What happens when you start getting wet feet? The revised standard for buoyancy and stability after flooding

Mori Flapan
National Marine Safety Committee Inc
mflapan@nmsc.gov.au

ABSTRACT

This paper describes the development of a new performance-based standard for buoyancy and stability after flooding on domestic commercial vessels. The standard specifies controls that reduce the consequences of flooding. Flooding is an event associated with by far the majority of vessel losses. The standard bridges the gap between relatively stringent international standards intended for full seagoing operations and standards applicable to small craft in sheltered conditions. Some of the key changes relative to current standards have been highlighted in the paper.

1. INTRODUCTION

The Australian domestic commercial vessel standard called the Uniform Shipping Laws Code[1] (USL Code) has been the subject of a progressive review by the National Marine Safety Committee[2] (NMSC). The objectives of the review include updating the standard to accommodate current and new technologies based on relevant international and national standards, and introduce a performance-based approach[3]. The revised standards are being published as the National Standard for Commercial Vessels[4]

The standards for subdivision and damaged stability contained in the USL Code were based on SOLAS provisions and US CFR 46[5] requirements from the 1970s. Apart from amendments to the criteria for damaged stability, there had been little change to the USL Code provisions since that time.

An analysis of 108 Australian commercial vessel losses over the last 15 years is given in Figure 1[6]. The requirements for buoyancy and stability after flooding work to directly reduce the consequence of the incidents that lead to a vessel being wrecked (i.e., grounding), being in collision and foundering (i.e., capsize, swamping or flooding). It also can play a role in reducing the consequences of fire by separating compartments and limiting the potential effects of flooding.

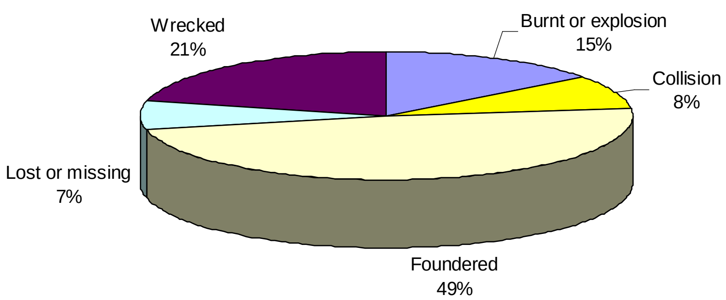

Figure 1—Analysis of 108 Australian vessel losses (1992-2007)

2. A MORE TAILORED APPROACH

The current USL Code requirements[7] for subdivision and damaged stability are largely centred around four grades of vessels: First they are differentiated by length; 35 metres and more or under 35 metres; then these are divided by the type of operation; passenger vessels and vessels not being passenger vessels. Within these groups are a few adjustments for length; but as a general observation, the grading of requirements tend to be relatively coarse. Application of the current USL Code standards frequently results in sub-optimal solutions, requiring the application of surveyor ñinterpretationò and discretion to provide a practical solution.

The revised standard aims to capture this surveyor experience within the standard and so avoid the need to exercise surveyor discretion that is frequently to some extent subjective and leads to less than consistent outcomes.

3. INTERNATIONAL STANDARDS SET THE UPPER BENCHMARK FOR NSCV

The buoyancy and stability after flooding requirements for passenger ships and large cargo ships engaged in international trade are contained in Chapter II-1 of SOLAS[8]. SOLAS is not applicable to fishing vessels or cargo ships of less than 500 gross tons. The flag state is given discretion to vary requirements for vessels engaged in international trade operating not more than 20 nautical miles from the coast. For domestic vessels, the new NSCV standard applies the IMO Regulations as the upper benchmark for ships engaged in domestic operations having levels of risk essentially similar to those engaged in international trade. Hence the NSCV refers to SOLAS requirements for passenger and cargo ships above a certain size that operate at sea. Because SOLAS is not applicable to fishing vessels, the buoyancy and stability after flooding requirements in the IMO Safety of Fishing Vessels Code[9] (SFV Code) form the upper benchmark for large seagoing domestic fishing vessels. The relevant SOLAS requirements are also applied to passenger vessels of smaller sizes engaged in unlimited domestic operations (Operational area A), and also certain passenger vessels carrying relatively large numbers of day passengers (more than 450) or berthed passengers (more than 36) in operations from 20 nautical miles up to 200 nautical miles from the coast.

SOLAS and SFV are also specified as alternative deemed-to-satisfy solutions for some of the remaining vessels; see Table 1 from the NSCV below. Thus a Class 1C passenger vessel 50 metres long carrying 200 day passengers could either apply SOLAS or the specific deemed-to-satisfy provisions contained in the NSCV. These alternative solutions have been provided so that a vessel imported into Australia that is built to international standards will be deemed-to-satisfy the NSCV.

The lower limit of application of the international standards is determined by the effective limits of their application. SFV for example, while nominally intended for fishing vessels 24 metres or more, only contains verifiable requirements for vessels 45 metres or more; the requirements below this length being applied at the discretion of the flag state. The NSCV requirements for fishing vessels between 24 metres and 45 metres represent the Australian interpretation of this discretion and so the interpretations of foreign states must be considered in the context of an equivalent solution. A key pillar that shapes the Australian interpretation is that differences in minimum achieved safety levels between fishing vessels and other non-passenger vessels should be eliminated[10].

Table 1 — Deemed-to-satisfy solutions for buoyancy and stability after flooding

Operational Area	Class 1 Passenger	Class 2 Non-passenger	Class 3 Fishing
A	SOLAS Chapter II-1	SOLAS Chapter II-1 if L_m Ó80 m	Torremolinos SFV if L_m Ó45 m
		or NSCV if L_m < 80 m	or NSCV if L_m < 100 m
B	SOLAS Chapter II-1	SOLAS Chapter II-1 if L_m Ó80 m	Torremolinos SFV if L_m Ó45 m
	or NSCV if L_m < 60 m (2)	or NSCV if L_m < 80m	or NSCV if L_m < 100 m
B20, C	SOLAS Chapter II-1	SOLAS Chapter II-1 if L_m Ó80 m	Torremolinos SFV if L_m Ó45 m
	or NSCV if L_m < 80 m	or NSCV if < 100 m	or NSCV if < 100 m
D, E	SOLAS Chapter II-1	SOLAS Chapter II-1 if L_m Ó80 m	Torremolinos SFV if L_m Ó45 m
	or NSCV	or NSCV	or NSCV

4. RECREATIONAL BOAT STANDARDS SET THE LOWER BENCHMARK

Recreational boat standards were not mandatory in Australia at the time the USL Code was first written in the 1970s. However, since the implementation of the Australian Builders Plate[11] in 2005, new recreational boats in Australia have been required to meet certain minimum standards for maximum number of persons, load capacity, engine power and, for vessels less than 6 m in length, buoyancy. The NSCV acknowledges that properly constructed recreational craft should suffice for use in the lowest risk categories for commercial service. Hence, the revision of the NSCV has used recreational boat standards as the lower benchmark for requirements, applicable to commercial vessels of lowest risk. The concepts of basic and level flotation used in the NSCV have been closely based on the US standards for recreational craft[12], with modifications to extend the application to vessels above 6 metres in length and to accommodate the wider range of configurations seen in commercial vessels. This should have the practical benefit of permitting the use of certain production recreational boats for certain applications. One significant departure however is the assumed mass of each person which has been adjusted from 63.5 kg to a minimum 80 kg per person to take into account important effects arising from changes in the physical characteristics of the community[13].

5. CATEGORIES OF FLOODING RISK BRIDGE THE GAP

Between the two extremes of IMO standards and recreation craft standards for buoyancy and stability after flooding; the new NSCV standard adopts a more comprehensive method of risk grading vessels to replace length as the prime driver of requirements. Four so-called flooding risk categories I, II, III and IV are defined taking account factors such as the Vessel Use (passenger, non-passenger, fishing), Area of Operation (Operational Areas A, B, C, etc), number of passengers on board and the number of berthed passengers on board. Table 2 from the standard shows how the Flooding Risk Category of a vessel is determined. This table also shows how the requirements specified in SOLAS are dovetailed into the NSCV requirements. The Flooding Risk Categories provide a framework that grades the requirements from those applied to recreational craft to the full SOLAS standard. This is illustrated in Figure 2. The estimated distribution of vessels into the Flooding Risk Categories is as follows: 45.6% in FLRC 1, 41.6% in FLRC II, 11.8% in FLRC III, 0.8% in FLRC IV and 0.2% are required to apply SOLAS[14]. By far the majority of vessels (87.2%) are expected to apply FLRC I or II.

Table 2 — Flooding Risk Categories of vessels

Operational area category (see NSCV Part B) **Vessel use category (see NSCV Part B)**	**Class A** Unlimited domestic operations	**Class B** Offshore operations	**Class B20** Offshore operations limited to 20 nm	**Class C** Restricted offshore operations	**Class D** Partially smooth waters	**Class E** Smooth waters
Class 1— Length of vessel		**< 60 m**	**< 80 m**	**< 80 m**	**All lengths**	**All lengths**
Class 1: 13 to 36 day passengers	SOLAS Ch. II-1	III	III	III	III	II
Class 1: 37 to 400 day passengers	SOLAS Ch. II-1	IV	IV	III	III	III
Class 1: 401 or more day passengers	SOLAS Ch. II-1	SOLAS Ch. II-1	IV	IV	III	III
Class 1: 13 to 36 berthed passengers	SOLAS Ch. II-1	IV	IV	III	III	III
Class 1: 37 or more berthed passengers	SOLAS Ch. II-1	SOLAS Ch. II-1	IV	IV	IV	III
Class 2— Length of vessel	**< 80 m**	**< 80 m**	**< 100 m**	**< 100 m**	**All lengths**	**All lengths**
Class 2: Nil passengers	II	II	II	I	I	I
Class 2: 1 to 12 passengers	III	II	II	II	I	I
Class 3— Length of vessel	**< 100 m**	**< 100 m**	**< 100 m**	**< 100 m**	**All lengths**	**All lengths**
Class 3	II	II	II	I	I	I

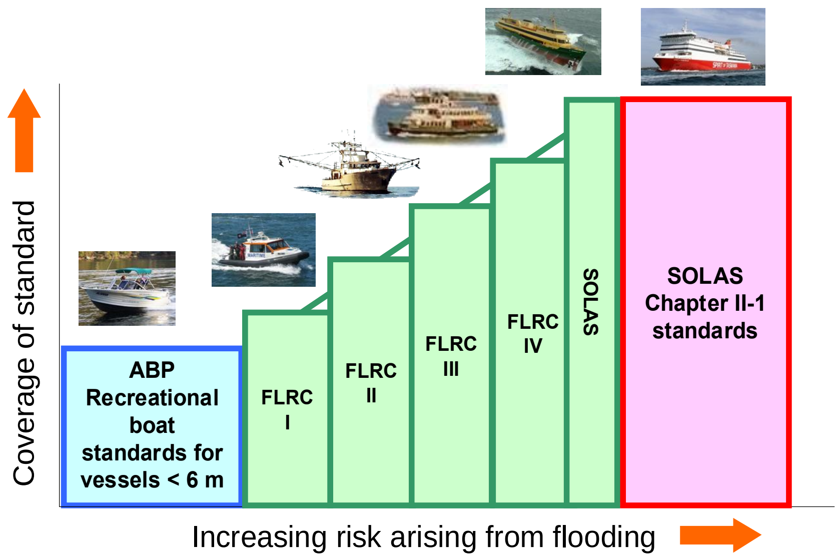

Figure 2—Illustration of how the Flooding Risk Categories provide a graded approach to the requirements for buoyancy and stability after flooding

6. OUTCOME RATHER THAN SOLUTION FOCUS

A significant difference between the USL Code provisions for subdivision and damage stability and the new NSCV standard ñBuoyancy and stability after floodingò is the focus on hazards and safety outcomes rather than specific solutions. This is reflected in the name of the standard. There are now specific chapters that deal with the key hazards of swamping, local flooding, grounding and collision (both bow collision and side collision). The provisions within each chapter determine the application of the chapter to a particular vessel. Graded requirements are specified depending on the magnitude of relevant key risk parameters, including the flooding risk category. Thus, while a small vessel may be subject to the swamping chapter, the grounding and collision chapters may not apply. Similarly, the swamping chapter may not apply to certain vessels required to meet the side collision requirements of the collision chapter.

7. KEY REFORMS IN DEEMED-TO-SATISFY SOLUTIONS

7.1 Clear requirement for certain vessels to withstand swamping

Swamping is defined in the standard as the unintentional entrapment of sea or fresh water within spaces open to the weather such as found on open vessels, or in the wells or cockpits on vessels. Chapter 4 of the new standard specifies that the following vessels are required to withstand swamping: Any vessel of measured length less than 6 m; or a vessel of FRC II of measured length 6 m or more and less than 24 m. However it does not apply to vessels having buoyancy spaces in the form of watertight compartments protected by decks with closures to openings and rapid drainage compliant with the NSCV requirements for Watertight and Weathertight Integrity[15]. Two standards of compliance are specified: Basic flotation and level flotation corresponding to the definitions used in the Australian Builders Plate and ABYC Rule H-8 standards.

7.2 Concept of local flooding

Previous standards have professed an ñall or nothingò approach to flooding. Either the vessel can survive flooding from a given extent of collision damage or it cannot. The reality of a one compartment standard that is commonly applied to domestic passenger vessels is that the probability of hitting and damaging the shell plating in way of a bulkhead is no less than that of damaging the equivalent length of shell plating between bulkheads. The probability of survival of a vessel designed to a one compartment standard in the event of collision may well be quite marginal depending upon the actual arrangement used. At the very least, this gives a false impression of the extent of protection.

The draft standard defines local flooding as the unintentional entry of sea or fresh water into a single buoyant space through an unintended opening, hole, crack or gap. This could include a limited amount of damage from grounding or collision, but does not purport to provide comprehensive levels of protection from a reasonably likely range of possible collision or grounding scenarios. Local flooding also includes flooding from failure of sea water systems, accidental flooding by persons, flooding from structural failure or corrosion, flooding past stern glands and vulnerable appendages.

The concept of local flooding provides a performance basis for the prescriptive requirements that specify bulkheads for vessels not required to survive flooding such as cargo and fishing vessels. These provisions are used to provide opportunities for reducing the consequences of flooding by providing time and protecting essential systems to try and prevent or limit flooding and for evacuation spaces and, if necessary, the vessel. Most importantly, the effect of the provisions is to modify the way that a vessel founders by preventing premature capsize. Provisions are provided for: Early warning of flooding (flooding detection systems), Separation of spaces liable to flooding, Measures to control the risks of local flooding causing premature capsize, Local flooding of enclosed Ro-Ro spaces, and Slack bilges in landing craft.

A challenge when adapting existing provisions to a performance-based framework is how to deal with apparent anomalies such as the acceptance of yachts without effective transverse subdivision.

Great care has to be taken to ensure that the new framework does not exclude hitherto acceptable arrangements. This has been dealt with by constraining the consequences of flooding by other means. Limits are placed on the power of machinery and the vessel must be of a type not prone to premature capsize when flooded; e.g., a vessel with a substantial ballast keel or of catamaran configuration.

7.3 Performance based options for protection from grounding

The USL Code requirements have focused on highly prescriptive requirements for double bottoms presented in such a way that they are hardly related to the hazard of grounding. Chapter 5 of the NSCV standard applies the approach used by the current version of SOLAS Chapter II-1 that provides the choice of either a prescriptive requirement without calculations or a more performance-based requirement determined using an assumed extent of bottom damage. This allows much greater flexibility of solution allowing the use of a double bottom, watertight compartments or a combination of both. A progressive approach to application has been adopted depending on Flooding Risk Category similar to the approaches used in the HSC Code 2000[16].

The chapter also includes damage scenarios involving vulnerable appendages. Changes to the design of keels on large yachts including the use of extreme fin keels and canting keels have meant that previous assumptions as to the robustness of ballast keels may be invalid. Instead of providing a degree of protection they may be a point of vulnerability. The provisions in the NSCV standard raise the issue and require appropriate consideration to be given to the risks of flooding.

7.4 Collision reforms

Two types of collision damage are considered. The first is bow collision, while the other is side collision. Bow collision incorporates the prescriptive requirements for the collision bulkhead, but with modifications that introduce performance-based concepts allowing for greater flexibility in the location of the collision bulkhead. One modification that could potentially affect some larger displacement vessels and vessels that operate at higher speeds is the introduction of a minimum distance from the bow for the collision bulkhead based on an energy coefficient based on the collision acceleration calculations in the HSC Code 2000[17]. It is unreasonable to expect that the degree of protection offered by a bulkhead located 5% from the bow will be the same for a vessel that travels twice as fast or displaces twice as much. However, this change should be more than offset by the much greater freedom the provisions provide.

Recent amendments to SOLAS Chapter II-1[18] have profoundly changed the basis on which passenger vessels are assessed for subdivision and damaged stability. Probabilistic methods are employed overlaid over a framework of deterministic criteria. The question of whether this new methodology should be applied to domestic commercial vessels was raised for public comment and was considered by the reference group formed to consider the public comments and steer the course of the revision. It was decided that a mandated direct use of the probabilistic method would be inappropriate for two reasons. The first was that its application to vessels of the type typically considered for the NSCV might not be valid because of differences in size and configuration. The second was the difficulties that would be faced by attempting to introduce the methodology into the industry and the burden of higher cost of analysis that would have to be borne by the industry. It was felt that the benefits would not warrant the burden.

Notwithstanding that the probabilistic methods have not been applied, a number of changes to the deterministic aspects of the new IMO standard have been incorporated into the new NSCV standard. The SOLAS provisions specify that vessels that carry 400 or more passengers are required to meet two compartment standard of subdivision[19]. Similar requirements have been incorporated into the NSCV to ensure that the highest risk vessels reflect community expectations as expressed within those International Standards. Not all the changes are more onerous. The NSCV standard incorporates the SOLAS extent of damage provisions which in some aspects represent a lesser requirement. Similarly, for vessels carrying 12 to 36 passengers, no side collision criteria are specified, these being replaced by local flooding requirements. For vessels carrying between 36 and 400 passengers, a one compartment standard is still specified but the assumed length of damage varies depending upon the Flooding Risk category.

7.5 Reforms to compliance criteria, more flexibility but with increased analysis

Chapter 8 of the new standard contains the criteria for compliance after application of the flooding scenarios specified in Chapters 4 to 7. The changes reflect the almost wholesale adoption of CAD and computer analysis for the design of vessel since the original USL Code. The main change has been the removal of the traditional reliance on non-immersion of the margin line, the removal of subdivision length analysis and the removal of permissible length calculations[20]. These have been replaced by more performance-based criteria based on SOLAS and the HSC Code 2000. The NSCV criteria now consider flooded freeboard, equilibrium angle, and for passenger vessels analysis of the flooded G_fZ curve looking at the range of stability and the height of maximum G_fZ. Two alternative sets of criteria are provided for the analysis of the flooded G_fZ curve, one from SOLAS and the other from HSC Code 2000.

7.6 Limits to the use of hinged watertight doors

A major point of contention in the USL Code was the use of watertight doors. The USL Code required watertight doors to be the minimum number practicable and prohibited hinged watertight doors entirely on passenger vessels 35 metres and more. The Code was ambivalent as to the application of hinged watertight doors on smaller vessels; leaving it largely to the discretion of the Authority. The result was that there was no consistent interpretation of requirements. Issues sometimes arose when a vessel transferred between jurisdictions.

The NSCV standard clearly specifies the extent and circumstances to which manual hinged watertight doors will be deemed-to-satisfy. Their use depends on the Flooding Risk Category, their size, the distance between the lowest sill of the door and the bulkhead deck and the number of such doors proposed.

Table 3 — Applicable Types of watertight doors

		Type 1 **Sliding door, operated by power and by manual gear**	**Type 2** **Sliding door, operated by manual gear only**	**Type 3** **Hinged door**
Additional limits on application		None	Door sill not more than 4 metres below the bulkhead or freeboard deck	Door sill not more than 2.5 metres below the bulkhead or freeboard deck Maximum width 800 mm
Flooding Risk Category	I	Required where Type 2 or Type 3 cannot apply	Optional for vessels having no more than four watertight doors per hull	Optional for vessels having one or two watertight doors per hull
	II	Required where Type 2 or Type 3 cannot apply	Optional for vessels having no more than four watertight doors per hull	Optional for vessels having one or two watertight doors per hull
	III	Required where Type 2 or Type 3 cannot apply	Optional for vessels having no more than three watertight doors per hull	Optional for vessels having a single watertight door per hull
	IV	Required where Type 2 cannot apply	Optional for vessels having a single watertight door per hull	Not applicable

A pragmatic yet cautious approach has been applied based loosely on the provisions contained in the US standards[21], see Table 4. There have been a number of incidents where watertight doors were found to be wanting at the time of need, both within Australia[22] and overseas[23]. Quite apart from the perennial problem of their being left open, there have been cases where the watertight door has been found incapable of providing an effective seal. Watertight doors should be installed sparingly, and only when absolutely necessary. Table 4 specifies the deemed-to-satisfy solution and does not preclude the proposal of an equivalent solution provided equivalent safety can be proven.

7.7 Collared vessels are covered

One of the most significant changes in the design of vessels over the last 30 years has been the development and increasingly widespread use of vessels employing collars. Collared vessels are defined[24] as a vessel with a rigid hull provided with one or more buoyant collars around the periphery of the vessel such thatð

a) the buoyant volume of the collars constitute greater than one-fifth of the total intact buoyant volume of the vessel, and

b) inclusion of the buoyancy of the collars is essential for the vessel to meet the applicable intact or damaged stability criteria.

The collar may be inflatable, foam filled or of rigid construction. Collared boats include RIBs (rigid inflatable boats). Such vessels were never envisaged in the USL Code and were not easily accommodated within the existing provisions. An interim set of guidelines was developed in 2005 that provided for separate standards applicable to inflatables and RIBs[25]. While the guidelines accommodated the majority of such vessels, they were not able to provide solutions for collared vessels that were not inflatable, nor large collared vessels of length greater than 12 metres. Another issue is the inconsistency in the safety outcomes provided by the standards for inflatable collared vessels compared to other vessels engaged in similar service. The challenge has been to consider collared vessels within the same overall framework provided by the graded approach contained within the NSCV, while at the same time acknowledging the strengths and addressing any particular weaknesses associated with the wide range of collared vessel configurations.

An analysis was made of the requirements specified by a number of relevant national and international standards to compare these against one another and also against the NSCV requirements for buoyancy and stability after flooding applicable to conventional (non-collared) vessels, see Table 4. This was used to help identify the differences between the conventional requirements and those for inflatable collared vessels. The standards imply that inflatable collars have advantages over rigid air chambers in that the status in regard to the effectiveness of the chamber is manifest and any time, while rigid air chambers may have a latent defect that is never identified until the critical moment in an emergency. Hence, the proposal allows for a reliability assumption that only one inflatable chamber need be considered deflated for swamping or local flooding, compared to the assumption that two rigid air chambers should be considered ineffective.

The standards indicate that inflatable chambers are considered more vulnerable to damage in certain situations such as bow collision, side collisions and raking damage. The draft standard provides for additional requirements applicable to inflatable chambers to provide equivalent safety.

The majority of provisions in the draft standard apply to collared vessels in just the same way as to other vessels. However, a number of specific provisions are also included that address the particular strengths and weaknesses of collared types. These are listed as follows:

7.3.7 Special provisions for bow collision on collared vessels with inflatable collars.	*10.6.2 Number and disposition of chambers*
7.4.5 Special provisions for side damage on collared vessels with inflatable collars.	*10.6.3 Collar to hull connection*
7.5 Measures to reduce the consequences of raking damage on collared vessels with an inflatable collar	*10.6.4 Fittings for inflation and deflation*
8.6.3 Criteria for basic flotation	*10.6.5 Additional tests for inflatable collars*
8.6.4 Alternative criteria for basic flotation	*10.6.6 Means to repair and reinflate collars*
8.7.4 Criteria for level flotation	*C4.5 Volume of additional buoyancy*
10.6 Inflatable collars	*E4.3 Weights to simulate swamped conditions*
10.6.1 Collar materials	*H3.6 Vessels with inflatable collars*

8. IMPACT OF THE NEW STANDARD

The review of the NSCV Buoyancy and Stability after Flooding Standard has been driven by a number of key constraints. These are:

a) Incorporation of a performance-based approach that focuses on safety outcomes rather than solutions

b) Consistency with relevant national and international standards; and in particular the changes to relevant IMO standards in SOLAS Chapter II-1 and SFV since 1979; and standards applicable to recreational craft in Australia.

c) Changes in technology in vessels and the methods of designing and analyzing vessels.

d) A desire for any changes not to burden the industry unless the benefits can be justified.

The new standard has been drafted to find a balance between these constraints. Some of the changes are more onerous, however others are less so. It is envisaged that the net effect should be relatively neutral in terms of overall cost to the industry. For some higher flooding risk vessels, the increased standards for two-compartment flooding that are based on the IMO requirements will undoubtedly add to the costs for individual vessels, but with a benefit to their safety. For the lowest level of flooding risk, certain recreational craft standards will suffice increasing the chance that a recreational craft can be bought off the shelf for commercial use.

The revised criteria for deemed-to-satisfy solutions are much more performance driven being limited by safety outcomes rather than limits of past available methods of analysis. It is envisaged that this should give designers more room for flexibility when considering deemed-to-satisfy solutions. As new technologies develop and new methods of analysis become available, there is the option to depart from the deemed-to-satisfy criteria by developing equivalent solutions that provide equivalent safety.

Part of the potential benefit of the new standard will take time to realize as designers become familiar with the content and learn to adapt their designs to take advantage of its enhanced features.

9. ACKNOWLEDGEMENTS

The author gratefully acknowledges the significant contributions made to the development of this standard by members of the Buoyancy and Stability after Flooding Reference Group and the many stakeholders from both industry and government who provided input through their public comment. A process that encourages the expression, consideration and balancing of a range of views as part of this drafting of this standard has done much to enrich the outcome.

Table 4 — Comparison of various standards for inflatable collared vessels

Scenario	New NSCV Conventional Vessels	NMSC RIB Guidelines[25]	ISO 6185.3[26]	ISO 6185.4[27]	MCA MGN 280[28]	SOLAS Chapter III Rescue boats	NZ Maritime Rules 40A and 40C[29]	NSCV inflatable Collared vessels
Swamping	Application: Vessels < 6 m FLRC II vessels 6m to 24 m. Excludes vessels with rapid drainage (i.e. most vessels) Recesses & drainage arrangments	Min freeboard of well deck with pumping criteria. USL Code Sec.10 Appendix N with 2 largest chambers excluded. Inherent buoyancy not less than 60% Appendix N	Drainage requirements Basic (?) flotation with largest chamber deflated	Hull drainage Bilge System if integral hull/deck. Drainage of totally flooded deck areas in less than 3 minutes	SOLAS Rescue boat if > 20 nm Swamped condition + drainage	Min 0.17 m3 inflated buoyancy per person. Inherently buoyant material of Basic flotation plus 280N of buoyant force per person.	Supports all persons when swamped, prove drainage effective.	Application as per Conventional using Level & Basic but with only largest collar air chamber excluded if inflatable, two if not.
Local flooding	Application: All vessels Largest 2 air chambers excluded.	USL Code Sec.10 Appendix N with 2 largest chambers excluded. Inherent buoyancy not less than 60% Appendix N	Min 2 compts in Rigid portion of RIB. Basic (?) flotation with largest chamber deflated	Min 2 compts in rigid portion of RIB. Min 5 chambers in collar. Residual inflated buoyancy at least 50% of manufacturers rated max load capacity after failure of largest chamber.	SOLAS Rescue boat if > 20 nm Swamped condition + drainage	Inherently buoyant material. Basic flotation plus 280N of buoyant force per person.	10 to 25 bhp requires 2 to 3 chambers. > 25 bhp requires 3 to 4 chambers	Application: As per conventional Level & Basic but with only largest collar air chamber excluded if inflatable, two if not.
Grounding	If > 50 m Vulnerable appendages if draft > 4 metres	No specific requirement	No specific requirement	No specific requirement	No specific requirement	No specific requirement	No specific requirement	If > 50 m Vulnerable appendages if draft > 4 metres
Bow collision	Application >16 m Collision bhd requirement Analysis in certain circumstances	No specific requirement	No specific requirement	No specific requirement	SOLAS Rescue boat if > 20 nm Bow chambers deflated	+ve freeboard over entire periphery with:bow chamber deflated	If <12m or <= 12 pax then +ve freeboard over entire periphery with bow chamber deflated	If > 16 m (where applicable) As per conventional plus collar in way of both sides of stem deflated. If < 16 m collar in way of both sides of stem deflated

Scenario	New NSCV Conventional Vessels	NMSC RIB Guidelines[25]	ISO 6185.3[26]	ISO 6185.4[27]	MCA MGN 280[28]	SOLAS Chapter III Rescue boats	NZ Maritime Rules 40A and 40C[29]	NSCV inflatable Collared vessels
Side collision	Application > 36 pax	Class 1 vessels only, as per conventional	No specific requirement	No specific requirement	Not applicable as <13 pax	Side impact while launching		As per conventional but assume 2 largest chambers in inflatable collar in way of damage deflated
Raking damage	No requirement	No specific requirement	No specific requirement	No specific requirement	SOLAS Rescue boat if > 20 nm	+ve freeboard over entire periphery with: 2. Entire buoyancy along one side deflated 3. Entire buoyancy along one side & bow chamber deflated.	Conventional damaged stability including allowable angle, min range, min GZ and min area under curve.	Inflatable collar along one side damaged. Level or basic flotation. No requirement for offset load in level flotation

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[19] *MSC 216(82)* Regulation 8
[20] Criteria devised to provide practical solutions when using manual calculation methods in the days prior to the widespread use of computer numerical analysis.
[21] *US Code of Federal Regulations title 46*. 170.250
[22] Sedco Helen 31st January 1970. Offshore supply vessel holed and sank with loss of 9 lives. WT door left open.
[23] The Ro-Ro passenger ship Express Samina that sank in Greece 26 Sept 2000 with the loss of 80 lives. Nine of the total 11 watertight doors had been left open. www.naval.ntua.gr/~sdl/Publications/Papers/SAMINA-PAPER.pdf .
[24] *NSCV Part C Subsection 6A—Intact stability criteria*. Clause 1.7 Definition
[25] National Marine Safety Committee. *Guidance circular for the survey of inflatable boats and RIBs of measured length less than 12 metres*. 2005.
[26] International Standards Organization. *ISO 6185-3:2001 - Inflatable boats -- Part 3: Boats with a maximum motor power rating of 15 kW and greater.* 2001
[27] International Standards Organization. *ISO 6185-4 - Inflatable boats -- Part 4: Boats with an overall length of between 8 m and 24 m and with a motor maximum power rating of 75 kW and greater*
[28] UK Marine and Coastguard Agency. *MGN 280(M) Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats – Alternative Construction Standards.*
[29] Maritime New Zealand. *Maritime Rules Part 40A Design, Construction and Equipment - Non-SOLAS Passenger Ships* and *Part 40C Design, Construction and Equipment - Non-SOLAS Non Passenger Ships*.