ATTACHMENT N 3

Stability Calculation, Intact Stability Standard, Stability Standard, Damage Stability, Element of Stability and Stability Documents for Yachts 24 metres and more in Length

1. Stability Calculation

1.1 An Intact Stability standard of a yacht 24 metres and more in length shall be submitted to an Appointed Surveyor or Recognized Organization for approval.

1.2 Yacht more than 500 GT, if present Permanent ballast, shall be positioned in accordance with a plan approved by an Appointed Surveyor or a Recognised Organisation and must be positioned in a manner that prevents its shifting or movement. Permanent ballast shall not be removed from the yacht without the prior approval of an Appointed Surveyor or Recognised Organisation and without the re-approval of an updated Stability Booklet. Details about any permanent ballast shall be noted in the yacht's stability booklet. Attention shall also be paid to the local or global hull structural requirements prior to adding any additional ballast.

1.3 If swimming pools, Jacuzzis and spas, which are prone to water free surface affect and which are open to the elements, are fitted onboard, their effect on Intact and Damage Stability shall be taken into consideration and included in both the Intact and Damage Stability Booklets. These elements may be omitted from the Stability Calculations if they are fitted with a fast drainage system enabling them to be drained even when the yacht is heeled.

1.4 Yachts which intend to operate in Polar Regions shall meet the requirements with IMO Guidelines for Polar Regions, Resolution A.1024(26), as amended.

2. Intact Stability Standard

2.1 The Monohull Yachts curves of statical stability for seagoing conditions shall meet the following criteria:

a) the area under the righting lever curve (GZ curve) shall not be less than 0.055 metre-radians up to 30° angle of heel and not less than 0.09 metre- radians up to 40° angle of heel, or the angle of downflooding, if this angle is less;
b) the area under the GZ curve between the angles of heel of 30° and 40° or between 30° and the angle of downflooding if this is less than 40°, shall not be less than 0.03 metre-radians;

c) the righting lever (GZ) shall be at least 0.20 metres at an angle of heel equal to or greater than 30°;
d) the maximum GZ shall occur at an angle of heel of preferably exceeding 30° but not less than 25°;
e) after correction for free surface effects, the initial metacentric height (GM) shall not be less than 0.15 metres, and;
f) In the event that the yacht's intact stability standard fails to comply with the criteria defined in 1 to 5 above the Administration may be consulted for the purpose of specifying alternative but equivalent criteria.

2.2 The Monohull Yachts operating as Short Range Yachts are unable to meet criteria above, the following criteria may be used:

a) The area under the righting lever curve (GZ curve) shall not be less than 0.07 metre-radians up to 15° angle of heel, when maximum GZ occurs at 15°, and 0.055 metre-radians up to 30° angle of heel, when maximum GZ occurs at 30° or above. Where the maximum GZ occurs at angles of between 15° and 30°, the corresponding area under the GZ curve, Areq shall be taken as follows:-

$A_{req} = 0.055 + 0.001 (30° - \theta_{max})$ metre-radians
Where θ_{max} is the angle of heel in degrees where the GZ curve reaches its maximum;

b) the area under the GZ curve between the angles of heel of 30° and 40° or between 30° and the angle of downflooding if this is less than 40°, shall not be less than 0.03 metre-radians;
c) the righting lever (GZ) shall be at least 0.20 metres at an angle of heel equal to or greater than 30°;
d) The maximum GZ shall occur at an angle of heel not less than 15°; 5.
e) After correction for free surface effects, the initial metacentric height (GM) shall not be less than 0.15 metres

2.3 The Multi-hulls yacht curves of statical stability for seagoing conditions shall meet the following criteria:

a) The area under the righting lever curve (GZ curve) shall not be less than 0.075 metre-radians up to an angle of 20° when the maximum righting lever (GZ) occurs at 20° and, not less than 0.055 metre-radians up to an angle of 30° when the maximum righting lever (GZ) occurs at angles between 20° and 30°. The corresponding area under the GZ curve shall be taken as follows:-

$A_{req} = 0.055 + 0.001 (30° - \theta_{max})$ metre-radians
Where θ_{max} is the angle of heel in degrees where the GZ curve reaches its maximum;

b) The area under the GZ curve between the angles of heel of 30° and 40° or between 30° and the angle of downflooding if this is less than 40° shall not be less than 0.03 metre-radians;
c) The righting lever (GZ) shall be at least 0.20 metres at an angle of heel where it reaches its maximum;
d) The maximum GZ shall occur at an angle of heel not less than 20°;
e) after correction for free surface effects, the initial metacentric height (GM) shall be not less than 0.15 metres, and;
f) If the maximum righting lever (GZ) occurs at an angle of less than 20° approval of the stability may be considered by the Administration as a special case.

2.4 High Speed Yachts In addition to the criteria above, designers and builders shall address the following hazards which are known to effect yachts operating in planning modes or these achieving relatively high speeds:

a) Directional instability, often coupled to roll and pitch instabilities;
b) Bow diving of planning yachts due to dynamic loss of longitudinal stability in calm seas;
c) Reduction in transverse stability with increasing speed in monohulls;
d) Porpoising of planning monohulls being coupled with pitch and heave oscillations;
e) Generation of capsizing moments due to immersion of chines in planning monohulls (chine tripping)

3. Stability Standard

3.1 The Monohulls sailing yacht Curves of statical stability (GZ curves) for at least the Loaded Departure with 100% consumables (but assuming slack tanks) and the Loaded Arrival with 10% consumables shall be produced.

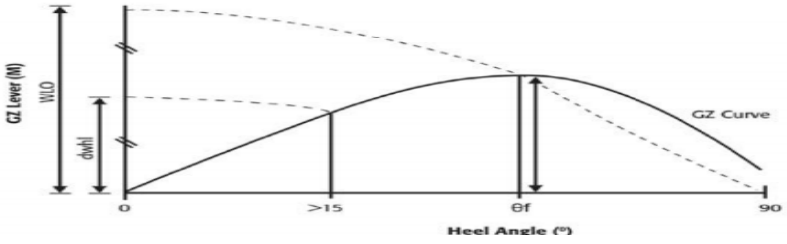
3.2 The GZ curves required as above shall have a positive range of not less than 90°. For yachts of more than 45m, a range of less than 90° may be considered but may be subject to agreed operational criteria.

3.3 In addition to the requirements mentioned above, the angle of steady heel shall be greater than 15° (see figure). The angle of steady heel is obtained from the intersection of a 'derived wind heeling lever' curve with the GZ curve required above.

In the figure:
'dwhl' = the 'derived wind heeling lever' at any angle θ°

$= 0.5 \times WLO \times \cos^{1.3}\theta$

where $WLO = \dfrac{GZ_f}{\cos^{1.3}\theta_f}$



WLO is the magnitude of the actual wind heeling lever at 0° which would cause the yacht to heel to the 'down flooding angle'.
θ is θ_f or 60° whichever is least.
GZ_f is the lever of the yacht's GZ at the down flooding angle (θ_f) or 60° whichever is the least.
θ_f is the angle at which the 'derived wind heeling' curve intersects the GZ curve. (If θ_d is less than 15° the yacht will be considered as having insufficient stability for the purpose of the Code).

θ $\frac{\Delta}{1500}$ where Δ = yacht displacement in tonnes.

θ_d the 'downflooding angle' is the angle of heel causing immersion of the lower edge of openings having an aggregate area, in square metres, greater than:

3.4 All regularly used openings for access and for ventilation shall be considered when determining the downflooding angle. No opening regardless of size which may lead to progressive flooding shall be immersed at an angle of heel of less than 40°. Air pipes to tanks can, however, be disregarded.

3.5 If as a result of immersion of openings in a superstructure, a yacht cannot meet the required standard, those superstructure openings may be ignored and the openings in the weather deck used instead to determine θ_f . In such cases the GZ curve shall be derived without the benefit of the buoyancy of the superstructure. It might be noted that provided the yacht complies with the requirements as stated in the sections above and is sailed with an angle of heel which is no greater than the 'derived angle of heel', it shall be capable of withstanding a wind gust equal to 1.4 times the actual wind velocity (i.e. twice the actual wind pressure) without immersing the 'down flooding openings', or heeling to an angle greater than 60°.

3.6 The Multi-hull Curves of statical stability in both roll and pitch shall be prepared for at least the Loaded Arrival with 10% consumables. The VCG shall be obtained by one of the three methods listed below:

a) Inclining of complete craft in air on load cells, the VCG being calculated from the moments generated by the measured forces, or;

b) Separate determination of weights of hull and rig (comprising masts and all running and standing rigging), and subsequent calculation assuming that the hull is 75% of the hull depth above the bottom of the canoe body, and that the VCG of the rig is at half the length of the mast (or a weighted means of the lengths of more than one mast), or;

c) Detailed calculation of the weight and CG position of all components of the yacht, plus a 15% margin of the resulting VCG height above the underside of canoe body.

$$\text{Trim angle} = \tan^{-1}\left|\frac{T_{FP} - T_{AP}}{L_{BP}}\right|$$

3.7 If naval architecture software is used in multi-hull yacht to obtain a curve of pitch restoring moments, then the trim angle must be found for a series of longitudinal centre of gravity (LCG) positions forward of that necessary for the design waterline. The curve can be derived as follows:

GZ in pitch = CG' x cos (trim angle)

Where:

CG' = shift of LCG forward of that required for design trim, measured parallel to baseline

T_{FP} = draught at forward perpendicular

T_{AP} = draught at aft perpendicular

L_{BP} = length between perpendiculars

Approximations to maximum roll or pitch moments are not acceptable.

$$V_w = \sqrt{\frac{1.5\,LM_R}{A'_s h \cos \Phi_R + A_D b}}$$

OR

$$V_w = \sqrt{\frac{1.5\,LM_P}{A'_s h \cos \Phi_P + A_D b}}$$

3.8 Data shall be provided to the user showing the maximum advised mean apparent wind speed appropriate to each combination of sails, such wind speeds being calculated as the lesser of the following:

Where:
V_w = maximum advised apparent wind speed (knots)
LM_R = maximum restoring moment in roll (N-m)
LM_P = limiting restoring moment in pitch (N-m), defined as the pitch restoring moment at the least angle of the following:
a) angle of maximum pitch restoring moment, or
b) angle at which foredeck is immersed
c) 10° from design trim
A'_s = area of sails set including mast and boom (square mtr)
h = height of combined centre of effort of sails and spars above the waterline
$Ø_R$ = heel angle at maximum roll righting moment (in conjunction with LMR)
$Ø_P$ = limiting pitch angle used when calculating LMP (in conjunction with LMP)
A_D = plan area of the hulls and deck (square mtr)
b = distance from centroid of AD to the centre line of the leeward hull.

3.9 If the maximum safe wind speed under full fore-and-aft sail is less than 27 knots, it shall be demonstrated by calculation according to ISO 12217-2 (2002).

3.10 The maximum safe wind speed with no sails set calculated above shall exceed 36 knots. For Short Range Yachts this wind speed shall exceed 32 knots.

3.11 Trimarans used for unrestricted operations should have sidehulls each having a total buoyant volume of at least 150% of the displacement volume in the fully loaded condition.

3.12 The stability information booklet shall include information and guidance on:

a) the stability hazards to which these craft are vulnerable, including the risk of capsize in roll and/or pitch;
b) the importance of complying with the maximum advised apparent wind speed information supplied;
c) the need to reduce the tabulated safe wind speeds by the yacht speed in following winds;
d) the choice of sails to be set with respect to the prevailing wind strength, relative wind direction and sea state;
e) the precautions to be taken when altering course from a following to a beam wind

3.13 In yachts required to demonstrate the ability to float after inversion (according to above) an emergency escape hatch shall be fitted to each main inhabited watertight compartment that allows escape even in the event of the yacht being capsized.

4. Damage Stability

4.1 The following requirements are applicable to all yachts, except those operating as Short Range Yachts. Whilst Short Range Yachts are not required to meet the damage stability criteria, it is recommended that the requirements regarding ultimate survivability after minor damage or flooding are complied with. It shall be noted that compliance with the damage stability criteria is not required for yachts that are fully in compliance with the ICLL conditions of assignment.

4.2 The watertight bulkheads of the yacht shall be so arranged that minor hull damage that results in the free flooding of any one compartment, will cause the yacht to float at a waterline which, at any point, is not less than 75mm below the weather deck, or bulkhead deck if not on the same level.

4.3 Minor damage shall be assumed to occur anywhere in the length of the yacht, but not on a watertight bulkhead.

4.4 Standard permeabilities shall be used in this assessment, as follows:

Space	Percentage Permeability
Stores	60
Stores but not a substantial quantity thereof	95
Accommodation	95
Machinery	85

4.5 In the damaged condition, considered in the mentioned attachment section 3, paragraph 3.2, 3.3, 3.4 and 3.5 the residual stability shall be such that any angle of equilibrium does not exceed 7° from any upright, the resulting righting lever curve has a range to the downflooding angle of at least 15° beyond any angle of equilibrium, the maximum righting lever within that range is not less than 100mm and the area under the curve is not less than 0.015 metre radians. For multi-hull yachts, a resultant angle of heel of up to 10° may be accepted.

4.6 A yacht of 85 metres and above shall meet a SOLAS one-compartment standard of subdivision, calculated using the deterministic damage stability methodology.

5. Elements of Stability

5.1 The lightship weight, vertical center of gravity (KG) and longitudinal center of gravity (LCG) of a yacht should be determined from the results of an inclining experiment.

5.2 An inclining experiment should be conducted in accordance with a detailed standard in the presence of an appointed Surveyor or recognized organization.

5.3 The report of the inclining experiment and the lightship particulars derived should be approved by the Administration prior to its use in stability calculations:

a) At the discretion of the owner(s) or managing agent(s) and prior to approval of the light ship particulars by the agency, a margin for safety may be applied to the light ship weight and KG calculated after the inclining experiment;
b) Such a margin should be clearly identified and recorded in the stability booklet;
c) A formal record should be kept in the stability booklet of alterations or modifications to the yacht for which the effects on lightship weight and vertical centres of gravity offset against the margin.

5.4 When sister yachts are built at the same shipyard, the Agency may accept lightweight check on subsequent yachts to corroborate the results of the inclining experiment conducted on the lead yacht of the class.

6. Stability documents

6.1 All yachts shall be provided with a Stability Booklet or Stability Calculations approved by an Appointed Surveyor or by a Recognised Organisation. The Stability Booklet for yachts ≥ 500 GT shall be approved by a Recognised Organisation. For Yachts where the Simplified Stability Test has been carried out, the relevant calculations shall be available onboard. A yacht with a previously approved stability booklet which undergoes a major alteration or refit shall be subjected to a complete reassessment of stability and provided with newly approved stability booklet. A lightweight check shall be carried out, at least, every 10 years during a renewal survey.

6.2 Sailing yachts should have mounted in a suitable position for the ready reference of the crew a copy of the 'Curves of Maximum Steady Heel Angle to Prevent Down flooding in Squalls'. This should be a direct copy taken from that contained in the approved stability booklet.