from the quality assurance standard EN ISO 9001 with the intervention of a notified body responsible for approving and controlling the quality system set up by the manufacturer.

<i>Directive/regulatory domain</i>	<i>Private domain</i>
Conformity assessment according to the appropriate module	Conformity assessment according to the agreement between the manufacturer and the certification body (the principles laid down in a module may be used)
Notified body	Certification body (which may be a notified body)
CE marking	Private logos and markings
Always COMPULSORY	Always VOLUNTARY

Article 9: Notified bodies

Article 9(1)

1. Member States shall notify the Commission and other Member States of the bodies which they have appointed to carry out the tasks pertaining to the conformity assessment procedures referred to in Article 8, together with the specific tasks which these bodies have been appointed to carry out and the identification numbers assigned to them beforehand by the Commission.

The Commission shall publish a list of the notified bodies, together with the identification numbers it has allocated to them and the tasks for which they have been notified, in the Official Journal of the European Communities. It shall ensure that the list is kept up to date.

Paragraph 1 stipulates that the Member States are responsible for informing the Commission of the bodies which they have appointed to carry out conformity assessment. The notification must indicate the specific field for which the body has been notified.

Appendix 4 provides a non-exhaustive list of notified bodies under the recreational craft directive and the conformity assessment modules they are entitled to apply. This list was updated at the time of going to press;

however, Member States may promote or withdraw a notified body at any time.

For more information on the principles of notification, the notification procedure and general responsibilities of notified bodies, see the *Guide to the implementation of directives based on the new approach and the global approach* ('blue book'). This guide is downloadable from the Enterprise DG's website on the Europa server at the following address: <http://europa.eu.int/comm/enterprise/newapproach/legislation/guide/legislation.htm>.

Article 9(2)

2. Member States shall apply the criteria laid down in Annex XIV in assessing the bodies to be indicated in such notification. Bodies meeting the assessment criteria laid down in the relevant harmonised standards shall be presumed to fulfil those criteria.

Article 9(3)

3. A Member State shall withdraw its approval from such a body if it is established that the latter no longer satisfies the criteria referred to in Annex XIV. It shall inform the Commission and the other Member States of its action forthwith.

Paragraphs 2 and 3 refer to the criteria for assessing the bodies to be notified (Annex XIV) and the possible withdrawal of approval.

Cheeki Rafiki's Declaration of Conformity

**Declaration of Conformity of Recreational Craft with the Design,
Construction and Noise Emission requirements of Directive 94/25/EC
as amended by Directive 2003/44/EC**

(To be completed by boat builder)

Name of craft manufacturer: CHANTIER BENETEAU SA

Address: ZI DES MARES BP 66

Town: ST HILAIRE DE RIEZ **Post Code:** 85270 **Country:** France

Name of Authorised Representative (if applicable):

Address:

Town: **Post Code:** **Country:**

Name of Notified Body for design and construction assessment (if applicable): I.C.N.N.

Address: 40, Avenue de Lazaret

Town: LA ROCHELLE **Post Code:** 17000 **Country:** France **ID Number:** 0607

EType-examination Certificate number: **Date:(yr/month/day)**

Name of Notified Body for noise emission assessment (if applicable):

Address:

Town: **Post Code:** **Country:** **ID Number:**

Module used for construction assessment: A ☐ Abis ☒ B+C ☐ B+D ☐ B+E ☐ B+F ☐ G ☐ H ☐

Module used for noise emission assessment: A ☒ Abis ☐ G ☐ H ☐

Other Community Directives applied:

DESCRIPTION OF CRAFT

Craft Identification Number (CIN)

F R B E Y 8 2 6 8 9 K 6 0 7

Brand name of the craft: FIRST 40.7

Type or number:

Type of craft

- ☒ sailboat ☐ motorboat
☐ inflatable
☐ other (specify):

Type of main Propulsion

- ☒ sails ☐ petrol engine
☐ diesel engine ☐ electric motor
☐ oars
☐ other (specify):

Type of hull

- ☒ monohull ☐ multihull
☐ other (specify):

Type of engine

- ☐ outboard ☐ inboard
☐ z or sterndrive without integral exhaust
☐ z or sterndrive with integral exhaust
☒ other (specify):

Construction material

- ☐ Aluminium, aluminium alloys ☒ plastic, fiber reinforced plastic
☐ steel, steel alloys ☐ wood
☐ other (specify):

Deck

- ☒ fully decked ☐ partly decked
☐ open
☐ other (specify):

Maximum Design Category:

For a Maximum number of persons ☒ A ☐ B ☐ C ☐ D

Max.recommended Engine power 30,00 kW

Installed engine power: 29,40 kW

Maximum recommended engine weight kG

Length of hull LH 11,92 m **Beam of hull BH** 3,78 m **Depth D** 1,69 m

Draught T 2,40 m **Sails surface (projected)** 74,89 m²

This declaration of conformity is issued under the sole responsibility of the manufacturer. I declare on behalf of the craft manufacturer that the craft mentioned above complies with all applicable essential requirements in the way specified (and is in conformity with the type for which above mentioned EType examination certificate has been issued).

Name and function
 (identification of the person empowered to sign on behalf of the manufacturer or his authorised representative)

Signature et titre:

CHANTIER BENETEAU SA

Z.I. DES MARES - B.P 66

85270 ST HILAIRE DE RIEZ

FRANCE

Essential requirements (Reference to relevant articles in Annex IA & IC of the Directive)	Standard	Other normative document/methods	Technical file	Please specify in more details (* : Mandatory Standards)
General requirements (2)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 8666
Craft identification Number - CIN (2.1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	EN ISO 10087
Builder's plate (2.2)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	EN ISO 14945
Protection from falling overboard and means of reboarding (2.3)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 15085
Visibility from main steering position (2.4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Owner's manuel (2.5)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 10240
Integrity and structural requirements (3)				
Structure (3.1)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Echantillonnage selon expérience de construction
Stability and freeboard (3.2)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO/CD 12217-2
buoyancy and floatation (3.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Opening in hull, deck, and superstructures (3.4)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO/DIS 12216
Flooding (3.5)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO/DIS 11812, EN ISO 15083
Manufacturer's maximum recommended load (3.6)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	EN ISO 14946
Liferaft stowage (3.7)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Escape (3.8)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Anchoring, mooring and towing (3.9)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Handling characteristics (4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Engines and engine spaces (5.1)				
Inboard engine (5.1.1)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Ventilation (5.1.2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Exposed parts (5.1.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Outboard engine starting (5.1.4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Fuel system (5.2)				
General - Fuel system (5.2.1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 10088, ISO 7840
Fuel tanks (5.2.2)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 10088
Electrical systems (5.3)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 10133, ISO 13297
Steering systems (5.4)				
General - steering systems (5.4.1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NF EN ISO 28847
Emergency arrangements (5.4.2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Gas systems (5.5)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO/DIS 10239.2
Fire protection (5.6)				
General - Fire protection (5.6.1)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 9094-1
Fire-fighting equipment (5.6.2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Navigation lights (5.7)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	COLREG
Discharge prevention (5.8)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 8099
Annex I.B - Exhaust Emissions				See the Declaration of Conformity of the engine manufacturer
Annex I.C - Noise Emissions	¹ <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Noise emission levels (I.C.1)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Owner's manual (I.C.2)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	ISO 10240

¹Only to be completed for boats with inboard engines or sterndrive engines without integral exhaust

YDSA report on its 'Investigation into the feasibility of a Beneteau First 40.7 to be compliant to the MCA SCV Codes of Practice at area Category 0 level'

**INVESTIGATION INTO THE FEASIBILITY
OF A BENETEAU FIRST 40.7 TO BE
COMPLIANT TO THE MCA SCV CODES OF
PRACTICE AT AREA CATEGORY 0 LEVEL**

Dated 3rd October 2014

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1 INTRODUCTION

- 1.1 Verbal and emailed instructions were received from [REDACTED] of the Marine Accident Investigation Branch (MAIB) to perform an investigation into the feasibility of a Beneteau 40.7 to be compliant to the MCA SCV codes of practice at area Category 0 level. With regard to the on-going investigation into the loss of *S/Y Cheeki Rafiki* in the Atlantic.
- 1.2 My understanding of the scope of work is to: check an existing Beneteau First 40.7 with the assumption that the dummy vessel was to the requirements MCA SCV MGN 280 area category 2 (60 miles from a safe haven) as against area category 0 (unlimited distance from a safe haven) requirements. This assessment is not to include further work with regard stability beyond considering intact stability by means of down flooding points; it is also to note if there may be any possibility the vessel could satisfy damaged stability requirements as noted in MGN 280. As far as is reasonably practicable consideration is to be made as to the location and assumed inventory of Life Saving Appliances (LSA) aboard *Cheeki Rafiki* at the time of the loss.
- 1.3 Marine Guidance Note 280 (MGN 280) is the “Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats” code of practice published by the Maritime and coastguard agency (MCA)
- 1.4 Reference as required (in the event of significant difference) is also made to the older MCA “Blue” code of practice for the construction, machinery, equipment, stability, operation and examination of sailing vessels, of up to 24 meters load line length, in commercial use and which do not carry cargo or more than 12 passengers.
- 1.5 No comments have been made with regard the Maritime Labour Convention as it not considered to be of relevance in this case.
- 1.6 I have conducted a phone interview with [REDACTED] of the MAIB to establish largely what was on-board *Cheeki Rafiki* with regard LSA and its location but this is not to say that my interpretation is completely correct given it is impossible to view the vessel as was.
- 1.7 I have attempted to clearly label what is fact and opinion throughout the report.
- 1.8 It is understood from the MAIB that the 40.7 came in only one layout. A third party 40.7 yacht was used for this assessment.
- 1.9 Area categories are as per section 3.2.1 of MGN 280. I note *Cheeki Rafiki* was at one time coded to area category 2 under MGN 280 (this had expired at the time of the loss) which is 60 miles from a safe haven (for 12 persons or 10 persons with more than 24 hours at sea) and that category 0 is unrestricted service from a safe haven.

2 CONSTRUCTION AND STRUCTURAL STRENGTH - CODE SECTION 4

- 2.1 *Cheeki Rafiki* was within her previous coding complaint with section 4.2.2 at area category 2 using under section 4.2.2.5.2 “in general accord with the standard of a vessel which has a record of at least five years’ history of safe operation in an area where the sea and weather conditions are no less severe than those likely to be encountered in the intended area of operation”. As it is understood this was the most simple route.
- 2.2 Whilst within 4.2.2.5.2 there is no reference to any difference between area category 2 and category 0 it is my opinion that there is an implicit difference; this is by way of sea and weather conditions experienced, in the two sea areas. Whatever base port in the world a vessel operates in at Category 2 it will for most arguments sake be possible in the event of severe weather to put to a safe haven. At Category 0 it is generally not, the sea and weather conditions are therefore more severe on a number of levels.
- 2.3 If a Beneteau First 40.7 does indeed have a record of at least five years “safe history” in sea and weather conditions no less severe than those likely to be encountered in the mid Atlantic (for example) is a moot point but one which would have had to be have been proved to be the case prior to allowing the vessel to operate at category 0 under 4.2.2.5.2.
- 2.4 If a 40.7 could satisfy the 5 year safe history requirement, would represent in my opinion the major hurdle as to if a 40.7 could be coded to category 0 with intact stability for 6 or less persons.
- 2.5 However it is noted that the Beneteau First 40.7 used as a dummy vessel has a plaque aboard (and presumably certificate somewhere on file for each 40.7 vessel - though this could not be found on the dummy vessel) noting it is built under some kind of type approval from Bureau Veritas (BV) (which is a UK load line assigning authority). Exactly what the plaque pertains to would need to be established.
- 2.6 There is no evidence to suggest *Cheeki Rafiki* or the dummy vessel had a certificate of construction for the hull itself (i.e the hull was built under direct BV supervision to an accepted standard) that would have allowed the vessel to be accepted under 4.2.2.3 of MGN 280.
- 2.7 The presence of an assumed type certification does raise a question with regard 4.2.2.5.1 of MGN 280 insomuch as it states: if a vessel (being considered of adequate strength after authorised person examination (i.e. certifying authority surveyor)) “in accordance with the hull certification standards for small vessels, recognised by one of the authorities” it would be acceptable.
- 2.8 The type certification would have to be considered further for compliance and the surveyor involved would have to prove this with supporting information (not in my experience always that easy on mass produced vessels) but it would seem possible from 4.2.2.5.1 of MGN 280 that a 40.7 would be perfectly acceptable on grounds of the BV type approval (noting ISO / RCD) as equivalent standard thus rendering the 5 years safe history argument unneeded and allowing the vessel to operate a area category 0; at least in terms of section 4.2 of MGN 280.

- 2.9 It is of course noted that the 40.7 class is counted (at least according to the plaque on the aft of the vessel) as a RCD category A Ocean yacht under the Recreational Craft Directive but it is under 12m hull length (ISO 8666) so would be interesting to know how far the technical file / subsequent build was scrutinised by BV / notified body. An element to consider would be (normally present in a new builds file) the declaration of conformity and which ISO's had been used to demonstrate conformity with the essential requirements. Then consider to what level a notified body would have been involved in any monitoring of build from hull #1 onwards? This line of thought is left open at this point as it begins to exceed the scope of this report.
- 2.10 Section 4.3.2.2.2 of MGN 280 details for sailing vessels that recesses in the weather deck (in the case of a 40.7 the cockpit) have means of drainage as per area category 2 but increased the area of this drainage from 10cm² to 20cm². As a 40.7 has twin 6.5cm diameter drain ports which give an area of 33.18cm² at any given 30° angle of heel or 2 x 33.18cm² at most angles of heel a 40.7 more than comfortably passes this requirement. There is no need to look further into the alternative arrangements possible in 4.3.2.3 of MGN 280.
- 2.11 As a side note section 4.4 of MGN 280 does cover watertight bulkheads with reference to lower area categories but as noted in section 8 of this report this is not of any relevance to a First 40.7.

3 WEATHER TIGHT INTEGRITY - CODE SECTION 5

- 3.1 5.4.7 of MGN 280 states the requirements for blanks for a vessel which operates more than 60 miles from a safe haven: "Blanks must be carried for at least 50% of windows". With regard the side glazing on *Cheeki Rafiki* such blanks are understood to not have been present.
- 3.2 In my opinion such blanks would not have been difficult to manufacture and this would not represent a significant barrier to allowing a 40.7 to reach category 0.
- 3.3 Blanks would have been present on *Cheeki Rafiki* for the hatches in the forward portion of the boat with aft hinges to satisfy 5.1.1.3 MGN 280 (aft hinged not allowed in previous blue code) which would have meant blanks where carried as per 5.4.7 for the upward opening hatches.

4 TANKAGE - CODE SECTION 7 (MACHINERY)

- 4.1 Section 7.2 of MGN 280 pertaining to Diesel engines states a vessel must have sufficient fuel tankage for its area of operation. Again this does not reference any difference between area category 2 and 0 specifically but there is an implicit difference in term of the area of operation requiring a lot more fuel for battery charging and propulsive power in limited wind to allow a timely passage.

- 4.2 It becomes a question of opinion but mine would be that the tankage available on a 40.7 is not sufficient for an Atlantic crossing or significant area category 0 passage making. Fuel could be carried in containers as it was on *Cheeki Rafiki* to my understanding. Carrying extra fuel in containers does of course have an impact on stability that would have to be accounted for in any stability book. As well as a debatable question of how the fuel may be stowed.

5 BILGE PUMPING - CODE SECTION 10

- 5.1 10.2 of MGN 280 notes the additional requirements for bilge pumping when operating in area category 1 or 0. This although open to a small amount of interpretation as to what “independent power bilge pump” can be constituted by: states “a vessel should have at least one hand bilge pump and one engine driven or independent power bilge pump, situated in not less than two separate spaces. All pumped spaces should be capable of being drained after the failure of one pump”.
- 5.2 The above rule need then be cross-referenced with the rest of section 10. The rule for a vessel such as a 40.7 in 10.2 is very similar to that of 10.3.1 (pertaining to the higher area categories) which a 40.7 has already passed. Given the bilge pumping available on a 40.7: 1 x electrical pump of 2.8 Gallons per minute (12.73 lpm) located in the main saloon and a Henderson manual bilge pump of approximately 35 litres per minute located in the cockpit with suction to the main bilge. A 40.7 satisfies 10.2 without further modification.

6 DOWN FLOODING - CODE SECTION 11 (INTACT STABILITY)

- 6.1 Assuming 6 or less persons aboard:
- 6.2 11.1.1.2 states that a vessel operating in area category 0 or 1 is required to have a stability information booklet (SIB) the content of such a book and the ability to pass such requirements or the alternative ISO requirements allowed are outside the scope of this report beyond a consideration of the down flooding points. A sailing monohull vessel complying to 11.1.13 (area category 2) has a more simple stability assessment as detailed 11.9 of MGN 280.
- 6.3 The requirements of section 12 of MGN 280 have also not been considered given lack of SIB.
- 6.4 11.8.3 details the critical down flooding angle allowed; the calculation of this is outside of the scope of this report.
- 6.5 All measurements below are approximate with a steel tape. The measurements taken from the waterline were taken as the sample boat was loaded in ‘race trim’ (i.e. fairly stripped out) how this might compare to freeboards once load case information is considered is unknown but suffice to say a vessel ready for a significant passage would sit lower in the water.

- 6.6 As per 11.8.8 (MGN 280) air pipes to tanks are disregarded. It would therefore appear that the first down flooding point of a first 40.7 is the aft intakes at the transom which were 890mm above the waterline on the sample vessel however these are looped up to the deck and despite the hose diameter are high than the cockpit side just forward of the transom which is under 1.1m once this is flooded it then allows access to the companion way which even if shut is not watertight.
- 6.7 It is noted that the blue code does have provision for lower number area categories (0 or 1) for vessels under 15m as to the 'STOPS' numeral (developed by the RYA) but MIN 153 followed by OAN 411 (expiry dates are noted) takes one back to MGN 280 rules so this has not been considered for the purposes of this report any further.

7 DAMAGE SURVIVABILITY - CODE SECTION 11.2

- 7.1 Section 11.2 pertains to damage survivability it applies a set of rules for vessels operating in area category 1 or 0 with 7 or more persons aboard.
- 7.2 The fundamentals of these rules mean that if one watertight compartment is flooded the vessel must remain afloat and satisfy certain criteria.
- 7.3 There does not appear to be any significant amount of reserve buoyancy on a 40.7 and there is excluding the anchor locker only one compartment.
- 7.4 It is my opinion (I would go so far as to say this is a fact) that a 40.7 will therefore never satisfy the damaged stability requirements, as there is only one compartment.
- 7.5 In order to satisfy the damaged stability criteria it would therefore be required that some form of watertight bulkhead be manufactured and that in this case would be a significant structural modification which would then debatably invalidate 4.2.

8 LIFE RAFTS - CODE SECTION 13.2

- 8.1 A vessel operating in area category 0 must have according to 13.2.1.1 a spare raft for all on board in event one be lost or damaged. This means there must be at least 2 x life rafts aboard. The rafts at area category 0 must be to SOLAS standard and be equip with a SOLAS A pack contained within the raft.
- 8.2 It is understood *Cheeki Rafiki* had on board only a ISO 9650 raft stowed in a cockpit locker. According to MIN 241 followed by MGN 499 (superseding MGN 280) this raft would be suitable depending on the exact certification (not confirmed) up to area Category 1 or 2 (notwithstanding insulated floor / temperature issues). It is understood this raft was equipped with the lower standard SOLAS B pack (area category 1 requires SOLAS A pack); it is unknown if this was in a grab bag or in the raft. There is some dispensation for the use of grab bags for SOLAS B packs at area category 2 and below.

- 8.3 13.2.1.3 states rafts when operating in area category 1 or 0 must also be contained in FRP containers which are stowed on the weather deck with a float free arrangement (hydrostatic release). There is dispensation in 13.2.1.4 for stowage and release arrangements which give an equivalent level of safety but in my opinion this would never be satisfied by a raft stowed in a locker as the life raft cannot inflate and float free from the vessel automatically which is the key point in vessels operating so far away from 'backup' as if the raft is not deployed then the risk of loss of life is much higher than if help is closer at hand.
- 8.4 Whilst raft stowage would be an interesting problem on a 40.7 (finding the location for 2 x SOLAS rafts would not be as easy as one might think in my opinion) upgrading a 40.7 to this standard would be possible. The affect of life rafts stowed on deck would in my opinion adversely affect the vessel as to the intact stability requirements though I cannot with the information available to me quantify this meaningfully.

9 LSA GENERAL - CODE SECTION 13

- 9.1 Table 13.1 states the LSA levels for MGN 280 coded vessels.
- 9.2 The increase in LSA from area category 2 to 0 is by way of increase in flares from 4 x parachute flares at category 2 to 12 at category 0.
- 9.3 An EPIRB (406MHz) is also required for vessels operating in area categories 1 and 0 which should be accessible, float free in the event of sinking and capable of being placed in the life raft.
- 9.4 It is understood *Cheeki Rafiki* did carry such an EPIRB but that it was not float free and thus would not fulfil the requirements of area category 0.
- 9.5 The table indicates a Search and Rescue Transponder (SART) should be carried. 13.8 of MGN 280 details that a SART is not required if a EPIRB with 121.5MHz frequency transmitting capability is carried. I note that from February 2009 the MCA announced that 121.5MHz EPIRB will no longer be processed by COSPAS - SARSAT but they still can be used as a 'homing device'. Pragmatically (my opinion) a SART should be carried by all vessels operating in area category 0 or 1. No such item is understood to have been aboard *Cheeki Rafiki*.
- 9.6 Placing the additional LSA inventory on a 40.7 would not be difficult.

10 FIRE SAFETY - CODE SECTION 14

- 10.1 14.2 of MGN 280 details the additional requirements for vessels operating in category 0 and 1 with regard fire safety.
- 10.2 14.2.2 pertains to FRP construction and state that machinery space boundaries should prevent the passage of smoke and flame for 15 minutes.
- 10.3 A First 40.7 does nominal have a machinery space boundary that would to an extent contain extinguishing medium (a design that is similar to most modern mass production GRP cruising yachts) as required in area category 2. This by way insulated steps and a ply box to its side opening up to loose ply boards under the aft under bunks.

- 10.4 It is my opinion that this arrangement is not adequate to prevent passage of smoke and flame without modification. *Cheeki Rafiki* would have required some modification to pass this section of the code.
- 10.5 14.7.2 covers the need for vessels operating in area category 1 or 0 to have efficient fire detectors fitted in the engine space and spaces containing open flame gas installations.
- 10.6 On *Cheeki Rafiki* this would have meant fire detectors in the engine space and at the galley. 14.7.5 notes that the fire detectors should be appropriate to the hazard identified and should give an audible warning that can be heard in the space and the control position with the vessel in operation.
- 10.7 I note section 14.8.2 applying to any category area, which states that in exceptional cases single means of escape from accommodation spaces is accepted but efficient fire detectors should be provided as needed for an early warning. Often this is loosely applied to the aft cabins on production sailing yachts of this size and the requirement is often (rightly or wrongly) made up of a domestic smoke detector in the saloon and aft cabins as these can be heard around the boat.
- 10.8 *Cheeki Rafiki* is understood to have not have had any fire detectors specifically at the galley or in engine space. Such detectors should have been fitted for a vessel operating in area category 0.
- 10.9 This would have been a possible modification but certainly the requirement for the engine space would have required the installation of a system more advanced than that of a domestic smoke alarm. This would have some bearing on electrical power available.

11 RADIO EQUIPMENT - CODE SECTION 16

- 11.1 Table 16.1 details the extra minimum / recommended radio equipment. To increase from area category 2 to 0 this would require a MF SSB radio with DSC as well as the recommendation for an Inmarsat ship earth station though the SSB can be dispensed with if a Inmarsat ship earth station is fitted. A NAVTEX is also required.
- 11.2 For completeness I note being in a category 0 region (assuming within 70° N/S of latitude) would put a vessel in the sea area A1, A2 and A3 in terms of GMDSS sea area.
- 11.3 It is understood *Cheeki Rafiki* had no SSB or Inmarsat ship earth station but that some form of satellite phone was present. One of these would have been required for category 0 operation as they would allow efficient communication.
- 11.4 Whilst upgrading the radio installation would seem a reasonably (if not costly) basic exercise to undertake the battery requirements do complicate matters and would have bearing on charging, battery storage and fuel allowance down the line. 16.2.5 of MGN 280 details that batteries used for radio equipment should provide sufficient hours operation to ensure effective use of the GMDSS installation bearing in mind the distance the vessel operates from the shore.
- 11.5 I also note that 1 portable VHF per life raft would be required which would increase from 1 required at category 2 to minimum 2 required at category 0.

12 MISCELLANEOUS EQUIPMENT - CODE SECTION 19

- 12.1 19.4.2 details that a sailing mono hull vessel operating in area category 1 or 0 should be provided with an inclinometer. It is unknown if one was present on *Cheeki Rafiki*.

13 WATER SERVICES 21.2.3

- 13.1 21.2.3.1 details that an adequate supply of drinking water should be provided it is therefore implicit that a large amount of water would need to be carried for long passages more so in my opinion than could be stowed in the yachts water tanks. Stowage of water would again have affect on stability.

14 MEDICAL SUPPLIES - CODE SECTION 23

- 14.1 It is detailed that for areas category 0, category A medical supplies are required. This is an extensive and expensive inventory when compared with the category C medical pack required at area category 2. It is understood *Cheeki Rafiki* did not have such supplies on board.

15 MANNING - CODE SECTION 26 (ANNEX 3)

- 15.1 26.2.1 of MGN 280 refers to annex 3 that gives the qualification levels required.
- 15.2 The specific commercial endorsements of certification has not been fully touched on within this section as I have not had direct access to the certification of the persons aboard *Cheeki Rafiki* but suffice to say all certificates of competency would have to be commercially endorsed whilst operating a commercial vessel.
- 15.3 On board a category 0 vessel should be at least one person holding a radio operators certificate for the equipment on board.
- 15.4 Given on *Cheeki Rafiki* there was not the radio equipment required to area category 0 it is not relevant to find if such a person was on board but a correctly qualified radio operator would be required to operate in area category 0.
- 15.5 The MAIB was asked as to the qualifications on board; no copies of any certification have been seen.
- 15.6 Annex 3 - 2.6 notes the need for the skipper and anyone else employed on board to have an ENG1 medical examination at area category 0 where as only a ML5 certificate is needed at area category 2. It is understood the skipper of *Cheeki Rafiki* did hold such a certificate to compliment the Ocean Yacht Master Certificate held.
- 15.7 Annex 3 2.8 states skippers of vessels operating in area category 0 should hold the ships captains medical care certificate (unless another member of crew holds a medical or nursing qualification of an equivalent or higher standard). One of the crew would need to hold such a qualification if operating in area category 0.

- 15.8 Table 1 of annex 3 details that the skipper (as present on *Cheeki Rafiki*) required to be a Yachtmaster ocean. The table also details that there should be at least a further Yachtmaster Ocean or Yachtmaster Offshore aboard in area category 0. It is understood no such second qualified person existed on *Cheeki Rafiki*.

16 EXAMINATIONS REQUIREMENTS - CODE SECTION 27

- 16.1 The table in 27.4.2 of MGN 280 details for a vessel carrying 15 or less persons and under 1000kg of cargo needs a authorised persons (a certifying authority surveyor) examination annually rather than as a mid term as late a 3 years after the initial out of water survey as allowed at area category 2.
- 16.2 *Cheeki Rafiki* was time expired from category 2 in any case.

17 CONCLUSION

- 17.1 By way of equipment required the works needed to get a 40.7 from area category 2 to 0 although costly would be perfectly possible.
- 17.2 It seems likely that owing to the BV type certification it would have been perfectly possible to satisfy the constructional requirements of MGN 280 for category 0.
- 17.3 Some modification to fuel load would be required and the extra supplies required would have an effect on stability. I question if the section 11 (MGN 280) downflooding requirements could be passed by a 40.7 for area categories 1 and 0.
- 17.4 A 40.7 will never pass the damaged stability requirements of MGN 280 without significant modification.
- 17.5 Works would be required with regard fire safety to allow a 40.7 go get to area categories 1 or 0.
- 17.6 Additional manning certification would have been required if *Cheeki Rafiki* was operating to area category 0 at the time of her loss.

MAIB Flyer to the Leisure Industry

FLYER TO THE LEISURE INDUSTRY

Loss of the yacht *Cheeki Rafiki* and its four crew



Image courtesy of United States Coast Guard

Narrative

On 16 May 2014, an alert was received from the personal locator beacon of the skipper of the United Kingdom (UK) registered yacht *Cheeki Rafiki*, which was on passage from Antigua to the UK, and located approximately 720 miles east-south-east of Nova Scotia, Canada. Despite a major search effort, during which the yacht's upturned hull was located but not recovered, *Cheeki Rafiki*'s four crew remain missing.

In the absence of survivors and material evidence, the causes of the accident remain a matter of some speculation. However it is concluded that the yacht capsized and inverted following a detachment of its keel. In the absence of any apparent damage to its hull or rudder other than that likely to have been directly associated with keel detachment, it is concluded unlikely that the vessel had struck a submerged object. Instead, a combined effect of previous groundings and subsequent repairs to its keel and matrix had possibly weakened the vessel's structure where the keel was attached to the hull. It is also possible that one or more keel bolts had deteriorated. A consequent loss of structural strength may have allowed movement of the keel which would have been exacerbated by increased transverse loading through sailing in worsening sea conditions.

Safety Lessons

1. Matrix detachment is possible in yachts where a GRP matrix and hull are bonded together. The probability of this occurring will increase with longer and harder yacht usage. There is therefore a need for regular structural inspection by a nominated competent person as part of a formal verifiable procedure, as well as before embarking on an ocean passage.
2. Owing to the continuous nature of a matrix where solid floors are in place, particularly where the keel is attached to the hull, it may be difficult to readily identify areas where a detachment has occurred. There are differing opinions among surveyors and GRP repairers with regard to what are appropriate methods of inspection and repair, including the circumstances in which the keel should be removed. There is therefore a desire for best practice industry-wide guidance to be developed.
3. Any grounding has the potential to cause significantly more damage than may be subjectively assessed or visually apparent, including matrix detachment. It is therefore important that all groundings, including those perceived to be 'light', result in an inspection for possible damage by a suitably competent person.
4. Ocean passages require comprehensive risk assessment and contingency planning. A compromise needs to be made between planning a high latitude route, to pick up favourable winds and ensure a speedier passage, and a low latitude route, to avoid particularly adverse weather at the expense of a slower passage possibly necessitating additional port calls. Weather routing, vessel tracking and frequent communications from a shore-based support cell can significantly reduce the risks.
5. Attached keels are a feature of modern yacht design. Operators and crews therefore need to be aware of the associated danger of keel detachment, and have preventive procedures in place to reduce the risk, e.g regular inspection of the keel attachment area and checking of keel bolts, and documented actions to take in the event of flooding, including reducing the load on the keel and preparing for the yacht capsizing and inverting.
6. Search and Rescue mid-ocean is hampered both by the time it takes fixed-wing search aircraft to arrive and their ability to assist when on scene. Consideration therefore needs to be given to how the alarm will be raised, both by the quickest means and with an accurate position. Wearing a Personal Locator Beacon provides additional assurance that the alarm can be raised if it has not been possible to deploy the vessel's EPIRB.
7. It is likely to take many hours or even days before SAR assistance can be provided mid-ocean, during which time being able to board a liferaft will be key to survival. In small craft there will be a trade-off between positioning the liferaft so it will deploy automatically in the event of an emergency, and the risk if it deploying accidentally in heavy weather. Whatever solution is chosen, for long passages it might be necessary to make other compromises to ensure that the liferaft is located in the best possible position to ensure its availability in the event of a catastrophic event, such as a sudden capsize.

This flyer and the MAIB's investigation report are posted on our website: www.gov.uk/maib

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Marine Accident Investigation Branch
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