South African Maritime Safety Authority

Ref: **SM6/5/2/1**

Date: 29 March 2012

Marine Notice No. 8 of 2012

Built-in Buoyancy and Alternative Standards for Survivability of Small Vessels – Minimum Requirements for Compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007 (as amended)

TO ALL REGIONAL MANAGERS, PRINCIPAL OFFICERS, SURVEYORS, AUTHORISED AGENTS, SAFETY OFFICERS, BOAT BUILDERS, BOAT DEALERS, BOAT OWNERS AND OTHER INTERESTED AND AFFECTED PARTIES

This Marine Notice replaces paragraph 9 and Annex 5 of Marine Notice 13 of 2011

Summary

This marine notice sets out SAMSA's policy for the provision of arrangements (built-in buoyancy, watertight sub-division or inflatable chamber configuration) on small boats for survivability when fully flooded, swamped or capsized, for compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007.

This marine notice does not apply to small boats which are passenger or pontoon vessels – SAMSA policy for these vessels is dealt with under separate marine notice.

This policy is kept under review and may be amended from time to time as the need arises.

This marine notice sets out SAMSA's policy in terms of the Merchant Shipping (National Small Vessel Safety) Regulations, 2007 (as amended). Regional Managers, Principal Officers and Surveyors must not deviate from this policy without the express permission of the Executive Head: Centre for Boating.

29 March 2012

SM6/5/2/1

Issued by and obtainable from:
The South African Maritime Safety Authority
161 Lynnwood Road
Brooklyn, Pretoria

PO Box 13186
Hatfield 0028

Tel: +27 12 366 2600
Fax:+27 12 366 2601
E-mail: marinenotices@samsa.org.za
Web Site : www.samsa.org.za

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Definitions

"Flooded" is when water ingress into the hull takes place either as a result of damage to the hull or a hull fitting or through the inadvertent opening of a drain plug (bung).

"Swamped" is when the open spaces of a vessel are filled with water either as a result of a wave(s) breaking on top of a boat or the waterline reaching a point on the boat, as a result of loading, heeling forces or "flooding" which allows water to flow freely into the boat.

"Capsize" is when external or internal forces acting on a boat result in it temporarily or permanently tipping/turning over until inverted.

"Survivability" is a boats inherent ability to survive an incident of flooding, swamping and/or capsize.

"Lightweight" is the weight of a completed boat but excluding all fittings and equipment's which are not permanently attached to the boat eg. Outboard engines, fuel, cargo, tools, equipment, crew and crew effects.

"Deadweight" is the weight of all weights making up the fully loaded condition of a boat eg. Outboard engines, fuel, cargo, tools, equipment, crew and crew effects. The total weight of a boat equals the boat "lightweight" plus "deadweight".

1. INTRODUCTION

The Merchant Shipping (National Small Vessel Safety) Regulations, 2007 (NSVR) have a number of prescriptions for small vessels when fully flooded, swamped or capsized to improve the chances of survivability of the crew and vessel following an incident at sea or on inland waters.

This marine notice details SAMSA's policy on acceptable arrangements and methods of achieving compliance with applicable provisions of the NSVR.

2. OPTIONS FOR COMPLIANCE WITH THE NSVR

2.1 The following options are provided for in the NSVR:

NSVR Reg 7, Annex 2, Item 38

Safety item No.	Description of safety appliances and equipment	Category of Vessel					Additional remarks
		A	B	C	D	E&R	
38	Approved self-inflating liferaft capable of carrying all persons on board and stowed on deck or in a readily accessible position.	X	X*	X*	X*	X*	* Not required on vessels, other than passenger vessels, provided the vessel complies with the built-in buoyancy in accordance with Annexure 1, Item 1. Not required for passenger vessels operating solely within the confines of the breakwater of a port. Not required for Category R vessels.

NSVR Reg 6, Annexure 1

1 Built-in Buoyancy

(1) The vessels described below may in lieu of carrying the liferafts contemplated in Annexure 2, be fitted or constructed with built-in buoyancy or comply with other arrangements as follows:

(a) Any category B, C, D and E vessel, other than a passenger vessel, may operate in an unrestricted manner if it has buoyancy built into the vessel which complies with sub items (2) and (3).

(c) Inflatable vessels of any category intending to go to sea, whether fully inflatable, or semi-rigid, may in lieu of the fitted buoyancy be constructed with at least three separate buoyancy chambers and have the capacity to stay afloat despite the largest two of the chambers being completely deflated. For the purpose of this paragraph, the hull of a semi-rigid inflatable vessel is not considered to be one of the three buoyancy chambers required.

(d) Category R vessels may make any suitable and reasonable provisions to ensure that the vessel retains positive buoyancy when fully flooded, swamped or capsized.

(2) Watertight compartments and watertight empty cases are not a substitute for built-in buoyancy referred to in sub item (1): Provided that a decked vessel may, instead of built-in buoyancy, be provided with at least two watertight bulkheads so positioned and of sufficient strength that, in the event of flooding of the largest compartment formed by the bulkheads, the vessel will remain afloat in its worst envisaged load condition with positive transverse stability.

(3) Built-in buoyancy must be capable of keeping the vessel afloat when fully flooded, swamped or capsized. It must be capable of floating the vessel, when capsized, in such a manner as to provide a level platform onto which the full complement can be secured.

3. PARTIALLY EXEMPTED VESSELS

3.1 The NSVR specifies partial exemptions for certain vessel types/operations as follows:

> NSVR Reg 6, Annex 1
> 1(1)(b) Sailing pleasure vessels are exempted from built-in buoyancy on sheltered waters and at sea when operating within 15 miles from shore and within 30 miles of a safe haven, provided that such vessels do not operate at night except for the period within two hours after sunset when within the designated limits of a commercial harbour.
>
> NSVR Reg 6, Annex 1
> 1(1)(e) Vessels participating in an organised event are exempted from the requirements for the duration of the event and whilst practicing for an event under the auspices of an authorised agency or affiliated club.
>
> NSVR Reg 37
> (3) Power-driven vessels not exceeding 15 horsepower, sailing dinghies and non-power driven vessels of less than seven metres in overall length need not comply with regulations 6, 9, Part 4 and Annexure 1, but must -
>
> (a) Have sufficient buoyancy to keep the vessel afloat when completely swamped.

3.2 The exemptions applicable to sailing pleasure vessels and vessels participating/practicing for an organised event are self-explanatory; however, the following comments apply for "Regulation 37" vessels.

a. An engine power indicated as being 15 horsepower, on the engine cover for example, is considered as "not exceeding 15 horsepower".

b. The vessels are required to be provided with buoyancy to keep the vessel positively buoyant when completely swamped ie. Not flooded or capsized. If such swamping results in the vessel flooding and/or capsizing then the buoyancy provisions must also keep the vessel positively buoyant in that condition.

c. When evaluating a vessel's ability to survive complete swamping the same methods used for evaluating non-exempted vessels should be used with the intact sections of the hull considered undamaged and providing buoyancy for the vessel.

4. CONFIRMATION OF VESSEL COMPLIANCE WITH THE NSVR

4.1 From paragraph 2 it can be seen that there are 3 alternatives to the provision of liferafts; viz,

DESCRIPTION	Category of Vessel						Inflatable Vessels	Sailing Vessels
	A	B	C	D	E	R	Cat A to R	Cat A to R
Liferafts	X	X	X	X	X	X(1)	X	X
		or	or	or	or	or	or	or
Built-in Buoyancy		X	X	X	X	X	X	X
		or	or	or	or			or
One-Compartment Flooding		X	X	X	X	X(1)		X
Two Chamber Deflation							X	

<u>Notes</u>:

(1) Acceptable alternative in the event that built-in buoyancy provisions are not provided to keep the vessel positively buoyant in the event of it being completely flooded, swamped or capsized.

4.2 These alternatives for compliance are dealt with under separate headings in the following sections.

5. BUILT-IN BUOYANCY

5.1 The NSVR does not specify the amount of buoyancy required to be installed but does specify the type of damage / occurrence which the vessel must be able to survive (flooded / swamped / capsized) as well as the required vessel status following such damage / occurrence. There are two (2) applicable standards:

a. <u>Category B to E Vessels</u> The built-in buoyancy must be capable of keeping a vessel afloat when fully flooded, swamped or capsized and additionally be capable of floating the vessel, when capsized, in such a manner as to provide a level platform onto which the full complement of the of the vessel can be secured.

b. <u>Category R Vessels</u> The built-in buoyancy must ensure that the vessel retains positive buoyancy when fully flooded swamped or capsized.

5.2 The weights which must be supported in the event a vessel being flooded, swamped or capsized are accordingly different for Category B to E and Category R vessels; viz,

a. <u>Category B to E Vessels</u> the built-in buoyancy must be able to support the weight of the vessel and all other deadweights that will contribute to the weight of the boat in the event of it capsizing. The weight of cargo which will fall out of the vessel in the event of capsize eg. Fish on deck, is therefore not included nor is the weight of the vessel fuel which is lighter than water (SG ≈ 0.85). The weight of the crew must be taken into account as they are required to be supported on the vessel (out of the water).

b. <u>Category R Vessels</u> The vessel is only required to remain positively buoyant when fully flooded, swamped or capsized. The weight of the boat and all other dead weights that will contribute to the weight in the event of it capsizing must therefore be taken into account. The weight of cargo which will fall out of the vessel in the event of capsize eg. Fish on deck, is therefore not included nor is the weight of the vessel fuel which is lighter than water (SG ≈ 0.85). The weight of the crew is also <u>not</u> taken into account as the crew are only required to be able to hold on or cling to the vessel in the water.

5.3 Compliance with the above may either be demonstrated practically or confirmed theoretically.

5.3.1 Practical Testing

5.3.1.1 In the event of the owner (or boat builder) wishing to prove compliance with the NSVR practically, then he or she is required to prepare the vessel in its worst envisaged load condition, substituting components which may be damaged with equivalent weights eg.Sandbags, for the test.

5.3.1.2 A SAMSA surveyor or Authorised Agency Safety Officer must then be contacted and arrangements made for the test to be witnessed and recorded (Practical testing will not be recognised unless witnessed by a SAMSA surveyor or Authorised Agency safety officer).

5.3.1.3 It must be emphasised that practical testing is carried out at the sole risk of the boat owner and that SAMSA will accept no liability for damage(s) which might be incurred as a result of such practical testing.

5.3.2 Theoretical Evaluation

5.3.2.1 An industry norm has been developed, in association with BIASA, which establishes the amount of additional buoyancy to be provided based on the vessels construction and area of operation. The method may be summarised as follows (See Expanded Illustrative Examples – Appendix B):

a. Category B to E vessels

i. Step 1 Determine the weight of vessel comprising of the vessels lightweight plus deadweight when capsized.

ii. Step 2 Determine the amount of additional buoyancy required based on the vessels material of construction ($V_{BIB\ REQUIRED}$).

$V_{BIB\ REQUIRED}$ = Weight x K_{factor}; with K_{factor} = Buoyancy Factor

The following $K_{factor's}$ apply:

Vessel Primary Construction	$\mathbf{K_{factor}}$
Wood or GRP	60%
Steel or Aluminium	100%

iii. Step 3 Determine the volume of spaces in which built-in buoyancy is installed or to be installed.

iv. Step 4 Determine the volume of built-in buoyancy installed based on the permeability of the buoyancy material ($V_{BIB\ INSTALLED}$).

$$\text{Permeability} = \frac{Volume\ of\ \ Built{-}in\ Buoyancy\ in\ Space}{Volume\ of\ Space} \text{ x100 [\%]}$$

v. Step 5 Determine whether the volume of built-in buoyancy provided in the aft 1/3 of the boat ($V_{BIB\ INSTALLED\ (AFT\ 1/3)}$) is greater than the partially submerged weight of the aft 1/3 of the boat in the capsized condition ($V_{BIB\ REQUIRED\ (AFT\ 1/3)}$). For determination of $V_{BIB\ REQUIRED\ (AFT\ 1/3)}$ the following $K_{factors}$ apply:

Description of Weight Element	$\mathbf{K_{factor}}$
Aft 1/3 of Boat; Wood or GRP	30%
Aft 1/3 of Boat; Steel or Aluminium	90%
Engine(s)	85%
1/3 of Crew Complement	100%
Miscellaneous weights (Aft 1/3)	100%

<u>Criteria</u>

If; $V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$

It may be concluded that the volume of built -in buoyancy is sufficient for the vessel to remain afloat in the event of it being flooded, swamped or capsized;

And, if; $V_{BIB\ INSTALLED\ (AFT\ 1/3)} > V_{BIB\ REQUIRED\ (AFT\ 1/3)}$;

it may be concluded that if capsized, the built-in buoyancy is sufficient to create a level platform to which the full complement of the crew can be secured.

Compliance with both criteria is required for Category B to E vessels.

b. Category R vessels

i. Step 1 Determine the weight of vessel comprising of the vessels lightweight plus deadweight when capsized (excluding the weight of the crew).

ii. Step 2 Determine the amount of additional buoyancy required based on the vessels material of construction ($V_{BIB\ REQUIRED}$).

$V_{BIB\ REQUIRED}$ = Weight x K_{factor}; with K_{factor} = Buoyancy Factor

The following $K_{factor's}$ apply:

Vessel Primary Construction	K_{factor}
Wood or GRP	30%
Steel or Aluminium	100%

iii. Step 3 Determine the volume of spaces in which built-in buoyancy is installed or to be installed.

iv. Step 4 Determine the volume of built-in buoyancy installed based on the permeability of the buoyancy material ($V_{BIB\ INSTALLED}$).

Criteria

If; $V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$

then it may be concluded that the volume of built -in buoyancy is sufficient for the vessel to remain afloat in the event of it being flooded, swamped or capsized.

5.3.2.2 Expanded illustrative example of the methods of theoretically calculating or confirming a vessels required buoyancy installation are included as Appendix B.

5.3.3 Alternative Standards

5.3.3.1 There are a number of alternative standards used internationally for the determination of built-in buoyancy requirements on small vessels eg. ABYC, CE, NMMA, ISO.

5.3.3.2 SAMSA will accept any alternative standard provided that it can be shown that the standard applied is at least equivalent to the minimum standard required by the NSVR for the vessel category (B to E or R). Note that it is the responsibility of the owner to prove the equivalence of the alternative standard to SAMSA.

6. TWO CHAMBER DEFLATION (INFLATABLE OR SEMI-RIGID INFLATABLE VESSELS)

6.1 The NSVR states that inflatable or semi-rigid inflatable vessels, may in lieu of fitted buoyancy, be provided with at least three separate buoyancy chambers and have the capacity to stay afloat despite the largest two of the chambers being completely deflated. It further states that the hull of a semi-rigid inflatable may not be considered as a buoyant chamber.

6.2 There is no specific requirement for level flotation, as is required for Category B to E boats provided with built-in buoyancy, and therefore the only difference between Category B to E and Category R vessels is that the weight of the crew must be taken into account for Category B to E vessels and not for Category R vessels.

6.3 Compliance with the above may again either be demonstrated practically or confirmed theoretically.

6.3.1 Practical Testing

The owner may demonstrate compliance with the NSVR practically in the same manner as for a vessel fitted with Built-in Buoyancy, but with the two largest buoyancy chambers of the inflatable vessel deflated (See paragraph 5.3.1).

6.3.2 Theoretical Evaluation

6.3.2.1 Compliance with the NSVR may be theoretically confirmed as follows (See Illustrative examples – Appendix C):

a. Step 1 Determine the weight of vessel comprising of the vessels lightweight plus deadweight when capsized.

b. Step 2 Determine the amount of additional buoyancy required based on the vessels material of construction ($V_{BIB\ REQUIRED}$).

$V_{BIB\ REQUIRED}$ = Weight x K_{factor}; with K_{factor} = Buoyancy Factor

The following $K_{factor's}$ apply:

Vessel Category	K_{factor}	Remarks
B to E	60%	
R	30%	Weight of Crew Excluded

c. Step 3 Assume that the largest two chambers of the boat are completely deflated and calculate the volume of the remaining chamber(s);
($V_{BIB\ INSTALLED}$).

Criteria

If; $V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$;

it may be concluded that the volume of built -in buoyancy is sufficient for the vessel to remain afloat with the largest two chambers completely deflated.

6.3.2.2 It should be noted that in the case of semi-rigid inflatable boats, the volume of the hull may only be included in the calculation of $V_{BIB\ INSTALLED}$ if built-in buoyancy is installed in the hull in which case the volume of buoyancy is calculated in accordance with the provisions of paragraph 5 above.

6.4 An expanded illustrative example of the method of theoretically confirming compliance with the two chamber deflation criteria is included as Appendix C.

7. ONE COMPARTMENT FLOODING (DECKED VESSELS)

7.1 The NSVR states that a decked vessel may, instead of built-in buoyancy, be provided with at least two watertight bulkheads so positioned and of sufficient strength that, in the event of flooding of the largest compartment formed by the bulkheads, the vessel will remain afloat in its worst envisaged load condition with positive transverse stability.

7.2 It can be seen that boats complying with this standard are only required to comply with flooding of the largest compartment - there is no requirement for the vessel to survive swamping or capsize. The loads to be taken into account differ therefore from the built-in buoyancy and two chamber deflation alternatives in that the vessel must remain afloat with positive transverse stability (may not capsize). All deadweight loads must therefore be taken into account including the full weight of any cargo and the fuel.

7.3 For this standard there is no difference for application between Category B to E and Category R vessels.

7.4 Compliance with the above may again either be demonstrated practically or confirmed theoretically.

7.4.1 Practical Testing

7.4.1.1 The owner may demonstrate compliance with the NSVR practically in the same manner as for a vessel fitted with Built-in Buoyancy (See paragraph 5.3.1), but with the flooding of the largest watertight compartment simulated.

7.4.1.2 Flooding is simulated by filling the largest watertight compartment to a point where the level of the water inside the vessel is equal to that outside the vessel thus simulating a damage scenario, with the vessel in its worst loaded condition.

7.4.2 Theoretical Evaluation

7.4.2.1 Except in cases where relatively small changes in the vessel draught occur as a result of flooding, determination of theoretical compliance with the NSVR is not easily achieved without use of a hydrostatics program.

7.4.2.2 Owners wishing to demonstrate theoretical compliance with the one compartment flooding criteria should contract the services of a naval architect to make a theoretical submission to SAMSA for approval.

7.5 Owners/builders electing to configure a boat with watertight bulkheads must bear in mind that:

a. Special attention needs to be made to ensure that the bulkheads are watertight and that any penetrations for pipes and/or electrical cabling are sealed watertight.

b. The NSVR (Reg 6, Annex 1.11 – Bilge Pumping Arrangements) prescribes that bilge pumping arrangements must be provided to pump out all compartments in a vessel with the exception of compartment(s) used exclusively for catches of fish which can be flooded without adversely affecting the vessels buoyancy or stability. Special consideration therefore needs to be given to compliance with this requirement while still maintaining the integrity of the watertight bulkheads.

8. DOCUMENTING BUILT-IN BUOYANCY (BUOYANCY CERTIFICATES)

8.1 The following NSVR provisions apply:

> NSVR Reg 6, Annex 1.1
>
> 1(4) It is the duty of the owner of a vessel to show, by certification, calculation or test that –
>
> (a) A vessel with watertight bulkheads complies with sub-item (2);
> (b) A vessel with built-in buoyancy complies with sub-item (3);
> (c) An inflatable vessel with buoyancy chambers complies with subitem (1)(c)
>
> NSVR Reg 6
>
> (3) It is an offence to sell a vessel that does not comply with the construction requirements of these regulations except where accompanied by a letter or certificate detailing the extent to which the vessel does not or cannot comply.

8.2 The NSVR require that owners be able to demonstrate to a surveyor, safety officers or any enforcement officer (SAPS, municipal police or any other designated enforcement officer) that their vessel complies with the NSVR which includes the relevant buoyancy standards.

8.3 From the previous sections it can be seen that practical or theoretical confirmation of the adequacy of a vessel's built-in buoyancy is a relatively lengthy process which cannot practically be demonstrated on each occasion that a survey (periodic or ad-hoc) is carried out.

8.4 It is accordingly required that owners maintain a <u>valid buoyancy certificate</u> for their vessel which can be produced at the time of survey or when required by another authorised person. Valid buoyancy certificates are required for all vessels to which the NSVR applies with the exception of the following vessel types:

a. Vessels carrying approved liferafts for the full number of persons carried.

b. Partially exempted vessels (See paragraph 3)

c. Passenger vessels - Stability book/statement required.

d. Vessel's under 3 metres in length*.

e. Personal water craft (Jet-ski's) for Category R operations, provided that the vessel has not been modified from its as-built configuration*.

<u>Note</u>: * *While SAMSA does not specifically require the provision of buoyancy certificates for the above-mentioned vessel types/operations, this does not exempt vessels from being required to comply with relevant sections of the NSVR and owners may be required to demonstrate compliance at the time of survey*

(For certain vessels it might be considered prudent to generate a buoyancy certificate to save time and costs at the time of survey).

9. FORM OF BUOYANCY CERTIFICATE

9.1 Buoyancy certificates issued by SAMSA are issued in a prescribed manner. There are in essence three (3) different formats which are illustrated in Appendix A, for:

a. Vessels provided with Built-in buoyancy;

b. Inflatable boats; and,

c. Vessels provided with watertight bulkheads.

9.2 Where SAMSA surveyors or Authorised Agency safety officers and inspectors are presented with alternative documentation produced by other parties, the buoyancy certification may only be accepted if it complies with the following provisions:

a. It must be clear who the issuer is eg. Boat builder, surveyor, safety officer, owner, etc.

b. The vessel must be clearly identified by photograph, serial number or similar.

c. The basic dimensions and build details of the vessel must be included to aid the reader with not only identifying the vessel but also with detecting vessel alterations which may affect the validity of the buoyancy certificate.

d. The quantity, type and distribution of buoyancy must be described in detail.

e. The lightweight (weight of boat, excluding engines, crew, equipment, etc) of the vessel must be listed as this is an effective method of monitoring absorbency or water retention of either foam or bottles.

f. The certificate must attest to compliance with the requirements of the NSVR Reg 6, Annex 1 or conversely state exactly what is being certified.

g. Any limitations, conclusions, or comments must be clearly noted eg. Validity period of installed buoyancy, particularly in the case of bottles which have a limited lifespan.

h. The buoyancy certificate must be endorsed by the person installing or supervising the installation of built-in buoyancy. On existing vessels, the person evaluating the buoyancy must specifically ensure that the built-in buoyancy is in fact installed – Assumptions based on a “Declaration” by the owner, for example, are not acceptable, even if signed by a Commissioner of Oaths (Existing “Buoyancy Declarations” have the same status as “Buoyancy Certificates” and in the event that the information required by this section is not provided on the “Buoyancy Declaration”, the owner may be required to generate a new “Buoyancy Certificate” and/or confirm the indicated Built-in Buoyancy provisions on the vessel.

10. ACCEPTABLE MATERIALS FOR USE AS BUILT-IN BUOYANCY

10.1 NSVR, Reg 6, Annex 1.1(3) states that built-in buoyancy must consist of a material such as foam, or approved plastic bottles that are not affected by oil or oil products.

10.2 The versatility of polymers makes it difficult to specify acceptable materials by material type only and a list of acceptable materials which may be used as built-in buoyancy is included as Appendix D.

10.3 Existing vessels which are not provided with buoyancy materials listed in Appendix D may continue to use such materials provided that the materials are inspected annually and found to be in satisfactory condition. Material found not to be in satisfactory condition must be replaced with materials listed in Appendix D.

10.4 New vessels must be provided with buoyancy materials listed in Appendix D.

10.5 Boat builders are encouraged to be innovative with built-in buoyancy installations - The ideal buoyancy installation would be one which rendered the vessel unsinkable and resulted in the vessel self-righting and draining in the event of capsize. Boat builders wishing to use alternative buoyancy materials must however submit their proposal to SAMSA for approval prior to installing such materials.

11. INSTALLATION OF BUILT-IN BUOYANCY

11.1 The ideal time for the installation of built-in buoyancy is at the time of the vessel being built, however, retrofit of buoyancy may be required for existing vessels or vessels which are modified or damaged.

11.2 While the installation of buoyancy must be carried out by a person(s) competent to perform the work, SAMSA does not accredit persons or organisations as built-in buoyancy installers.

11.3 A credible buoyancy certificate must however be provided by persons installing or evaluating built-in buoyancy installations. The buoyancy certificate must reflect the installed built-in buoyancy or alternative provision for vessel survival following damage and must be retained on board the vessel for evaluation by SAMSA surveyors, Authorised Agency safety officers and enforcement officers at the time of survey or inspection.

11.4 In the event that sub-standard installations are identified at the time of survey or any other intervention SAMSA may carry out an appropriate investigation in accordance with provisions of the Merchant Shipping Act, Act 57 of 1951, which may result in action being taken against the installer/evaluator of the buoyancy (The person who has endorsed the buoyancy certificate).

12. INSPECTION OF BUILT-IN BUOYANCY PROVISIONS

12.1 Surveyors and safety officers are required to confirm the vessel’s provisions for survivability in the event of flooding, swamping or capsize, as appropriate to the vessel category and survivability provision, at every survey.

12.2 For built-in buoyancy installations there are three (3) important considerations:

a. Are the relevant vessel weights correct (lightweight and/or deadweight)?

The owner should have supporting information for the lightweight of the boat eg. Weighbridge certificate and in the event that the surveyor doubts the credibility of the weight(s) listed on the “Buoyancy Certificate” he/she may require that the vessel be re-weighed.

b. Is the buoyant material actually installed on the boat?

Two (2) situations could occur:

i. The amount of buoyancy installed could be overstated. If the surveyor considers that it is not possible for the indicated amount of buoyancy to be installed in a space, he/she should calculate the volume of the space(s) using the methods described in Appendix B for confirmation.

ii. The vessel might not be provided with any buoyancy. The surveyor must prudently evaluate the buoyancy certificate and any supporting information which the owner might have (eg. photogaraphs) against the vessel presented. In the event that the surveyor suspects that the indicated buoyancy is not installed then he/she may require partial opening of the space(s) for physical inspection thereof.

c. Is the buoyant material in satisfactory condition?

All materials are subject to deterioration. The surveyor should take the recommendations of the person originally generating the buoyancy certificate as well as the recommended periods between inspections provided in Appendix D when considering the extent of inspection required. The type of built-in buoyancy provided should also impact on the vessel inspection arrangements ie. If a vessel is provided with PET bottles, required to be inspected annually, then inspection hatches to all spaces containing bottles on the boat should be provided. If, however, the boat hull is filled with closed cell polyurethane foam and the deck sealed then the following options would be more suitable for inspection:

i. Weigh the boat and compare the lightweight with that contained on the buoyancy certificate.

ii. Make a small opening in the deck and take a core sample of the foam

12.3 In general, complete lifting of the deck of a boat for inspection of a buoyancy installation should only be carried out in the event that the surveyor has sound reason to believe that the indicated buoyancy is either not installed or is no longer fit for purpose due to water absorption for example.

13. INSPECTION OF OTHER SURVIVABILITY PROVISIONS

13.1 Vessels provided with means other than built-in buoyancy for survivability in the event of damage ie. watertight sub-division or two chamber deflation are subject to similar inspections at the time of survey ie.

a. The weights (lightweight and/or deadweight) indicated on the buoyancy certificate must be confirmed correct.

b. Indicated watertight bulkheads must be confirmed watertight or in the case of inflatable vessels, the baffles sub-dividing each air chamber must be confirmed as not being defective.

13.2 Surveyors and safety officers must bear in mind that partial exemptions apply for certain vessel operations (See paragraph 3).

14. CONCLUSION

14.1 The importance of installing the requisite amount of Built-in Buoyancy in a boat or ensuring compliance with an alternative standard provided for in the NSVR should be clear to boat builders and owners – A boat which is in compliance with the NSVR has a significantly improved chance of survivability in the event of an incident at sea or on sheltered waters.

14.2 The provision of a Buoyancy Certificate complying with the provisions of this marine notice will further ensure peace of mind for the owner and enable surveyors, safety officers and other authorised persons to carry out requisite surveys and inspections of small boats with the minimum of inconvenience and potential cost to the owner.

14.3 This marine notice communicates SAMSA’s policy on arrangements to be provided for survivability, in the event of being fully flooded, swamped or capsized, on vessels subject to the Merchant Shipping (National Small Vessel Safety) Regulations, 2007 which are aimed at ensuring the safety of life and property at sea. This policy is accordingly kept under review and may be amended from time to time as the need arises.

APPENDIX A

BUILT-IN BUOYANCY CERTIFICATE EXAMPLES

SMALL VESSEL
BUOYANCY CERTIFICATE

CERTIFICATE TYPE – BUILT-IN BUOYANCY (DECKED VESSEL) – Cat B to E

Vessel Name: FISHY STORY	Vessel No. DTC 1234D

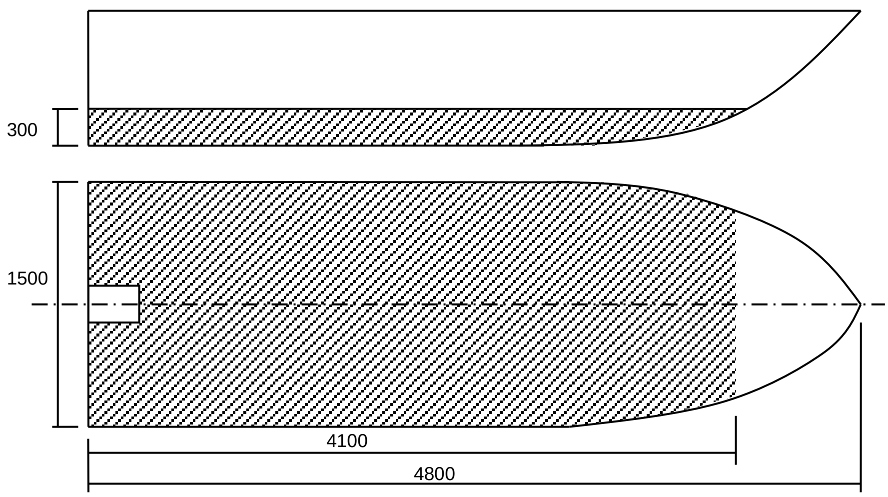
Description:
4.8m Monohull GRP small fishing vessel.

Build Details	Principal Dimensions
Builder: ###### Marine	Length Overall: 4.80 [m]
Date of Build: 2005/6	Breadth Overall: 2.10 [m]
Model: 16' ######## Ski	

Propulsion
1. The recommended propulsion for the vessel is 2 x 40 hp outboard engines
2. The maximum allowable weight of the outboard motors fitted may not exceed 160kg.

Built-in Buoyancy

1. The underdeck of the vessel is filled with closed cell polyurethane foam as is indicated on the sketch below.
   Volume ≈ 0.926 m^3



Design Weight

Light weight:	650 kg	Deadweight	
		2 x Outboard Engines (2 x 70 kg)	140 kg
		4 x Crew (4 x 75 kg)	300 kg
Deadweight	590 kg	Crew Effects/Equipment	150 kg
Maximum Weight	1240 kg		

➔ Foam Volume = 0.926 m^3 ≈ 926 kg
➔ Maximum vessel weight = 1240 kg

Conclusion and Comments

1. Percentage of Built-in Buoyancy provided (With crew and effects) ≈ 74.7%.
2. The vessel may be expected to remain afloat when fully flooded, swamped or capsized and when capsized, provide a level platform to which the full complement of the vessel can be secured.
3. Vessel buoyancy provisions satisfactory for category B to R operations.
4. This buoyancy certificate should be retained on board with the vessels Local General Safety Certificate or Certificate of Fitness.
5. Partial inspection of the buoyancy installation should be carried out every 5 years provided that the hull is not damaged.

____________________________ ________________________
Boat Builders Representative Date

SMALL VESSEL
BUOYANCY CERTIFICATE

CERTIFICATE TYPE – BUILT-IN BUOYANCY (DECKED VESSEL) – Cat R

Vessel Name: ##########	Vessel No. DTC 1234R

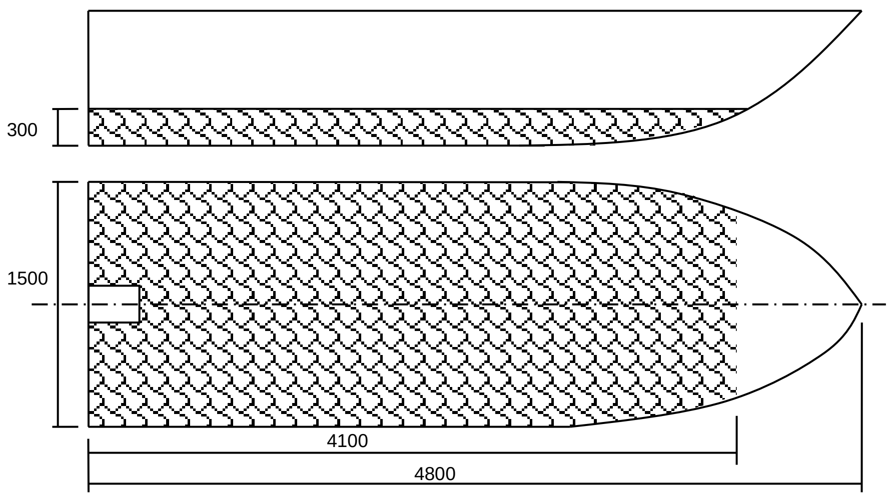
Description:
4.8m Monohull GRP small fishing vessel.

Build Details	Principal Dimensions
Builder: ###### Marine	Length Overall: 4.80 [m]
Date of Build: 2005/6	Breadth Overall: 2.10 [m]
Model: 16' ######## Ski	

Propulsion
1. The recommended propulsion for the vessel is 2 x 40 hp outboard engines
2. The maximum allowable weight of the outboard motors fitted may not exceed 160kg.

Built-in Buoyancy

1. The underdeck of the vessel is filled with 480 x 750 ml PET bottles as is indicated on the sketch below.
   Volume ≈ 0.360 m^3



Design Weight

Light weight:	650 kg	Deadweight	
		2 x Outboard Engines (2 x 70 kg)	140 kg
Deadweight	290 kg	Crew Effects/Equipment	150 kg
Maximum Weight	940 kg		

➔ Volume Bottles = 0.360 m^3 ≈ 360 kg
➔ Maximum vessel weight = 940 kg

Conclusion and Comments

1. Percentage of Built-in Buoyancy provided (excluding crew) ≈ 38%.
2. The built-in buoyancy provisions are sufficient to ensure that the vessel will remain positively buoyant when fully flooded, swamped or capsized. The provisions will not support the weight of the crew who should be able to hold on / cling to the vessel in the water.
3. The vessel buoyancy provisions suitable for Category R operations.
4. This buoyancy certificate should be retained on board with the vessels Local General Safety Certificate or Certificate of Fitness.
5. Partial inspection of the buoyancy installation should be carried out every 5 years provided that the hull is not damaged.

Boat Builders Representative   Date

SMALL VESSEL
BUOYANCY CERTIFICATE

CERTIFICATE TYPE – BUILT-IN BUOYANCY (UNDECKED VESSEL) – Cat B to E

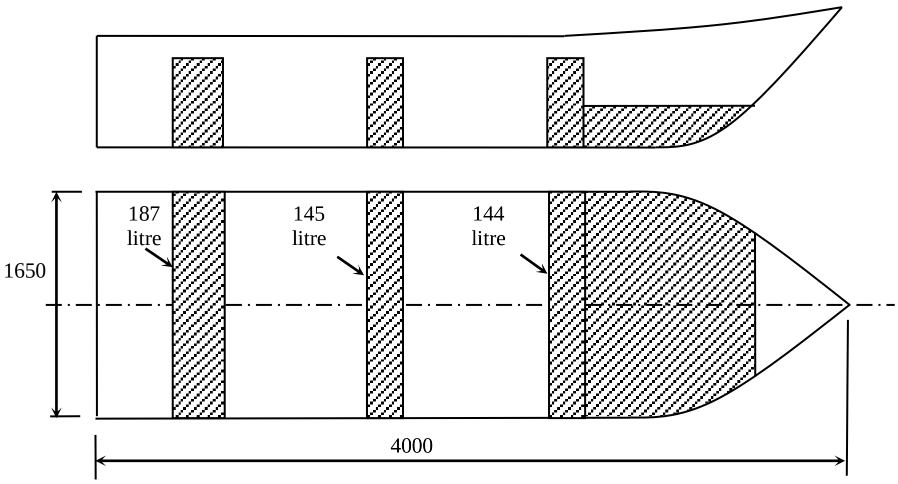
Vessel Name: FISHY STORY	Vessel No. DTC 1234E

Description:
Small monohull GRP fishing vessel.

Build Details	Principal Dimensions
Builder/Model: ####	Length Overall: 4.00 m
Date of Build: Not Known	Breadth Overall: 1.65 m

Propulsion
1. The recommended propulsion for the vessel is 1 x 30 hp or 1 x 40 hp outboard engine.
2. The maximum allowable weight of the outboard motors fitted may not exceed 80kg.

Built-in Buoyancy
1. The vessel is provided filled with foam in the seats and in the forward part of the boat as is indicated on the sketch.
   Foam Type: Closed cell polyurethane foam.
2. Total Volume of Foam ≈ 0.476 m^3 = 476 litres



Design Weight

Light weight:	290 kg	
Deadweight	427 kg	
Maximum Weight	717 kg	

Deadweight

1 x Outboard Engines (2 x 50 kg)	77 kg
4 x Crew (4 x 75 kg)	300 kg
Equipment	50 kg

➔ Foam Volume = 426 litres ≈ 476 kg
➔ Maximum vessel weight = 717 kg
➔ Installed Additional Buoyancy ≈ 66.4%

Conclusion and Comments

1. Ratio of vessel built-in buoyancy to maximum vessel weight (With crew and effects) ≈ 66.4%.
2. The vessel may be expected to remain afloat when fully flooded, swamped or capsized in such a manner as to provide a level platform onto which the full complement of the vessel can be secured.
3. Vessel buoyancy provisions satisfactory for category B to R operations.
4. Partial inspection of the buoyancy installation should be carried out every 5 years provided that the hull is not damaged.

(Signature of Person Installing or Supervising Installation of Built-in Buoyancy) Date

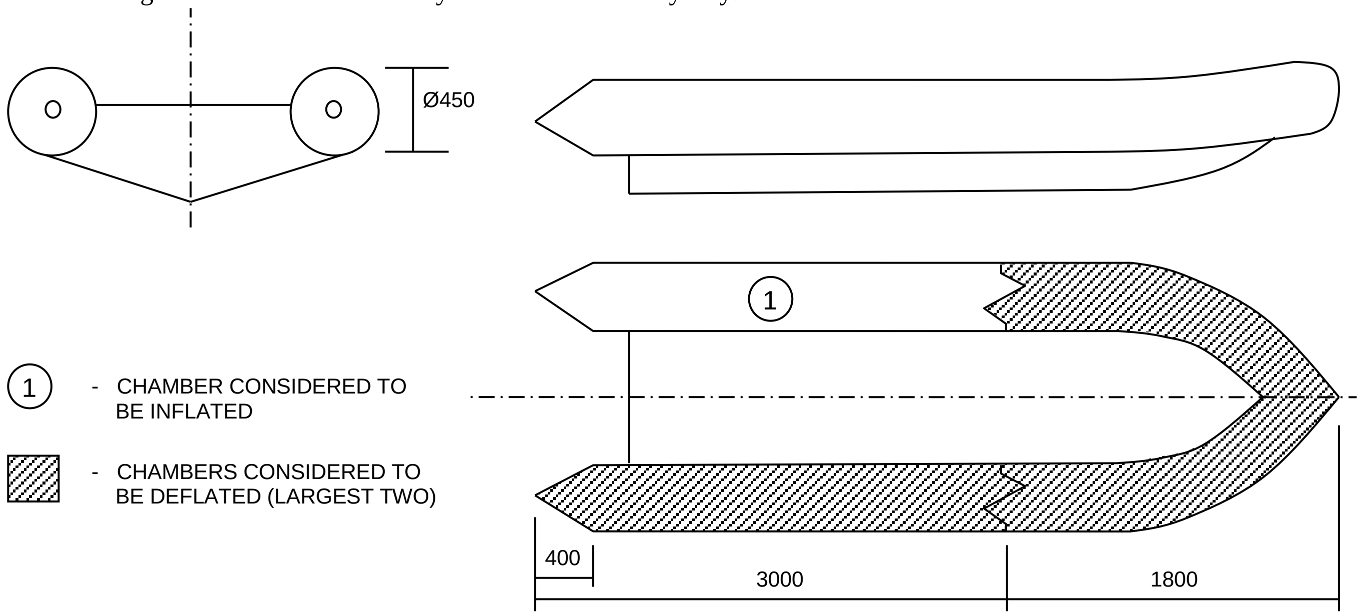
SMALL VESSEL
BUOYANCY CERTIFICATE

CERTIFICATE TYPE – INFLATABLE BOAT / RIGID HULLED INFLATABLE BOAT – Cat B to E

Vessel Name: #######	Vessel No. #######
Description: Small RHIB - GRP rigid hull with hypalon sponsons.	
Build Details Builder/Model: Wildcat Date of Build: Not Known	Principal Dimensions Length Overall: 4.80 m Breadth Overall: 1.50 m

Propulsion
1. The recommended propulsion for the vessel is 1 x 60 hp or 2 x 40 hp outboard engine.
2. The maximum allowable weight of the outboard motors fitted may not exceed 80kg.

Buoyant Chambers
1. The vessel is provided with three (3) buoyant chambers as is indicated on the sketch below.
2. Total rigid hull is not filled with any form of built-in buoyancy.



Design Weight
Light weight: 280 kg

Deadweight
1 x Outboard 60 hp engine 80 kg
4 x Crew (4 x 75 kg) 300 kg
Equipment 50 kg

adweight 430 kg

Total Weight 710 kg

➔ Volume of Inflated Chamber (Largest 2 Deflated) = 435 litres

Maximum vessel weight = 710 kg

➔ Inflated Chamber Buoyancy Percentage ≈ **61.3%**

Conclusion and Comments

1. Percentage of buoyancy provided with 2 largest chambers deflated (With crew and effects) ≈ 61.3%.
2. The vessel may be expected to remain afloat despite the 2 largest chambers being fully deflated.
3. Vessel buoyancy provisions satisfactory for category B to R operations.
4. This buoyancy certificate will remain valid for the duration of the vessels life provided that the vessel configuration is not changed and the pontoons and baffles are maintained in good condition.
5. This buoyancy certificate should be retained on board with the vessel's Local General Safety Certificate or Certificate of Fitness.

(Signature of Person Evaluating Vessel Buoyancy) Date

SMALL VESSEL
BUOYANCY CERTIFICATE

CERTIFICATE TYPE – WATERTIGHT SUB-DIVISION (DECKED VESSEL)

Vessel Name: FISHY STORY

Vessel No. DTC 1234D

Description:
4.8m Monohull GRP General Purpose/Patrol vessel.

Build Details

Builder:	###### Marine
Date of Build:	2004
Model:	16’ ######## Ski

Principal Dimensions

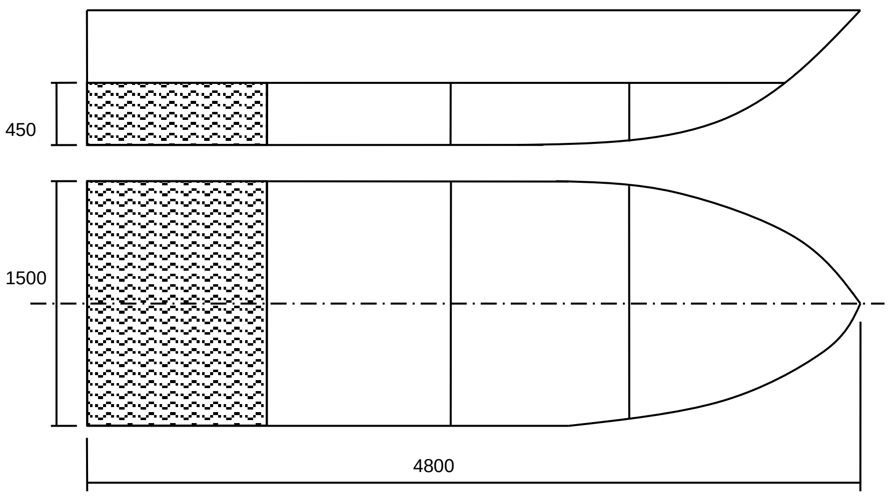
Length Overall:	4.80 [m]
Breadth Overall:	2.10 [m]
Depth (Gunnel to USK):	1.05 [m]

Propulsion

1. The recommended propulsion for the vessel is 2 x 40 hp outboard engines
2. The maximum allowable weight of the outboard motors fitted may not exceed 140kg.

Watertght Sub-division

1. The decked vessel is provided with three (3) x watertight bulkheads as is indicated on the sketch below.
2. The largest compartment formed by the watertight bulkheads is the aft compartment (shaded below).



Deadweight (Worst case loaded Condition)

2 x Outboard Engines (2 x 70 kg)	140 kg
4 x Crew (4 x 75 kg)	300 kg
Fuel (2 x25 litre)	50 kg
Crew Effects/Equipment	150 kg
	640 kg

Conclusion and Comments

1. Vessel survivability practically demonstrated by filling the aft compartment with sea water to a point where the water level inside the compartment was equal to that outside the compartment (Test witnessed by the undersigned surveyor/safety officer).
2. The vessel remained afloat with positive transverse stability in the indicated worst case load condition.
3. The indicated watertight bulkheads must be maintained in a watertight condition at all times.
4. Means must be provided for the skipper to confirm the condition of the watertight compartments prior to every voyage.
5. This buoyancy certificate should be retained on board with the vessels Local General Safety Certificate or Certificate of Fitness.

SAMSA Surveyor/ Authorised Agency Safety Officer

Date

APPENDIX B

BUILT-IN BUOYANCY CALCULATION

ILLUSTRATIVE EXAMPLES

Built-in Buoyancy Calculation

Illustrative Example

Conventional Monohull or Multihull Vessel

INTRODUCTION

This illustrative example consists of three (3) sections. Section 1 is an expanded illustrative example and provides clear guidance on the manner in which a theoretical built-in buoyancy calculation should be carried out. Persons understanding the principles presented in section 1 will be able to provide clear guidance on the amount, type and position of built-in buoyancy required to be provided in a boat which is to be built or retro-fitted, for compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007 and also to accurately assess the the validity of a vessels Buoyancy Certificate.

Sections 2 and 3 are a repeat of the illustrative example of section 1 but aimed primarily at providing guidance to surveyors in the field on how to carry out a simple evaluation of the correctness of a buoyancy certificate presented at the time of survey (Section 2 – Category B to E vessels; Section 3 – Category R vessels).

Persons conducting surveys/inspections on behalf of SAMSA are expected to have a sound understanding of Sections 1, 2 and 3 and it is recommended that section 1 be reviewed first followed by Sections 2 and 3.

SECTION 1 – EXPANDED ILLUSTRATIVE EXAMPLE

Applicability of the Method Prior to carrying out the evaluation, the surveyor must be satisfied that the method may be applied to the concerned vessel.

This method may be used for vessels of standard construction. Special care must be exercised for vessels of novel construction, in particular where step changes occur in the hull construction and/or the vessel has an asymmetric hull shape.

This method may further be used for vessels of wood, GRP, steel or aluminium construction, provided that the correct buoyancy factor (Kfactor) is used (See Step 2).

The hull volume calculation using Simpsons 2^{nd} Rule is only considered valid for vessel deck lengths of less than 15m ie. h/3 < 5m.

SAMSA should be contacted where doubt exists over the validity of the method.

Steps 1 to 5 should be followed for Category B to E vessels and Steps 1 to 4 should be followed for Category R vessels (Level flotation and support of crew in the event of capsize not required for Category R vessels).

STEP 1 - Determine the Total Weight of the Boat when Capsized

This is most easily achieved by measuring the lightweight of the boat and then adding to it the Deadweight (Weight of engines, crew, equipment, etc).

Lightweight of the Boat The most accurate method of establishing the vessel weight is to take the boat and trailer to a weigh-bridge and to obtain a weight print-out. The boat should then be removed from the trailer and a second weight printout obtained. The boat weight can then be determined by deducting the trailer weight from the boat and trailer weight.

An alternative method could be to suspend the boat from slings from a crane or gantry with a calibrated load cell fitted in line.

Eg.	Boat and trailer Weight =	2436 kg
	Less Trailer Weight =	824 kg
	Less Engines Weight =	200 kg
	Boat Weight =	1412 kg

Note: It is important for the owner to maintain a record of the boats lightweight as this is one of the best methods of confirming whether built-in buoyancy eg. Foam is retaining water and making the boat heavier.

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

Deadweight of the Boat Weights which are expected to remain on board and contribute to the weight of the vessel in the event of capsize must be taken into account. These weights include the weight of the engines, crew (Cat B to E vessels only, not Cat R), cargo, equipment, etc. Cargo which will fall free of the vessel in the event of capsize eg. Fish, is excluded from the calculation. Fuel is also excluded due to it being lighter than water SG ≈ 0.85.

Eg.	Crew (x5) = 5 x 75kg =	375 kg	
	Engines (2 x 100kg) =	200 kg	
	Equipment =	200 kg	(Anchor, Equipment, Safety Equipment, etc)
	Total =	775 kg	

Note: In the example shown, the boat was weighed with the engines attached. The engine weights were then deducted to obtain the boat lightweight and then added as deadweight.

Determine the Total Weight of the Boat

Eg. Total Weight = Lightweight + Deadweight
= 1412 kg + 775 kg
= 2187 kg

STEP 2 - Determine the Additional Volume of Built-in Buoyancy (BIB) Required to be Provided for the Boat $V_{BIB\ REQUIRED}$

Additional Weight of BIB Required = Total Weight of Boat x K_{factor}

with; K_{factor} to be used based on the primary construction material of the boat; viz,

Category B to E Operation
- Wood and/or GRP Construction - K_{factor} = 60%
- Steel and/or Aluminium Construction - K_{factor} = 100%

Category R Operation (Weight of Crew not considered)
- Wood and/or GRP Construction - K_{factor} = 30%
- Steel and/or Aluminium Construction - K_{factor} = 100%

Eg. The boat is of GRP construction and is to be used for Category C operations

Therefore;

Additional Weight of BIB Required = Total Weight of Boat x K_{factor}
= 2187 x 60%
= 1312.2 kg

To convert the "Additional Weight of BIB Required" to $V_{BIB\ REQUIRED}$ we need to know the specific gravity (SG) of the liquid which the boat will be operating on which will normally be either Sea Water or Fresh Water. $V_{BIB\ REQUIRED}$ is then calculated from the following formula:

Weight = SG x Volume

And therefore; Volume = Weight/SG

Sea water has an average SG of 1.025 and Fresh water an average SG of 1.0. These SG's may be specifically used, however, due to the small difference an SG of 1.0 should be used for calculation purposes ie.

Volume = Weight/1.0

Therefore; Volume = Weight

or; $V_{BIB\ REQUIRED}$ = Additional Weight of BIB Required

Continuing with the Illustrative Example;

$V_{BIB\ REQUIRED}$ = 1312.2 / 1.0
= 1312.2 [litres] or 1.312 [m^3]

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

STEP 3 - Determine the Volume of Built-in Buoyancy which is installed or is to be installed ($V_{BIB\ INSTALLED}$)

This illustrative example may be used by persons planning to install Built-in Buoyancy (BIB) or persons evaluating an existing BIB installation. Persons installing BIB are at an advantage as following from Step 2, it will be known how much additional BIB must be installed and it is then only a matter of deciding where to place the BIB so that level flotation is achieved (See Step 5).

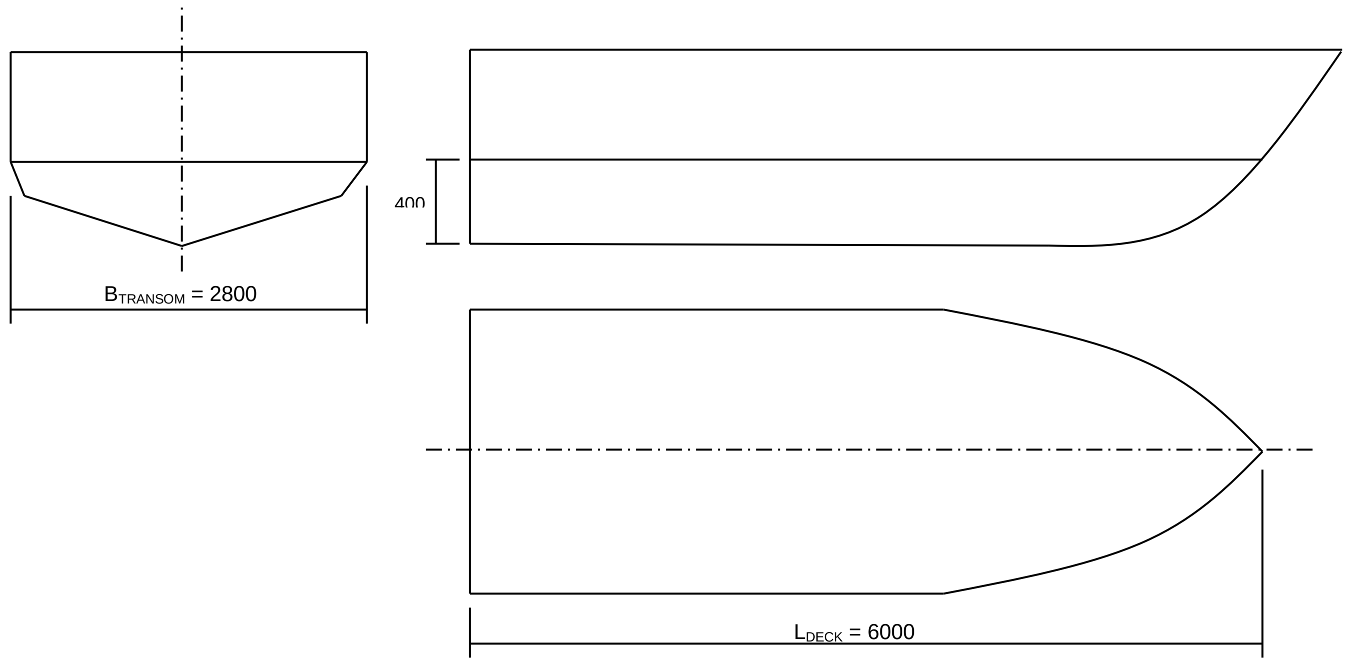
It is however less easy for an existing installation to be evaluated, primarily due to the fact that the installed BIB, particularly under the deck, is normally not visible. The volumes of other spaces in which BIB is installed such as under seats or gunwales is normally relatively easily calculated due to the geometry of the shape(s). The volume under the hull is however less easily calculated due to the hull shape.

Once the below deck volume and volume of other spaces containing BIB has been calculated the actual volume or “permeability” of the type of BIB installed must also be taken into account.

Methods of calculating the deck volumes and taking the type of BIB installed into account are therefore addressed in this section.

Calculating the Below Deck Volume

For the illustrative example a monohull chined vessel is considered (See below):



Drawing 1 - Simple sketch of Monohull

There are numerous ways in which the below deck volume of the hull can be calculated:

Method 1 - Prismatic Coefficient Method

Method 2 - Simpson’s Rule Method

Method 3 - Geometric formula Method

Method 4 - Computer Model Method

Method 5 - Miscellaneous Methods

The various methods are illustrated/discussed below:

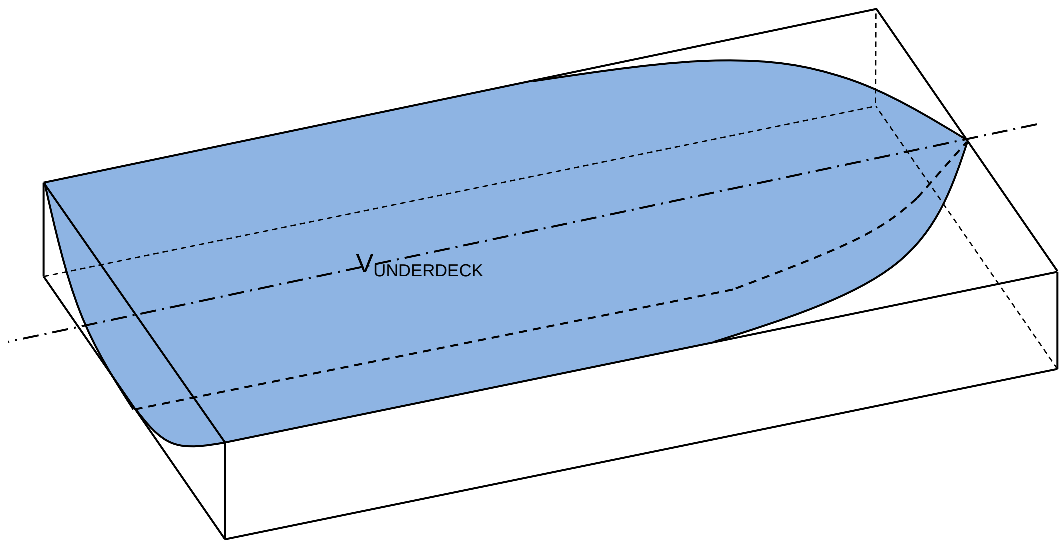
Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

Method 1 – Prismatic Coefficient Method

The prismatic coefficient method uses an assumed prismatic coefficient (Cp) for the hull, where;

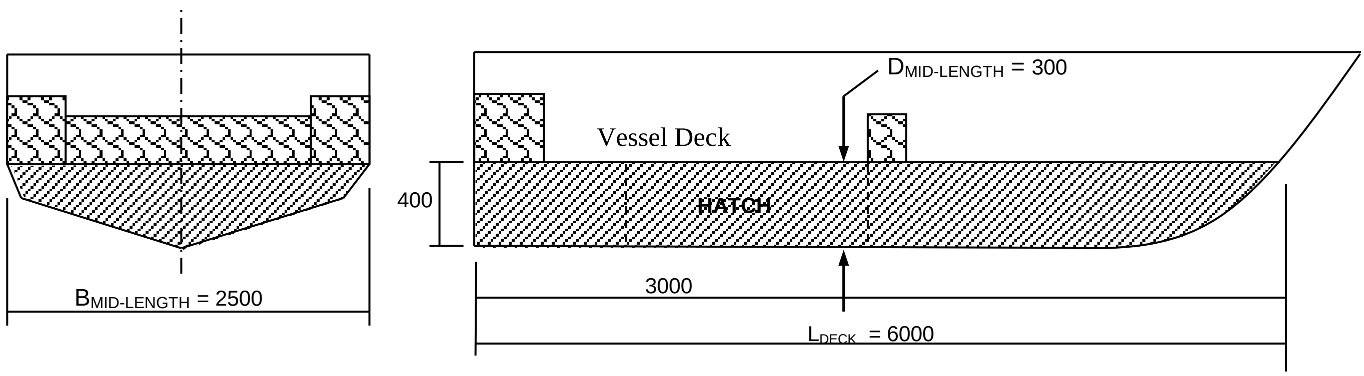
Prismatic coefficient, $Cp = \frac{Volume\ Hull}{Volume\ Box\ (Prism)}$

Therefore; *Volume Hull Underdeck* = Cp x Volume Box (Prism)
= Cp x (L_{DECK} x $B_{MID\text{-}LENGTH}$ x $D_{MID\text{-}LENGTH}$)



Drawing 2 - Illustration of Prismatic Coefficient, Cp – Volume of Hull vs Volume of Box (Prism)

For a conventional hull shape where the bow section is included in the hull volume calculation, Cp = 0.6 may be used. For a conventional hull shape where the bow section is **not** included in the hull volume calculation, Cp = 0.65 may be used.



Drawing 3 - Two dimensional sketch of illustrative example vessel

For the example: L_{DECK} = 6.00 [m]
$B_{MID\text{-}LENGTH}$ = 2.50 [m]
$D_{MID\text{-}LENGTH}$ = 0.30 [m]

Therefore: $V_{UNDERDECK}$ = $Cp \times (L_{DECK} \times B_{MID\text{-}LENGTH} \times D_{MID\text{-}LENGTH})$

$= 0.6 \times (6.00 \times 2.50 \times 0.30)$

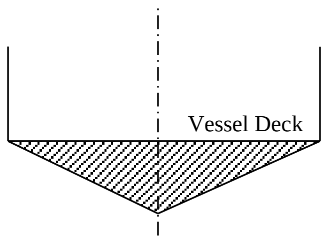
$= 0.6 \times (4.50)$

$= \underline{2.70\ [m^3]}$

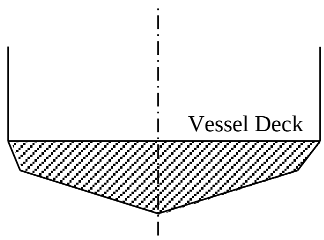
<u>Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)</u>

<u>NB</u> - The prismatic coefficient method may only be used on conventional shaped hulls. For the hull shapes shown below, following comments apply:

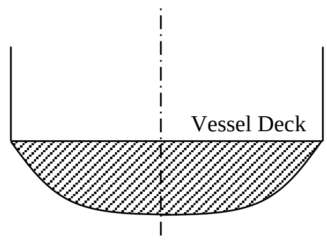
a.	Monohull shapes -	The hulls may be regarded as conventional.
b.	Symmetrical catamaran -	The individual hulls may be regarded as conventional.
c.	Assymetrical catamaran -	Not regarded as conventional. Simpson’s or other method to be used for hull volume calculation.
d.	Pontoon Hulls -	Not regarded as conventional. Simpson’s or other method to be used for hull volume calculation.



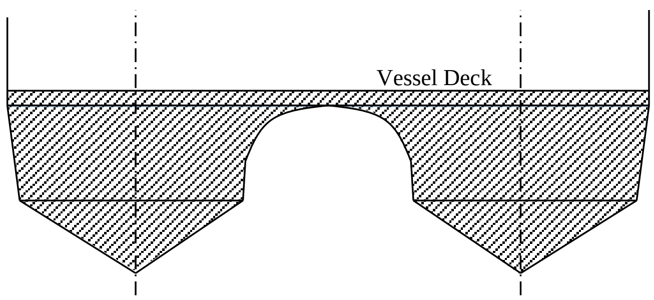
<u>Monohull - Single Chine</u>



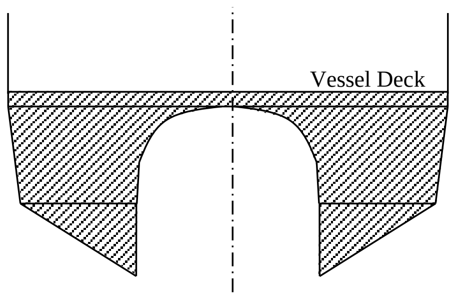
<u>Monohull - Double Chine</u>



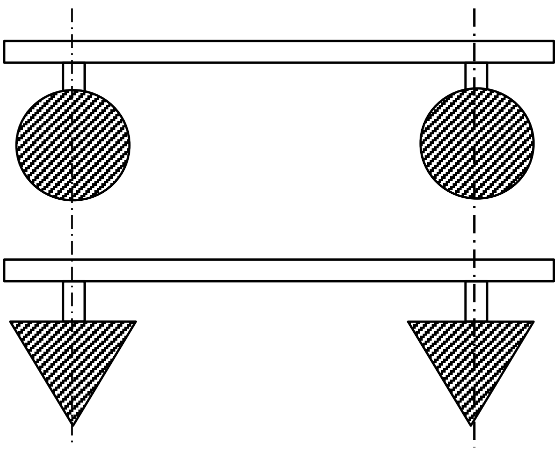
<u>Monohull - Curved Hull</u>



<u>Symmetrical Catamaran Hull</u>



<u>Asymmetrical Catamaran Hull</u>



<u>Pontoon Hulls</u>

Drawing 4 - Examples of different hull shapes which may be encountered in service

Where the hull shape is not considered to be conventional or a greater level of accuracy is required, then

Simpson's Rule, computer modelling or geometric volume formula's must be used to determine the hull volume with a suitable level of accuracy.

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

Method 2 – Simpson's Rule Method

The first step of the calculation is to measure the length of the deck. If the length of the deck or deck section is less than 3m then the underdeck volume can be calculated by calculating the section area at each end of the section eg. A_1 & A_2 and then multiplying the mean of Area's A_1 & A_2 by the length; viz,

$$Vsection = \left(\frac{\text{A1+A2}}{2}\right) \times L$$ ----------------------------- Equation 1

In the event of the hull section being more than 3m in length but less than 15m in length then Simpson's 2nd rule should be used to calculate the underdeck volume ie.

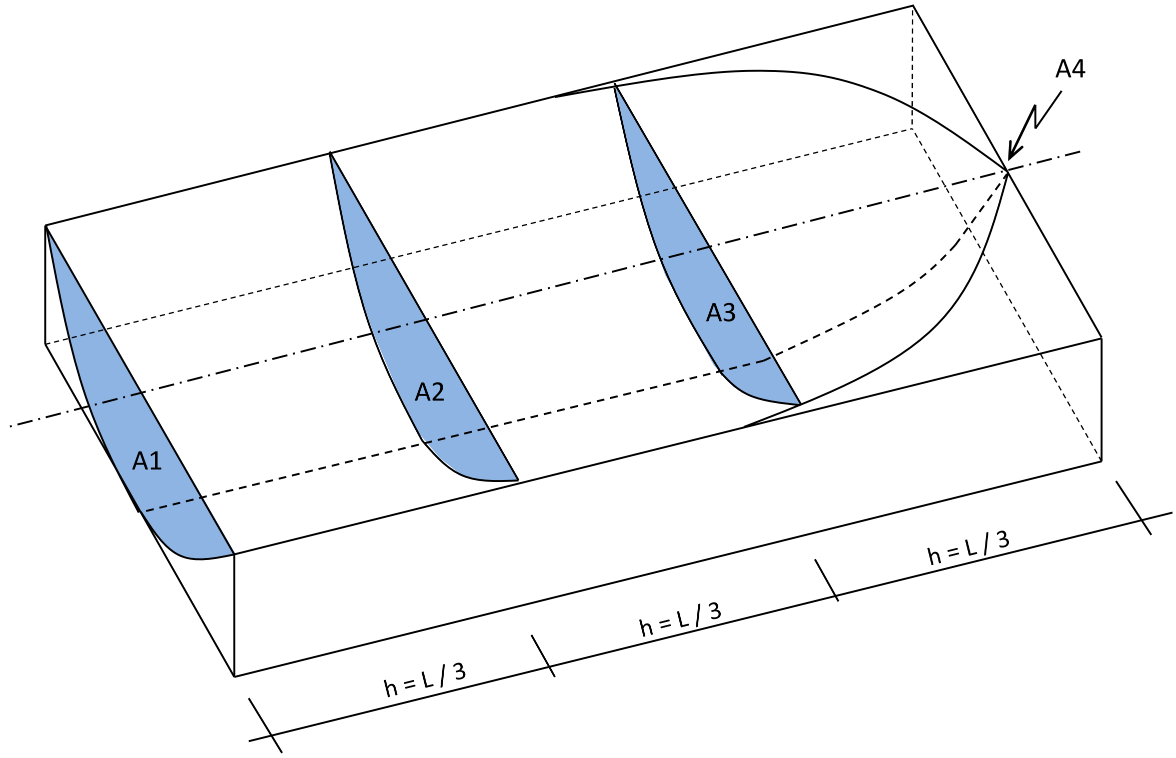
$$Vunderdeck = \frac{3}{8} \times h \times (1 \text{ x } A1 + 3 \text{ x } A2 + 3 \text{ x } A3 + 1 \text{ x } A4)$$ ----------------------------- Equation 2

with; h = $\frac{Ldeck}{3}$

therefore Equation 2 becomes;

$$Vunderdeck = \frac{Ldeck}{8} \times (1 \text{ x } A1 + 3 \text{ x } A2 + 3 \text{ x } A3 + 1 \text{ x } A4)$$ ----------------------------- Equation 3

with A1, A2, A3 & A4 = Area of each "slice" of hull section created by dividing the hull into 3 sections (See sketch below).

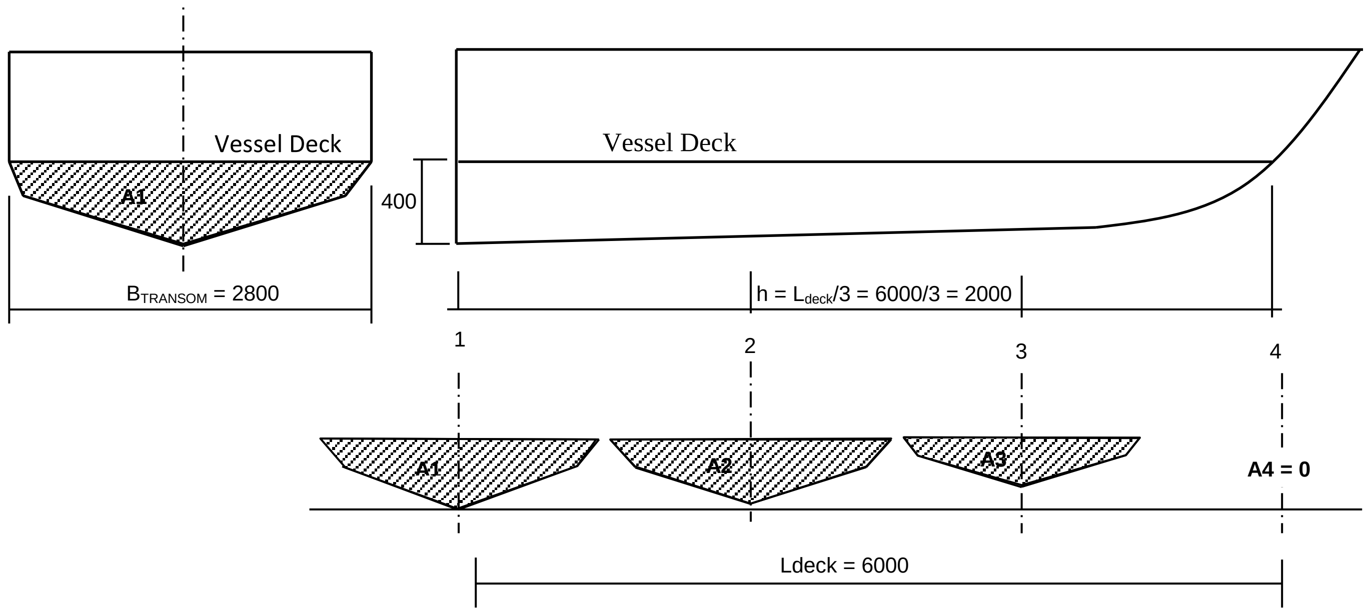


Drawing 5 - Sketch of Monohull showing Area's ("slices") of the hull which need to be calculated

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

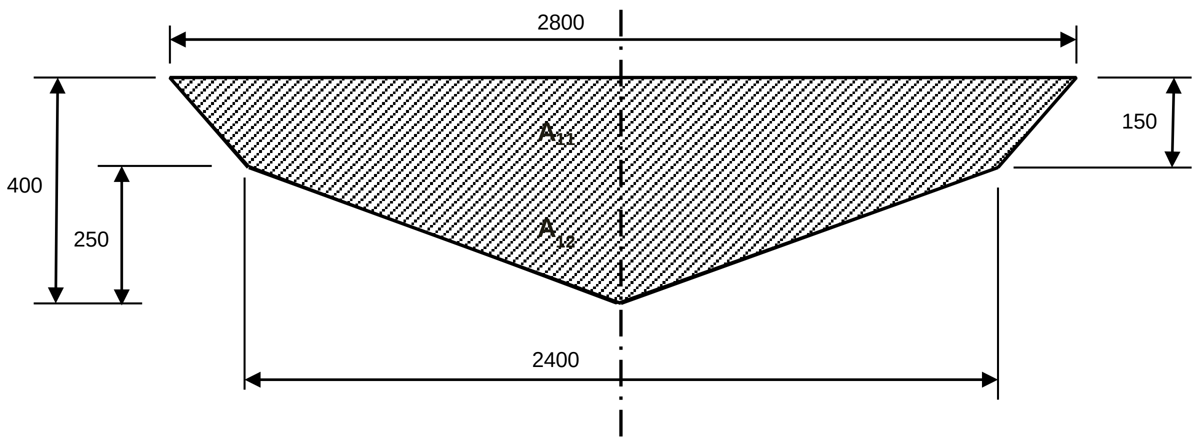
For calculation of the underdeck volume ($V_{underdeck}$) the hull is divided into 3 sections and the area's of the resultant four sections ("slices") are then calculated, using simple geometry equations or other suitable method, and entered into equation 3.

Converting Drawing 5 into a two-dimensional drawing we proceed as follows:



Drawing 6 – Two dimensional sketch showing area's of each section ("slice") of the hull for the Underdeck Volume Calculation using Simpson's 2nd Rule

From Drawing 6, the Area of Area 1 (at transom) would typically be calculated as shown below:



Drawing 7 - Detail of Area, A1

$A_1 = A_{11} + A_{12}$ with $A_{11} = \frac{(2800+2400)}{2} \times 150$ = 390000 [mm^2] or 0.390 [m^2]

and $A_{12} = \frac{1}{2} \times 2400 \times 250$ = 300000 [mm^2] or 0.300 [m^2]

Therefore $A_1 = 0.390 + 0.300 = \underline{0.690\ [m^2]}$

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

Using the same approach for Area's A2 & A3 (values estimated for illustration purposes – in practice, these would have to be measured in the same manner as for A1), the resultant areas can be tabled as follows:

	A_1	A_2	A_3	A_4
Area [m^2]	0.690	0.590	0.440	0

Table 1 – Hull Section Areas

The results (See Table 1) are then inputted into equation 3; viz,

$$Vunderdeck = \frac{Ldeck}{8} \times \ (1 \text{ x } A1 + 3 \text{ x } A2 + 3 \text{ x } A3 + 1 \text{ x } A4)$$

Therefore $V_{underdeck}$ $= \frac{6.000}{8}$ x $\left((1 \text{ x } 0.690) + (3 \text{ x } 0.590) + (3 \text{ x } 0.440) + 0\right)$
$= 0.750$ x $(0.690 + 1.770 + 1.320 + 0)$
$=$ 2.835 [m^3]

Method 3 - Geometric Formula Method

In the event of the hull being made of simple geometric sections, eg. Rectangular, triangular or cylindrical sections then the underdeck volume could be calculated using standard geometric formula's such as:

Volume = Area Section x Length

ie. For a rectangular hull shape - Underdeck Volume = Breadth x Depth x Length

For a triangular hull shape - Underdeck Volume = ½ Breadth x Depth x Length

For a cylindrical hull shape - Underdeck volume = π x radius^2 x Length

Method 4 - Computer Model Method

A naval architect may be approached to model the hull of the boat in a hydrostatics program which will calculate the hull volume accurately.

Method 5 - Miscellaneous Methods

Any other method of volume calculation which gives an acceptable level of accuracy may be used from complex integration formula's to filling the hull with water and then measuring that quantity which will be equivalent to the hull volume.

The volume of spaces filled or available to be filled with built-in buoyancy can then be determined from the following formula:

Volume of Spaces Filled/Available for BIB = $V_{UNDERDECK} + V_{ADDITIONAL\ SPACES} - V_{DEDUCTED\ SPACES}$

with;

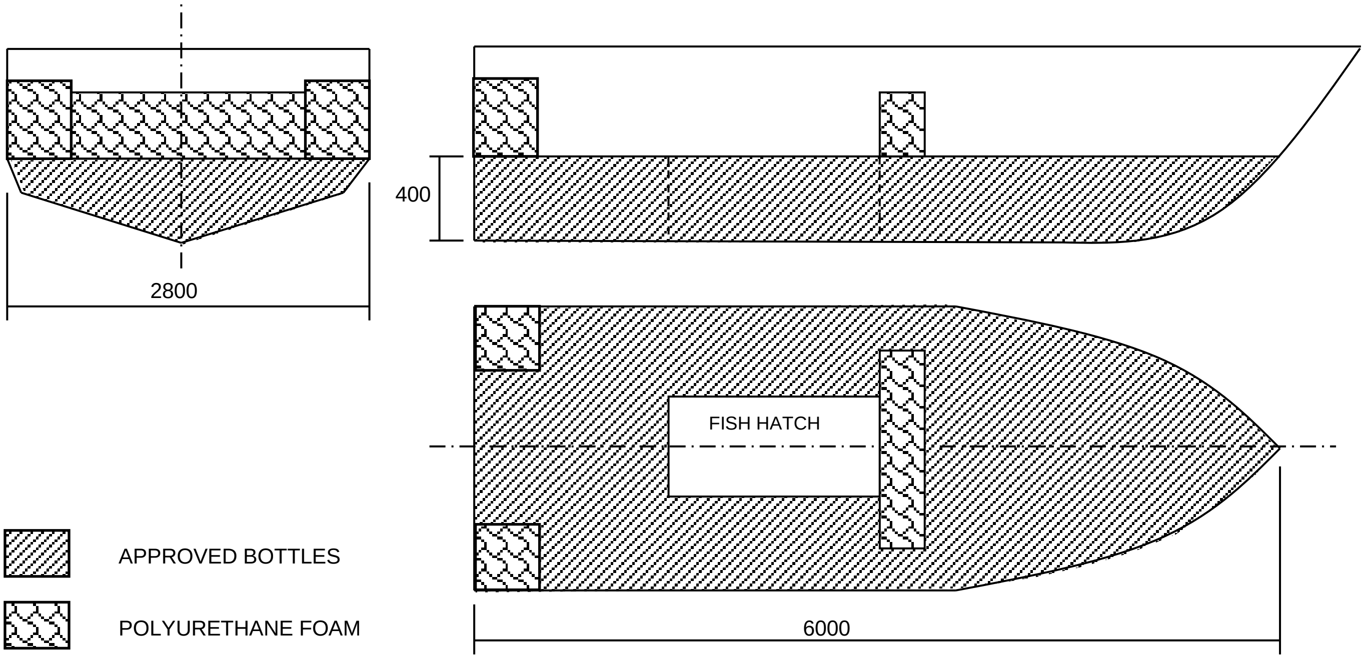
$V_{ADDITIONAL\ SPACES}$ = The volume of other spaces, above the deck, filled, or available for the installation of built-in buoyancy must then also be calculated.

$V_{DEDUCTED\ SPACES}$ = Any volume(s) below the deck which cannot be filled with built-in buoyancy must be deducted from the calculated $V_{UNDERDECK}$ eg. Fish hatch or fuel hatches.

These volumes may normally be calculated from standard geometric formula's.

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

For the illustrative example the built-in buoyancy, for the boat, is as per the drawing below:



The Total Volume of Spaces filled/available for Built-in Buoyancy can be tabulated as follows:

Description	Volume [m³]	Remark
$V_{UNDERDECK}$	2.835	From Simpson's Rule Calculation
Less Fish Hatch Volume (below deck)	0.510	Illustrative Value
Therefore; $V_{UNDERDECK}$ available for BIB	**2.325**	
Add Volume in Centre Seat	0.120	Illustrative Value
Add Volume below gunnels (aft 1/3 of boat)	0.100	Illustrative Value
TOTAL VOLUME OF SPACES AVAILABLE FOR BIB	**2.545**	**[m³]**

Table 2 - Summary of Spaces Filled / Available for Built-in Buoyancy

The volume of the space(s) on the boat which are available to be filled with Built-in Buoyancy has now been determined. The volume of the space(s) actually filled with Built-in Buoyancy must however now be determined.

A surveyor will normally not be able to inspect the complete space which is indicated as being filled with Built-in Buoyancy. The Buoyancy Certificate will however indicate the location and type(s) of Built-in Buoyancy installed which must be prudently evaluated. In order to do this the permeability of the installed built-in buoyancy must be calculated or estimated.

$$\text{Permeability} = \frac{Volume\ of\ Actual\ Space\ Filled\ with\ Built\text{−}in\ Buoyancy}{Total\ Volume\ of\ Space\ in\ which\ the\ Built\text{−}in\ Buoyancy\ is\ located} \quad \text{x100 [\%]}$$

An accurate assessment of the permeability of a built-in buoyancy type may be made by taking a sample of the built-in buoyancy and using it to fill a box of known volume in the same manner in which it is packed on the boat. The volume of built-in buoyancy and volume of the box can then be entered in the above equation to determine the permeability.

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

An estimate of the built-in buoyancy may however also be made as follows.

If foam were used as the built-in buoyancy medium which filled the entire space/volume in which it was installed then the permeability of the Built-in Buoyancy would be 100%.

If approved bottles were however fitted then the permeability would be less. The permeability would be dependent on the bottle shape and way in which they were packed into the hull and would typically vary between 50% and 60%. In the absence of carrying out a theoretical test, the following typical permeability values may be used:

Foam -	100%
Bottles (Tightly packed) -	60%
Bottles (Loosely packed) -	50%

For the illustrative example the hull below deck is filled with bottles (tightly packed) and foam in the spaces above deck. Table 3 can therefore be developed as follows to determine the volume of Built-in Buoyancy installed in the vessel.

Description	Volume [m^3]	Type of BIB Installed	Permeability [%]	Volume of BIB Installed [m^3]
$V_{UNDERDECK}$	2.835			
Less Fish Hatch Volume (below deck)	0.510			
Therefore; $V_{UNDERDECK}$ available for BIB	**2.325**	Bottles	60	1.395
Add Volume in Centre Seat	0.120	Foam	100	0.120
Add Volume below gunnels (aft 1/3 of boat)	0.100	Foam	100	0.100
			$V_{BIB\ INSTALLED}$ [m^3]	**1.515**

Table 3 - Summary of Additional Built-in Buoyancy Installed in the boat

STEP 4 - Determine whether the Boat is Provided with Sufficient Built-in Buoyancy to Remain Afloat in the event of it being Flooded, Swamped or Capsized

Comparison of the results of Step 2 and Step 3 is required ie.

From Step 2; $V_{BIB\ REQUIRED}$ = **1.312 [m^3]**

From Step 3; $V_{BIB\ INSTALLED}$ = **1.515 [m^3]** (69.3% of Total Boat Weight)

$V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$, therefore it may be concluded that sufficient additional built-in buoyancy is provided in the vessel and that it may be expected to remain afloat in the event of being flooded, swamped or capsized.

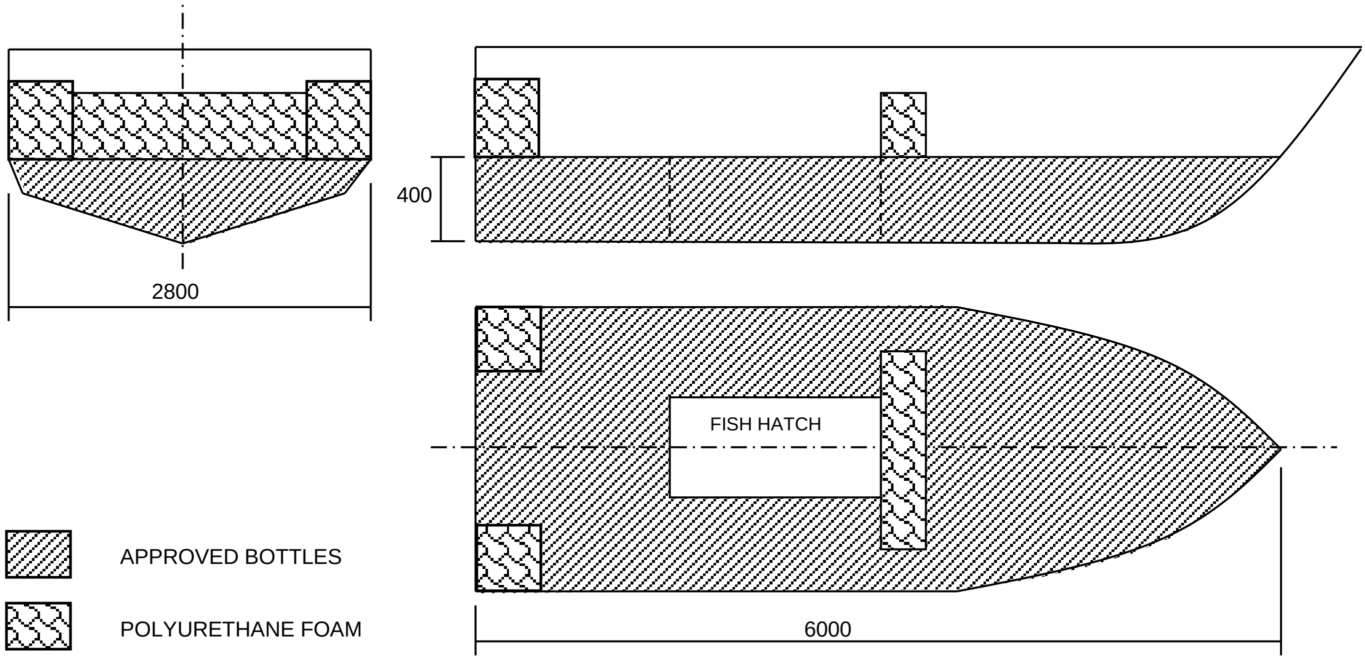
It remains only to confirm that the distribution of the Built-in Buoyancy is sufficient to create a level platform to which the entire complement (crew) can be secured in the event of the boat being flooded, swamped or capsized.

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

STEP 5 - Confirmation of Satisfactory Built-in Buoyancy Distribution (Not required for Category R vessels)

The Merchant Shipping (National Small Vessel Safety) Regulations, 2007 states that "Built-in Buoyancy must be capable of keeping the vessel afloat when fully flooded, swamped or capsized. It must be capable of floating the vessel. When capsized, in such a manner as to provide a level platform onto which the full complement can be secured."

For the calculations of the previous sections, the Built-in Buoyancy is installed as is shown below:



An acceptable theoretical method of confirming that a level platform will be created is to compare the built-in buoyancy provided in the aft 1/3 of the boat with the weight of the aft 1/3 of the boat as follows:

Step 5.1 - Determine the Weight of the Aft 1/3 of the Boat

Boat Lightweight — The lightweight of the boat is assumed to be evenly distributed ie. Lightweight of aft 1/3 of Boat = 1412/3 = 470.7 [kg]

Boat Deadweights — Determine the deadweights in the aft 1/3 of the boat which need to be taken into account.

The following principles apply:

- The boat engines must be taken into account if they are located in the aft 1/3 of the boat (almost always the case).
- The crew is assumed to be evenly distributed along the length of the boat at an average weight of 75 kg per person.
- Any other miscellaneous weights located in the aft 1/3 of the boat which will contribute to the weight of the boat in the event of capsize ie. which will not fall out, must be taken into account.

For the illustrative example, the following deadweights need to be considered:

a. Boat Engines (2 x 100 kg) = 200 [kg]
b. Crew Weight 1/3 of 5 x crew = 1/3 x (5 x 75 kg) = 125 [kg]
c. Miscellaneous weight(s) in aft 1/3 of the boat = 20 [kg]

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

Step 5.2 - Calculate the Volume of Additional Built-in Buoyancy Required in the Aft 1/3 of the Boat ($V_{BIB\ REQUIRED}$)

The following K_{factor} values must be used:

Description	K_{factor}
Boat Construction Material – Steel or Aluminium	90%
Boat Construction Material – GRP or Wood	30%
Engine(s)	85%
Crew	100%
Miscellaneous Items	100%

Table 5 - K_{factor} values to be used for Aft 1/3 "partly submerged" vessel condition

The weight of additional Built-in Buoyancy required in the aft 1/3 of the boat can then be calculated as follows:

Description	Weight [kg]	K_{factor}	Weight [kg]
Lightweight of Aft 1/3 of Boat	470.7	30%	141
Add Engine Weights	200	85%	170
Add 1/3 of Crew Weights (1/3 x 5 x 75 kg)	125	100%	125
Add Miscellaneous Weight(s) in Aft 1/3	20	100%	20
TOTAL WEIGHT OF ADDITIONAL BUOYANCY REQUIRED IN AFT 1/3 OF BOAT, [KG]			457

Table 6 - Total Weight of Additional Built-in Buoyancy Required in Aft 1/3 of Boat

The required weight of additional Built-in Buoyancy is then converted to Volume of Additional Built-in Buoyancy Required in the Aft 1/3 of the boat ($V_{BIB\ REQUIRED}$); viz,

$V_{BIB\ REQUIRED}$ = Weight BIB Required x SG of water
= 457 x 1.0
= 457.0 [litres] (SG taken as equal to 1.0 for Sea Water and Fresh Water)
= <u>0.457 [m^3]</u>

Step 5.3 - Calculate the Volume of Built-in Buoyancy Installed, or to be Installed, in the Aft 1/3 of the Boat

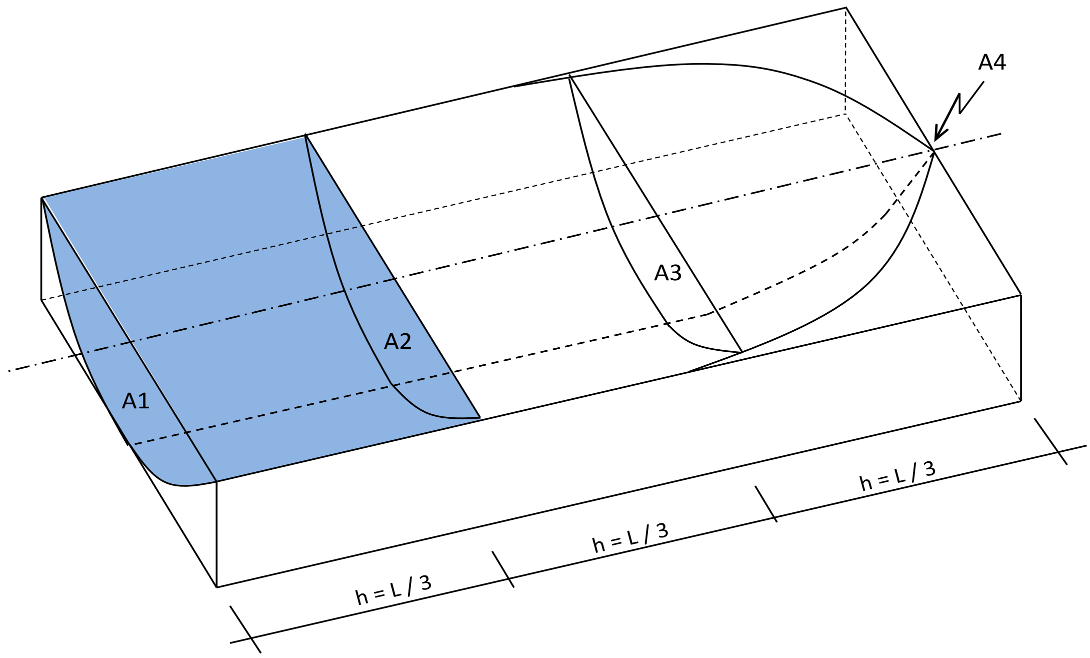
As was described in Step 3, there is more than one method of calculating the volume of the underdeck space in the aft 1/3 of the boat. The following methods may be used:

Method 1 - Prismatic coefficient Method

Method 2 - Average Section Area x Aft 1/3 Length Method

Method 3 - Geometric Volume Calculation Method

Method 4 - Computer Model Method



Drawing 8 - Sketch Illustrating Volume of Aft 1/3 of Monohull (Volume to be Calculated)

Method 1 - Prismatic Coefficient Method

Similarly to Step 3, the prismatic coefficient method uses an assumed prismatic coefficient (Cp), however, due to the exclusion of the bow from the volume calculation, a coefficient of 0.65 instead of 0.6 is used; viz,

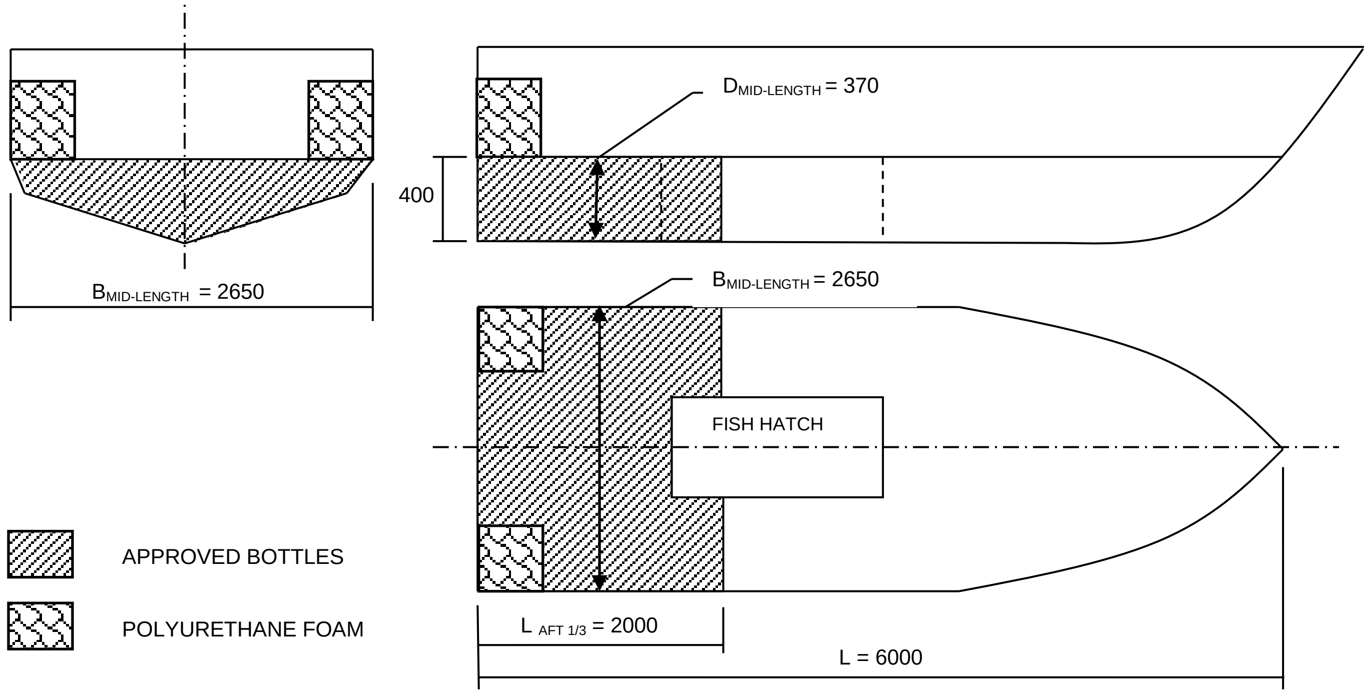
Prismatic Coefficient; Cp = $\frac{Volume\ Hull}{Volume\ Box\ (Prism)}$

We need to calculate the volume of the Aft 1/3 of the hull;

Therefore; $V_{UNDERDECK\ (Aft\ 1/3)}$ = Cp x Volume Box (Aft 1/3)

= Cp x ($L_{AFT\ 1/3}$ x $B_{MID\text{-}LENGTH}$ x $D_{MID\text{-}LENGTH}$)

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)



Drawing 9 - Illustrative Sketch of Aft 1/3 Volume Calculation

For the example:	$L_{AFT\ 1/3}$ = 6.00/3	=	2.00 [m]	(See Drawing 9)
	$B_{MID\text{-}LENGTH}$	=	2.65 [m]	(See Drawing 9)
	$D_{MID\text{-}LENGTH}$	=	0.37 [m]	(See Drawing 9)

Therefore:	$V_{UNDERDECK\ AFT\ 1/3}$	=	Cp x ($L_{AFT\ 1/3}$ x $B_{MID\text{-}LENGTH}$ x $D_{MID\text{-}LENGTH}$)
		=	0.65 x (2.00 x 2.65 x 0.37)
		=	0.65 x 1.961
		=	1.275 [m^3]

Method 2 - Average Section Area x Aft 1/3 Length Method

This method calculates the volume of the hull section from the equation:

$V_{SECTION} = \left(\frac{A1+A2}{2}\right) \times L$ where; A_1 = Area of section ("slice") at transom
A_2 = Area of section ("slice") 1/3 forward of transom
L = Length of Aft 1/3 of vessel

Continuing with the illustrative example, if Simpson's 2nd Rule was used to calculate the complete volume underdeck of the hull, the area's A1 and A2 have already been calculated (If the prismatic coefficient, Cp method was used, however, the area's would need to be measured).

From Table 1; A_1 = 0.69 [m^2] and A_2 = 0.59 [m^2];

From Drawing 9; $L_{AFT\ 1/3}$ = 2.00 [m]

Therefore $V_{SECTION}$ $= \left(\frac{A1+A2}{2}\right) \times L$

$= \left(\frac{0.69+0.59}{2}\right) \times 2.00$

= 0.64 x 2.00

= 1.280 [m^3]

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

The volume of spaces filled or available to be filled with built-in buoyancy, in the aft 1/3 of the boat, can then be determined from the following formula:

Volume of Spaces Filled/Available for BIB = $V_{UNDERDECK} + V_{ADDITIONAL\ SPACES} - V_{DEDUCTED\ SPACES}$

with; $V_{ADDITIONAL\ SPACES}$ = The volume of other spaces, above the deck, in the aft 1/3 of the boat, filled, or available for the installation of built-in buoyancy must then also be calculated.

$V_{DEDUCTED\ SPACES}$ = Any volume(s) below the deck, in the aft 1/3 of the boat, which cannot be filled with built-in buoyancy must be deducted from the calculated $V_{UNDERDECK}$ eg. Fish hatch or fuel hatches.

The results for the aft 1/3 of the boat can then be tabulated as follows:

Description	Volume [m^3]	Remark
$V_{UNDERDECK\ (AFT\ 1/3\ of\ VESSEL}$	1.280	Average section area method
Less Fish Hatch Volume (below deck)	0.200	Illustrative Value
Therefore; $V_{UNDERDECK}$ available for BIB	**1.080**	
Add Volume below gunwales (aft 1/3 of boat)	0.100	Illustrative Value
TOTAL VOLUME OF SPACES AVAILABLE FOR BIB IN AFT 1/3 OF BOAT	**1.180**	**[m^3]**

Table 7 - Summary of Spaces available for the Installation of Built-in Buoyancy (Aft 1/3 of Boat)

As per Step 3, the permeability of the installed built-in buoyancy must be taken into account. For the illustrative example, bottles (tightly packed) are installed underdeck and foam in the spaces under the gunwales.

The volume of built-in buoyancy in the aft 1/3 of the boat, can therefore be tabled as follows:

Description	Volume [m^3]	Type of BIB Installed	Permeability [%]	Volume of BIB Installed [m^3]
$V_{UNDERDECK\ (AFT\ 1/3\ of\ VESSEL}$	1.280			
Less Fish Hatch Volume (below deck)	0.200			
Therefore; $V_{UNDERDECK}$ available for BIB	**1.080**	Bottles	60	0.648
Add Volume below gunwales (aft 1/3 of boat)	0.100	Foam	100	0.100
			$V_{BIB\ INSTALLED\ (AFT\ 1/3)}$; [m^3]	**<u>0.748</u>**

Table 8 - Summary of Total Volume of Additional BIB installed in Aft 1/3 of the Boat

Step 5.4 - Conclude whether the Boat is Provided with Sufficient Built-in Buoyancy in the Aft 1/3 to create a level platform, to which the full complement may be secured in the event of capsize.

Comparison of the results of Step 5.2 and Step 5.3 is required ie.

From Step 5.2; $\mathbf{V_{BIB\ REQUIRED\ (AFT\ 1/3)}}$ = **0.457 [m^3]**

From Step 5.3; $\mathbf{V_{BIB\ INSTALLED\ (AFT\ 1/3)}}$ = **0.748 [m^3]**

It can be seen that; $\mathbf{V_{BIB\ INSTALLED(AFT\ 1/3)} > V_{BIB\ REQUIRED\ (AFT\ 1/3)}}$;

therefore it may be concluded that the distribution of the Built-in Buoyancy is sufficient to create a level platform to which the entire complement (crew) can be secured in the event of the boat being capsized.

Section 1 - Expanded Illustrative Example – Conventional Monohull/Multihull Vessel (continued)

Additional Remarks

The method described above consist of 4 basic steps:

Step 1 - Determine the Weight of the Boat

Step 2 - Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)

Step 3 - Determine the Volume of The Spaces available for Built-in Buoyancy

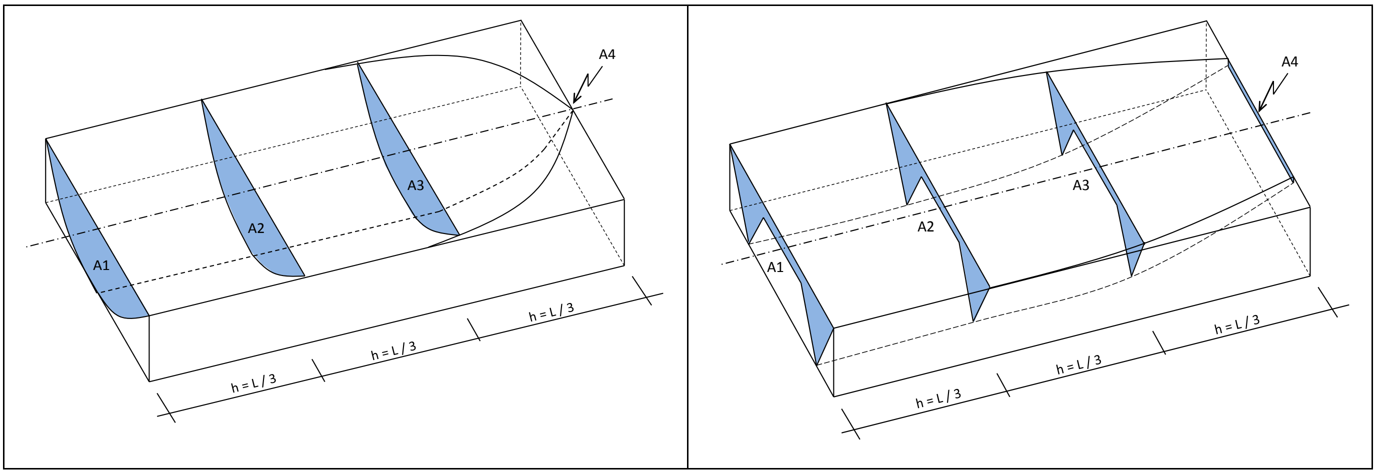
Step 4 - Determine the Actual Volume of Built-in Buoyancy installed by taking the Permeability of the Actual Built-in Buoyancy Installed, or to be Installed, into account ($V_{BIB\ INSTALLED}$)

Steps 1 to 4 are in essence repeated when confirming level flotation of Category B to E vessels except that only the weights and volumes in the aft 1/3 of the vessel are considered (Illustrated in Step 5).

Of the 4 basic steps, calculation of the underdeck volume of the boat (part of step 3) is the most challenging:

For surveyors in the field, the prismatic coefficient method may be used, however, it must be realised that this is an approximate method which is only valid for conventional hull shapes.

Use of Simpson's 2nd Rule for calculation of the underdeck volume and the Average Section Area Method for calculation of the Aft 1/3 of the underdeck volume provide greater accuracy and persons installing Built-in Buoyancy should either use these methods of calculation or a method which provides a greater level of accuracy eg. Computer modelling.



Drawing 10 - Sketches Illustrating that Simpson's 2nd Rule may be Effectively used to Calculate the Underdeck Volume of Various Hull Shapes provided that the Area's of the Sections ("Slices") can be Calculated with a Sufficient Level of Accuracy.

If the actual volume of Built-in Buoyancy installed ($V_{BIB\ INSTALLED}$) is greater than the volume of Additional Built-in Buoyancy Required ($_{VBIB\ REQUIRED}$) then the Built-in Buoyancy provisions are sufficient. If not, then the owner has 3 options to achieve compliance:

Option 1 - Reduce the Boat Weight (Lightweight and/or Deadweight)

Option 2 - Install additional Built-in Buoyancy

Option 3 - Replace the Built-in Buoyancy with Built-in Buoyancy of greater permeability eg. Bottles (permeability ≈ 60%) could be replaced with foam (permeability ≈ 100%).

Section 2 – Shortened Method for Surveyors in the Field – Category B to E Vessels

(Monohull Example)

The illustrative example in Section 1 describes the minimum standard/level of accuracy which may be applied for determination of the amount of Built-in Buoyancy required to be installed in a vessel. In the field, however, a surveyor often needs to make a quick judgement call on whether the Built-in Buoyancy claimed to be installed is in compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007.

Using the previous example, the following method should be followed:

Step 1 - **Determine the Total Weight of the Boat**

Eg. Total Weight = Lightweight + Deadweight; viz,

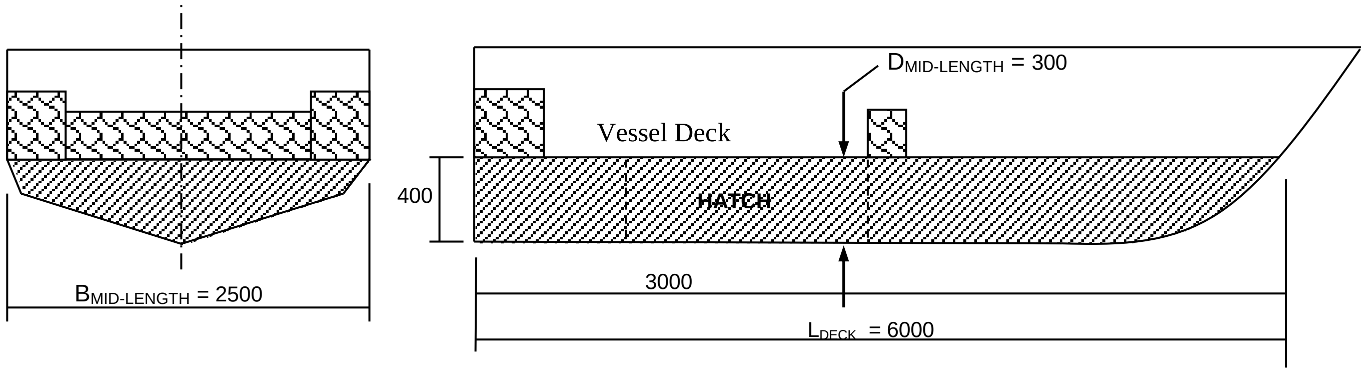
Lightweight =		1412 kg
Add Boat Engines =	200 kg	
Add Crew (x5) = 5 x 75 kg =	375 kg	
Add Fixed Equipment =	200 kg	775 kg
Therefore Total Weight =		2187 kg

Step 2 - **Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)**

The K_{factor} used is based on the vessel construction material ie. For GRP K_{factor} = 60%

Therefore VBIB REQUIRED = Total Weight x K_{factor}
= 2187 x 60%
≈ **1312 [litres]** or **1.312 [m^3]**

Step 3 - **Calculate the Volume of Spaces Provided with Built-in Buoyancy (V_{SPACES})**



V_{SPACES} = ($V_{UNDERDECK}$ – $V_{HATCHES\ BELOW\ DECK}$) + $V_{SPACES\ ABOVE\ DECK}$

with $V_{UNDERDECK}$ = Cp x (L_{DECK} x $B_{MID\text{-}LENGTH}$ x $D_{MID\text{-}LENGTH}$)
= 0.60 x (6.00 x 2.50 x 0.30)
= 2.70 [m^3]

$V_{HATCHES\ BELOW\ DECK}$ = 0.51 [m^3] (Illustrative Value)

$V_{SPACES\ ABOVE\ DECK}$ = 0.22 [m^3] (Illustrative Value)

Therefore; V_{SPACES} = (2.70 – 0.51) + 0.22
= 2.19 + 0.22
= 2.41 [m^3]

Step 4 - **Determine the Actual Volume of Built-in Buoyancy Installed ($V_{BIB\ INSTALLED}$) by taking the Permeability of the Actual Built-in Buoyancy into account**

For bottles (tightly packed); Permeability = 60% and for Foam; Permeability = 100%

Therefore; $V_{BIB\ INSTALLED}$ = ($V_{UNDERDECK}$ x 60%) + ($V_{SPACES\ ABOVE\ DECK}$ x 100%)
= (2.19 x 60%) + (0.22 x 100%)
= 1.314 + 0.22
= 1.534 [m^3]

Conclusion: $V_{BIB\ INSTALLED}$ > $V_{BIB\ REQUIRED}$; (1.534 [m^3] > 1.312 [m^3]) Therefore it can be concluded that the vessel will remain afloat in the event of it being flooded, swamped or capsized. Evaluation of the BIB in the aft 1/3 of the vessel must be completed to confirm level flotation.

Section 2 – Shortened Method for Surveyors in the Field – Category B to E Vessels

(Monohull Example - Continued)

Step 5 - Confirmation of Level Flotation (Not Required for Category R vessels)

The same process as for determination of the overall built-in buoyancy provisions is followed except that only the weight and buoyancy provisions in the aft 1/3 of the boat are now considered.

Step 5.1 Determine the Total Weight of the Aft 1/3 of the Boat

The total weight of the Aft 1/3 of the boat is made up of the boat lightweight, engine(s) weight, crew weight and miscellaneous weights. Continuing with the illustrative example of Section 1:

Boat Lightweight The lightweight of the boat is assumed to be evenly distributed over the length ie. Weight of Aft 1/3 of Boat = Lightweight/3 = 1412/3 = 470.7 [kg]

Engine Weights Normally always aft on vessel = 2 x 100 [kg] = 200.0 [kg]

Crew Weight The crew weight is assumed to be evenly distributed over the length ie.1/3 of 5 x crew = 1/3 x (5 x 75 kg) = 1/3 x 375 = 125.0 [kg]

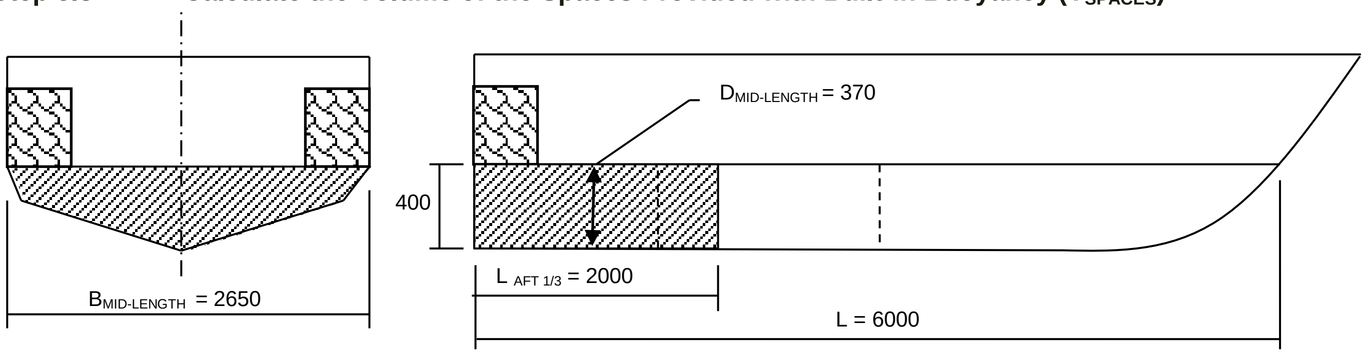
Miscellaneous Weights Any weights located in the aft 1/3 of the boat which will not fall out in the event of capsize = 20 [kg]

Step 5.2 Determine the Volume of Additional Built-in Buoyancy Required in the Aft 1/3 ($V_{BIB\ REQUIRED}$)

Description	Weight [kg]	K_{factor}	Weight [kg]
Lightweight of Aft 1/3 of Boat	470.7	30%	141
Add Engine Weights	200	85%	170
Add 1/3 of Crew Weights (1/3 x 5 x 75 kg)	125	100%	125
Add Miscellaneous Weight(s) in Aft 1/3	20	100%	20
TOTAL WEIGHT OF ADDITIONAL BUOYANCY REQUIRED IN AFT 1/3 OF BOAT; [kg]			**457**

Therefore; $V_{BIB\ REQUIRED(AFT\ 1/3)}$ = Weight x SG
= 457 x 1.00 (SG Fresh/Sea Water ≈ 1.00)
= 457 [litres] or 0.457 [m^3]

Step 5.3 Calculate the Volume of the Spaces Provided with Built-in Buoyancy (V_{SPACES})



V_{SPACES} = ($V_{UNDERDECK}$ – $V_{HATCHES\ BELOW\ DECK}$) + $V_{SPACES\ ABOVE\ DECK}$

with $V_{UNDERDECK\ (AFT\ 1/3)}$ = Cp x ($L_{1/3\ DECK}$ x $B_{MID-LENGTH}$ x $D_{MID-LENGTH}$)
= 0.65 x (2.00 x 2.650 x 0.37)
= 1.285 [m^3]

$V_{HATCHES\ BELOW\ DECK}$ = 0.20 [m^3] (Illustrative Value)

$V_{SPACES\ ABOVE\ DECK}$ = 0.10 [m^3] (Illustrative Value)

Therefore; V_{SPACES} = (1.285 – 0.20) + 0.10

= 1.085 + 0.10

= 1.185 $[m^3]$

Section 2 – Shortened Method for Surveyors in the Field – Category B to E Vessels

(Monohull Example - Continued)

Step 5.4 - Determine the Actual Volume of Built-in Buoyancy Installed in the aft 1/3 of the boat ($V_{BIB\ INSTALLED\ AFT\ 1/3}$) by taking the Permeability of the Actual Built-in Buoyancy into account

For bottles (tightly packed); Permeability = 60% and for Foam; Permeability = 100%

Therefore; $V_{BIB\ INSTALLED}$ = ($V_{UNDERDECK}$ x 60%) + ($V_{SPACES\ ABOVE\ DECK}$ x 100%)

= (1.085 x 60%) + (0.10 x 100%)

= 0.651 + 0.10

= 0.751 $[m^3]$

Conclusion: $V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$; (0.751 $[m^3]$ > 0.431 $[m^3]$) Therefore; it can be concluded that the volume of Built-in Buoyancy provided for the vessel is sufficient to keep the vessel afloat when fully flooded, swamped or capsized and when capsized, in such a manner as to provide a level platform to which the full complement of the crew can be secured.

Section 2 – Shortened Method for Surveyors in the Field – Category B to E Vessels

(Twin Hull Example)

The illustrative example in Section 1 describes the minimum standard/level of accuracy which may be applied for determination of the amount of Built-in Buoyancy required to be installed in a vessel. In the field, however, a surveyor often needs to make a quick judgement call on whether the Built-in Buoyancy claimed to be installed is in compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007.

Using the previous example, the following method should be followed:

Step 1 - **Determine the Total Weight of the Boat**

Eg. Total Weight = Lightweight + Deadweight; viz,

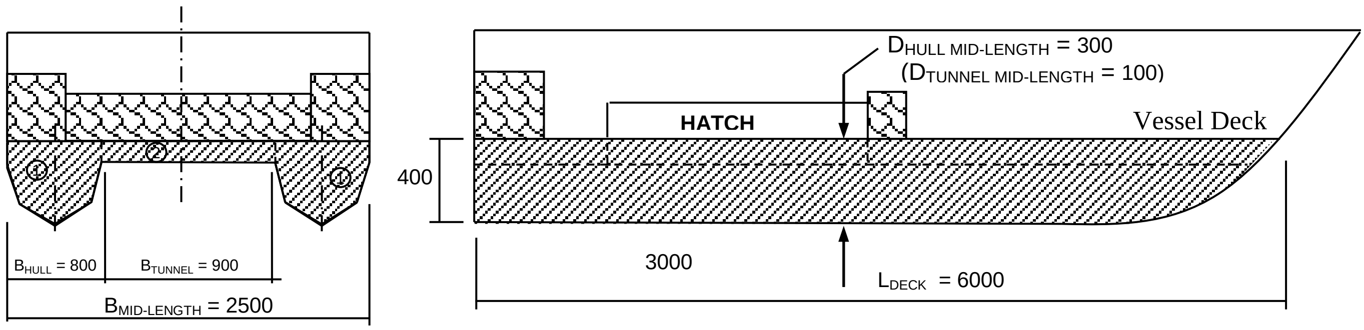
Lightweight =		1412 kg
Add Boat Engines =	200 kg	
Add Crew (x5) = 5 x 75 kg =	375 kg	
Add Fixed Equipment =	200 kg	775 kg
Therefore Total Weight =		2187 kg

Step 2 - **Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)**

The K_{factor} used is based on the vessel construction material ie. For GRP K_{factor} = 60%

Therefore VBIB REQUIRED = Total Weight x K_{factor}
= 2187 x 60%
≈ **1312 [litres]** or **1.312 [m^3]**

Step 3 - **Calculate the Volume of Spaces Provided with Built-in Buoyancy (V_{SPACES})**



V_{SPACES} = ($V_{UNDERDECK}$ – $V_{HATCHES\ BELOW\ DECK}$) + $V_{SPACES\ ABOVE\ DECK}$

with $V_{UNDERDECK}$ = 2 x Hull Sections + 1 x Tunnel Section
= 2 x $Volume_1$ + 1 x $Volume_2$

with $Volume_1$ = Cp x(L_{DECK} x B_{HULL} x $D_{MID-LENGTH}$)
= 0.60 x (6.00 x 0.80 x 0.30)
= 0.864 [m^3]

and $Volume_2$ = L_{DECK} x B_{TUNNEL} x D_{TUNNEL}
= 6.00 x 0.90 x 0.10
= 0.540 [m^3]

Therefore; $V_{UNDERDECK}$ = 2 x 0.864 + 1 x 0.540
= 2.148 [m^3]

less $V_{HATCHES\ BELOW\ DECK}$ = 0.30 [m^3] (Illustrative Value)

add $V_{SPACES\ ABOVE\ DECK}$ = 0.22 [m^3] (Illustrative Value)

Therefore; V_{SPACES} = (2.148 – 0.30) + 0.22
= 1.848 + 0.22
= 2.068 [m^3]

Section 2 – Shortened Method for Surveyors in the Field – Category B to E Vessels

(Twin Hull Example - Continued)

Step 4 - Determine the Actual Volume of Built-in Buoyancy Installed ($V_{BIB\ INSTALLED}$) by taking the Permeability of the Actual Built-in Buoyancy into account

For bottles (tightly packed); Permeability = 60% and for Foam; Permeability = 100%

Therefore; $V_{BIB\ INSTALLED}$ = ($V_{UNDERDECK}$ x 60%) + ($V_{SPACES\ ABOVE\ DECK}$ x 100%)
= (1.848 x 60%) + (0.22 x 100%)
= 1.109 + 0.22
= 1.329 [m^3]

Conclusion: $V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$; (1.329 [$m^3$] > 1.312 [$m^3$]) Therefore it can be concluded that the vessel will remain afloat in the event of it being flooded, swamped or capsized. Evaluation of the BIB in the aft 1/3 of the vessel must be completed to confirm level flotation.

Step 5 - Confirmation of Level Flotation (Not Required for Category R vessels)

The same process as for determination of the overall built-in buoyancy provisions is followed except that only the weight and buoyancy provisions in the aft 1/3 of the boat are now considered.

Step 5.1 Determine the Total Weight of the Aft 1/3 of the Boat

The total weight of the Aft 1/3 of the boat is made up of the boat lightweight, engine(s) weight, crew weight and miscellaneous weights. Continuing with the illustrative example of Section 1:

Boat Lightweight The lightweight of the boat is assumed to be evenly distributed over the length ie. Weight of Aft 1/3 of Boat = Lightweight/3 = 1412/3 = 470.7 [kg]

Engine Weights Normally always aft on vessel = 2 x 100 [kg] = 200.0 [kg]

Crew Weight The crew weight is assumed to be evenly distributed over the length ie.1/3 of 5 x crew = 1/3 x (5 x 75 kg) = 1/3 x 375 = 125.0 [kg]

Miscellaneous Weights Any weights located in the aft 1/3 of the boat which will not fall out in the event of capsize = 20 [kg]

Step 5.2 Determine the Volume of Additional Built-in Buoyancy Required in the Aft 1/3 ($V_{BIB\ REQUIRED}$)

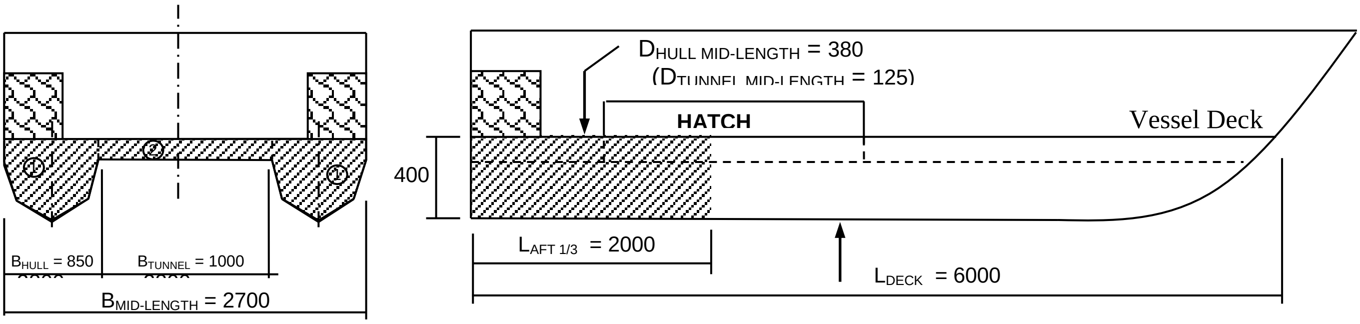
Description	Weight [kg]	K_{factor}	Weight [kg]
Lightweight of Aft 1/3 of Boat	470.7	30%	141
Add Engine Weights	200	85%	170
Add 1/3 of Crew Weights (1/3 x 5 x 75 kg)	125	100%	125
Add Miscellaneous Weight(s) in Aft 1/3	20	100%	20
TOTAL WEIGHT OF ADDITIONAL BUOYANCY REQUIRED IN AFT 1/3 OF BOAT; [kg]			**457**

Therefore; $V_{BIB\ REQUIRED(AFT\ 1/3)}$ = Weight x SG
= 457 x 1.00 (SG Fresh/Sea Water ≈ 1.00)
= 457 [litres] or 0.457 [m^3]

Section 2 – Shortened Method for Surveyors in the Field – Category B to E Vessels

(Twin Hull Example - Continued)

Step 5.3 **Calculate the Volume of the Spaces Provided with Built-in Buoyancy (V_{SPACES})**



V_{SPACES} = ($V_{UNDERDECK}$ – $V_{HATCHES\ BELOW\ DECK}$) + $V_{SPACES\ ABOVE\ DECK}$

with $V_{UNDERDECK\ (AFT\ 1/3)}$ = 2 x Hull Sections + 1 x Tunnel Section
= 2 x $Volume_1$ + 1 x $Volume_2$

with $Volume_1$ = Cp x($L_{1/3\ DECK}$ x B_{HULL} x $D_{MID-LENGTH}$)
= 0.65 x (2.00 x 0.85 x 0.38)
= 0.420 [m^3]

and $Volume_2$ = L_{DECK} x B_{TUNNEL} x D_{TUNNEL}
= 2.00 x 1.00 x 0.125
= 0.250 [m^3]

Therefore; $V_{UNDERDECK(AFT\ 1/3)}$ = 2 x 0.420 + 1 x 0.250
= 1.090 [m^3]

less $V_{HATCHES\ BELOW\ DECK}$ = 0.10 [m^3] (Illustrative Value)

add $V_{SPACES\ ABOVE\ DECK}$ = 0.22 [m^3] (Illustrative Value)

Therefore; V_{SPACES} = (1.090 – 0.100) + 0.22
= 0.990 + 0.22
= 1.210 [m^3]

Step 5.4 - **Determine the Actual Volume of Built-in Buoyancy Installed in the aft 1/3 of the boat ($V_{BIB\ INSTALLED\ AFT\ 1/3}$) by taking the Permeability of the Actual Built-in Buoyancy into account**

For bottles (tightly packed); Permeability = 60% and for Foam; Permeability = 100%

Therefore; $V_{BIB\ INSTALLED}$ = ($V_{UNDERDECK}$ x 60%) + ($V_{SPACES\ ABOVE\ DECK}$ x 100%)
= (0.990 x 60%) + (0.22 x 100%)
= 0.594 + 0.10
= 0.814 [m^3]

Conclusion: $V_{BIB\ INSTALLED}$ > $V_{BIB\ REQUIRED}$; Therefore; it can be concluded that the volume of Built-in Buoyancy (0.814 [m^3] > 0.431 [m^3]) provided for the vessel is sufficient to keep the vessel afloat when fully flooded, swamped or capsized and when capsized, in such a manner as to provide a level platform to which the full complement of the crew can be secured.

Section 3 – Shortened Method for Surveyors in the Field – Category R Vessels

(Monohull Example)

The illustrative example in section 1 describes the minimum standard/level of accuracy which may be applied for determination of the amount of Built-in Buoyancy required to be installed in a vessel. In the field, however, a surveyor often needs to make a quick judgement call on whether the Built-in Buoyancy claimed to be installed is in compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007.

The following example for surveyors in the field is for Category R vessels. It will be seen that the process to be followed is the same as for Category B to E vessels with the following two (2) important differences:

a. The weight of the crew is not taken into account.

b. A level flotation calculation is not required.

Step 1 - Determine the Total Weight of the Boat (NB – Crew weight not taken into account)

Eg. Total Weight = Lightweight + Deadweight; viz,

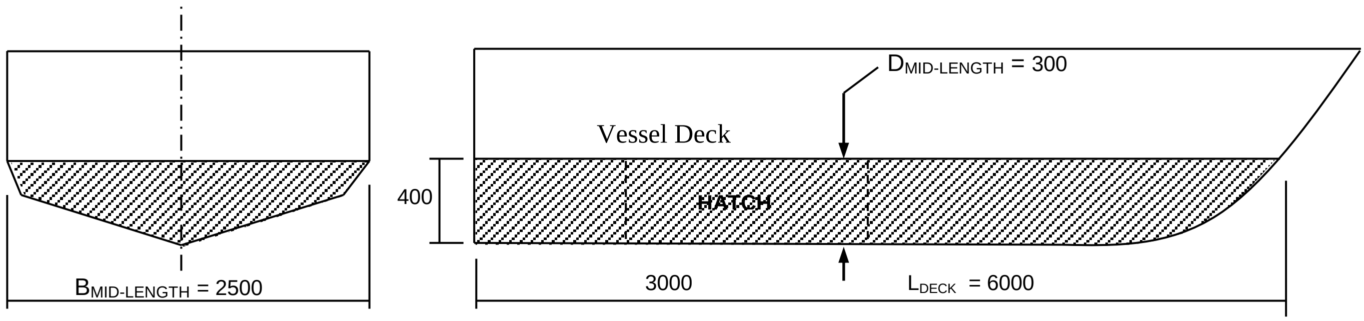
Lightweight =		1412 kg
Add Boat Engines =	200 kg	
Add Fixed Equipment =	200 kg	400 kg
Therefore Total Weight =		1812 kg

Step 2 - Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)

The K_{factor} used is based on the vessel construction material ie. For GRP K_{factor} = 30%

Therefore $V_{BIB\ REQUIRED}$ = Total Weight x K_{factor}
= 1812 x 30%
≈ **544 [litres] or 0.544 [m^3]**

Step 3 - Calculate the Volume of Spaces Provided with Built-in Buoyancy (V_{SPACES})



V_{SPACES} = ($V_{UNDERDECK}$ – $V_{HATCHES\ BELOW\ DECK}$) + $V_{SPACES\ ABOVE\ DECK}$

with $V_{UNDERDECK}$ = Cp x (L_{DECK} x $B_{MID-LENGTH}$ x $D_{MID-LENGTH}$)
= 0.60 x (6.00 x 2.50 x 0.30)
= 2.70 [m^3]

$V_{HATCHES\ BELOW\ DECK}$ = 0.51 [m^3] (Illustrative Value)

Therefore; V_{SPACES} = (2.70 – 0.51) + 0
= 2.19 + 0
= 2.19 [m^3]

Step 4 - Determine the Actual Volume of Built-in Buoyancy Installed ($V_{BIB\ INSTALLED}$) by taking the Permeability of the Actual Built-in Buoyancy into account

For bottles (tightly packed); Permeability = 60% and for Foam; Permeability = 100%

Therefore; $V_{BIB\ INSTALLED}$ = ($V_{UNDERDECK}$ x 60%) + ($V_{SPACES\ ABOVE\ DECK}$ x 100%)
= (2.19 x 60%) + (0 x 100%)
= 1.314 [m^3]

Conclusion: $V_{BIB\ INSTALLED}$ > $V_{BIB\ REQUIRED}$; (1.314 [m^3] > 0.544 [m^3]) Therefore it can be concluded that the vessel will remain afloat in the event of it being flooded, swamped or capsized in such a manner that the full complement can hold on/cling to the vessel.

Section 3 – Shortened Method for Surveyors in the Field – Category R Vessels

(Twin Hull Example)

Step 1 - Determine the Total Weight of the Boat (NB – Crew weight not taken into account)

Eg. Total Weight = Lightweight + Deadweight; viz,

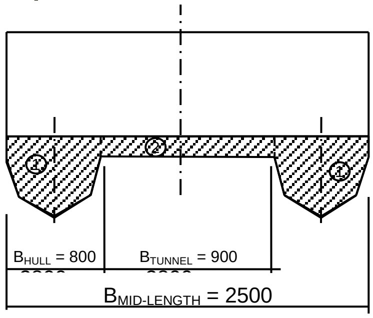
Lightweight =		1412 kg
Add Boat Engines =	200 kg	
Add Fixed Equipment =	200 kg	400 kg
Therefore Total Weight =		1812 kg

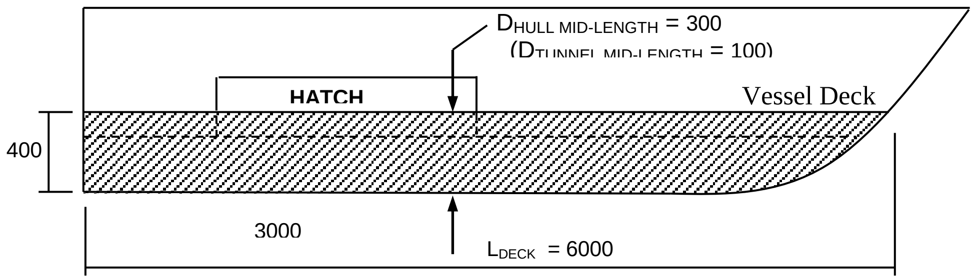
Step 2 - Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)

The K_{factor} used is based on the vessel construction material ie. For GRP K_{factor} = 30%

Therefore $V_{BIB\ REQUIRED}$ = Total Weight x K_{factor}
= 1812 x 30%
≈ **544 [litres] or 0.544 [m^3]**

Step 3 - Calculate the Volume of Spaces Provided with Built-in Buoyancy (V_{SPACES})





V_{SPACES} = ($V_{UNDERDECK}$ – $V_{HATCHES\ BELOW\ DECK}$) + $V_{SPACES\ ABOVE\ DECK}$

with $V_{UNDERDECK}$ = 2 x Hull Sections + 1 x Tunnel Section
= 2 x $Volume_1$ + 1 x $Volume_2$

with $Volume_1$ = Cp x(L_{DECK} x B_{HULL} x $D_{MID\text{-}LENGTH}$)
= 0.60 x (6.00 x 0.80 x 0.30)
= 0.864 [m^3]

and $Volume_2$ = L_{DECK} x B_{TUNNEL} x D_{TUNNEL}
= 6.00 x 0.90 x 0.10
= 0.540 [m^3]

Therefore; $V_{UNDERDECK}$ = 2 x 0.864 + 1 x 0.540
= 2.148 [m^3]

less $V_{HATCHES\ BELOW\ DECK}$ = 0.30 [m^3] (Illustrative Value)

Therefore; V_{SPACES} = (2.148 – 0.30)
= 1.848 [m^3]

Step 4 - Determine the Actual Volume of Built-in Buoyancy Installed ($V_{BIB\ INSTALLED}$) by taking the Permeability of the Actual Built-in Buoyancy into account

For bottles (tightly packed); Permeability = 60% and for Foam; Permeability = 100%

Therefore; $V_{BIB\ INSTALLED}$ = ($V_{UNDERDECK}$ x 60%) + ($V_{SPACES\ ABOVE\ DECK}$ x 100%)
= (1.848 x 60%) + (0 x 100%)
= 1.109 [m^3]

Conclusion: $V_{BIB\ INSTALLED}$ > $V_{BIB\ REQUIRED}$; (1.109 [m^3] > 0.544 [m^3]) Therefore it can be concluded that the vessel will remain afloat in the event of it being flooded, swamped or capsized in such a manner that the full complement can hold on/cling to the vessel.

APPENDIX C

BUOYANCY EXAMPLE CALCULATION – INFLATABLE VESSELS

Inflatable Vessel Example – Category B to E Vessels

The illustrative example in Section 1 describes the minimum standard/level of accuracy which may be applied for determination of the amount of Built-in Buoyancy required to be installed in a conventional vessel. In the field, however, a surveyor often needs to make a quick judgement call on whether the Built-in Buoyancy claimed to be installed is in compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007.

Compliance is confirmed as follows:

Step 1 - **Determine the Total Weight of the Boat**

Eg. Total Weight = Lightweight + Deadweight; viz,

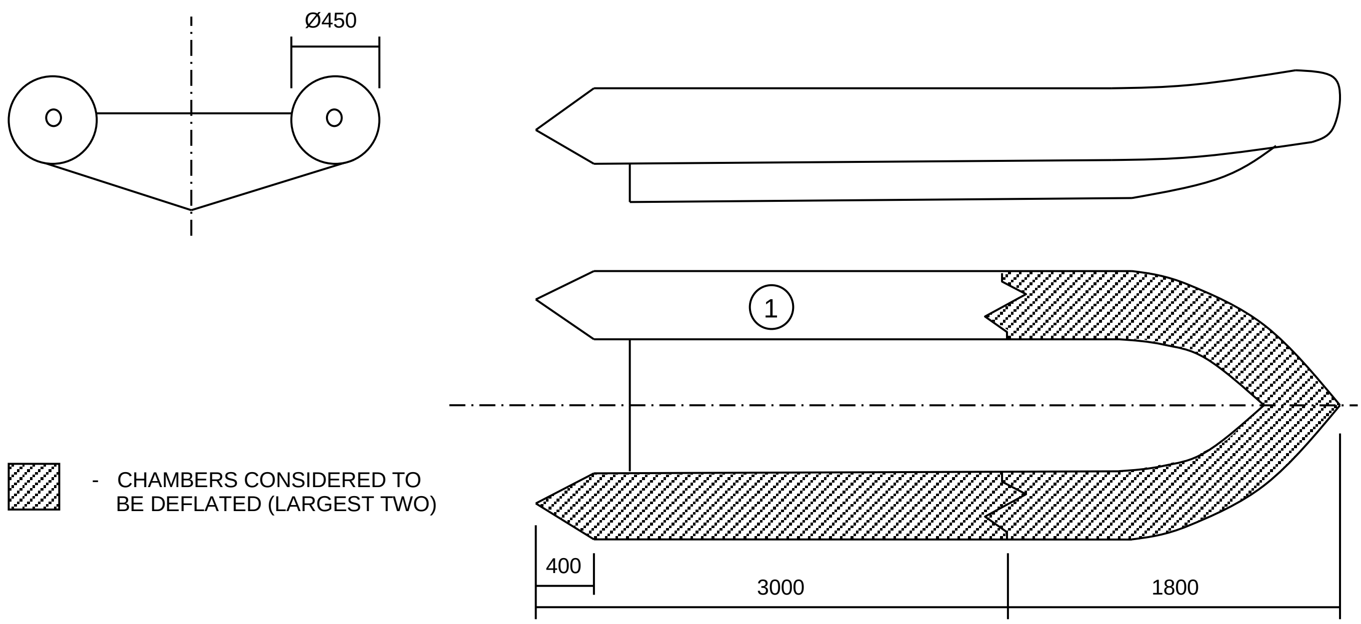
Lightweight =		280 kg
Add Boat Engine =	80 kg	
Add Crew (x4) = 4 x 75 kg =	300 kg	
Add Fixed Equipment =	50 kg	430 kg
Therefore Total Weight =		710 kg

Step 2 - **Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)**

The K_{factor} used is based on the vessel construction material ie. For GRP K_{factor} = 60%

Therefore $V_{BIB\ REQUIRED}$ = Total Weight x K_{factor}
= 710 x 60%
≈ **426 [litres] or 0.426 [m³]**

Step 3 - **Calculate the Volume of Intact Buoyancy Chambers**



The RHIB shown is provided with 3 buoyant chambers. With the two largest chambers considered deflated, only one buoyant chamber remains intact. Calculating the volume of the buoyant chamber:

V_1= Volume Cylinder + Volume Cone
= πr^2 x length + ⅓ x πr^2 x length   with r = chamber radius
= $(\pi(0.225)^2$ x (3.0 – 0.40)) + (⅓ x $\pi(0.225)^2$ x 0.40)   = 450/2
= (0.159 x 2.6) + (⅓ x 0.159 x 0.40)   = 225 [mm] or 0.225 [m]
= 0.4134 + 0.0212
≈ 0.435 [m³] = $V_{BIB\ INSTALLED}$

Conclusion: $V_{BIB\ INSTALLED}$ > $V_{BIB\ REQUIRED}$; Therefore it can be concluded that the vessel will remain afloat (0.435 [m³] > 0.426 [m³]) despite the largest two chambers being completely deflated.

Inflatable Vessel Example – Category R Vessels

The illustrative example in Section 1 describes the minimum standard/level of accuracy which may be applied for determination of the amount of Built-in Buoyancy required to be installed in a conventional vessel. In the field, however, a surveyor often needs to make a quick judgement call on whether the Built-in Buoyancy claimed to be installed is in compliance with the Merchant Shipping (National Small Vessel Safety) Regulations, 2007.

Compliance is confirmed as follows:

Step 1 - **Determine the Total Weight of the Boat (NB – Crew weight not taken into account)**

Eg. Total Weight = Lightweight + Deadweight; viz,

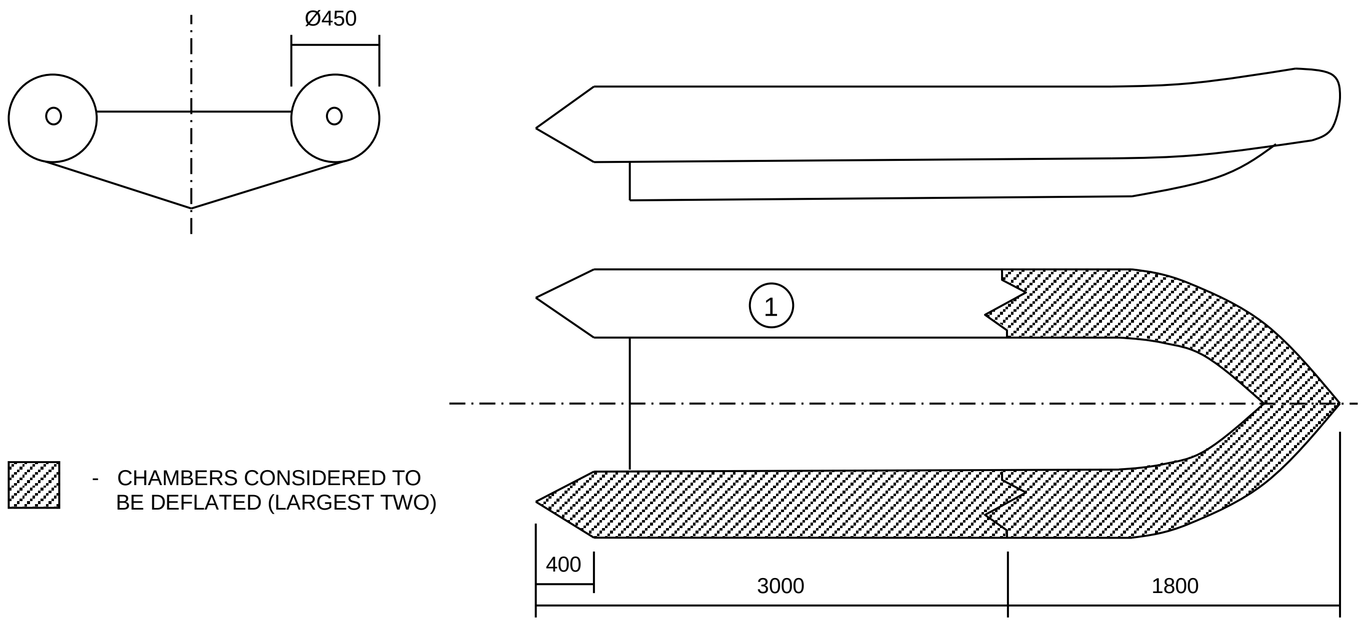
Lightweight =		280 kg
Add Boat Engine =	80 kg	
Add Fixed Equipment =	50 kg	130 kg
Therefore Total Weight =		410 kg

Step 2 - **Determine the Volume of Additional Built-in Buoyancy Required ($V_{BIB\ REQUIRED}$)**

The K_{factor} used is based on the vessel construction material ie. For GRP K_{factor} = 30%

Therefore VBIB REQUIRED = Total Weight x K_{factor}
= 410 x 30%
≈ **123 [litres] or 0.123 [m^3]**

Step 3 - **Calculate the Volume of Intact Buoyancy Chambers**



The RHIB shown is provided with 3 buoyant chambers. With the two largest chambers considered deflated, only one buoyant chamber remains intact. Calculating the volume of the buoyant chamber:

V_1= Volume Cylinder + Volume Cone
= πr^2 x length + ⅓ x πr^2 x length   with r = chamber radius
= ($\pi(0.225)^2$ x (3.0 – 0.40)) + (⅓ x $\pi(0.225)^2$ x 0.40)   = 450/2
= (0.159 x 2.6) + (⅓ x 0.159 x 0.40)   = 225 [mm] or 0.225 [m]
= 0.4134 + 0.0212
≈ 0.435 [m^3] = $V_{BIB\ INSTALLED}$

Conclusion: $V_{BIB\ INSTALLED} > V_{BIB\ REQUIRED}$; (0.435 [m^3] > 0.123 [m^3]) Therefore it can be concluded that the vessel will remain afloat despite the largest two chambers being completely deflated so that the full complement can hold on/cling to the vessel.

APPENDIX D

ACCEPTABLE MATERIALS FOR USE AS BUILT-IN BUOYANCY

APPENDIX D

TABLE OF ACCEPTABLE MATERIALS FOR USE AS BUILT-IN BUOYANCY[1]

Material Type	Description	Maximum Allowable Moisture Absorption	Minimum Density[2] [kg/m^3]	Area's where may not be utilised	Recommended Period Between Inspections[3][4]	Remarks
Sandwich Construction	Any material forming part of a GRP lay-up of a hull, deck or deck structure eg. Structural foam, polyurethane, balsa wood.	5%	N/A	None	Duration of vessels life unless damaged.	Supporting documentation to be provided by boat builder.
Foam	Closed cell polyurethane	5%	28	None	5 years	
Foam	Cross linked, closed cell expanded polyethylene	5%	30	None	5 years	
Foam	Expanded Polystyrene	5%	20	1. Any area where fuel or fuel oil contamination may occur. 2. Below decks	2 years	
Bottles	High Density Polyethylene (HDPE)	0%	45		3 years	The use of purpose moulded "boat floats" is recommended.
Bottles	Polyethylene terephthalate (PET)	0%			1 year	- Commercial soft drink bottles - Must be screw top

Notes:

(1) This list of acceptable materials is valid from the date of publication of this marine notice. If existing vessels are provided with built-in buoyancy which is not listed on this table, then:

(a)The material may be used as long as it is maintained in satisfactory condition. In the event that the material is found to be in poor condition (no longer fit for purpose) then the unsatisfactory material must be replaced with acceptable materials listed in this table.

(b)The recommended period between inspections for materials not listed in this tale is one (1) year provided that a surveyor/safety officer may endorse the buoyancy certificate allowing a longer period between inspections but only after satisfactory inspection of the material.

(2) A maximum allowable density is not specified. Installers must however be aware that the installation of built-in buoyancy with high density will have a negative effect on the overall weight of the vessel.

(3) The recommended period between inspections is provided for the guidance of installers and surveyors. Installers may extend or reduce the recommended period between inspections. The recommended period between inspections must be stated on the buoyancy certificate with any necessary clarifications/qualifications. If a recommended period between inspections is not provided on the buoyancy certificate then the surveyor/safety officer must use this table for guidance.

(4) Inspection of Built-in Buoyancy provisions is to be carried out as follows:

a. At time of specified inspection

i. Foam Installations

(1) Weigh vessel and compare lightweight to that reflected on the Buoyancy Certificate.

(2) Physically inspect foam condition at minimum of two locations.

ii. <u>Bottles Installation</u> Physically inspect condition of 10% of bottles at a minimum of two locations

Carry out further inspections if doubt exists over condition of the Built-in Buoyancy.

b. At periods between inspections

Carry out inspection of vessel with reference to the vessels buoyancy certificate. Inspect condition of accessible buoyancy. If built-in buoyancy is not accessible carry out careful inspection of hull and other adjacent spaces. Only require opening of hull for inspection of buoyancy if doubt exists over presence or condition of indicated built-in buoyancy.

NB - A surveyor/safety officer may require inspection of the built-in buoyancy installation at any time, with associated opening of deck and other spaces, as considered necessary, in the event that he/she suspects that the buoyancy installation is damaged/no longer fit for purpose or is not as is reflected on the vessels buoyancy certificate.

(5) The list of acceptable materials for use as Built-in buoyancy will be reviewed periodically. Boat builders and/or other interested parties wishing to propose alternative materials should submit to SAMSA for consideration with appropriate specification and sample(s).