MARITIME SAFETY STANDARD FOR STABILITY OF FLOATING EQUIPMENT OF THE PANAMA CANAL AUTHORITY

1.0 PURPOSE

Establishing and regulating the parameters vessels must follow to keep a safe stability and prevent the loss of lives, the floating equipment, and the cargo they carry.

2.0 BACKGROUND

This standard does not exist, and the Canal needs to establish these parameters.

3.0 SCOPE

This standard applies to all floating equipment of the Panama Canal Authority (ACP) and vessels of contractors and third parties that carry out work or activities in Canal waters or under the responsibility of the ACP.

4.0 LEGAL FOUNDATION

This standard is established pursuant to Agreement No. 12 of the ACP Board of Directors, Risk Control and Occupation Health Regulations, Chapter IV, Article 26.

5.0 DEFINITIONS

For the purpose of this Standard, the following definitions apply:

5.1 Stability: a vessel's ability to return to its point of equilibrium when it is tilted by an external force.

5.2 Displacement

5.2.1 Maximum displacement: it is the vessel's weight at its maximum draft, including the maximum cargo capacity, fuel, and everything its needs to navigate.

5.2.2 Displacement (Δ): it is the vessel's weight at any draft, including cargo, ballast, fuel, and everything it needs to navigate.

5.2.3 Ballast displacement: it is the vessel's weight including its light weight plus ballast, special effects, fuel, water, the crew, and everything it needs to navigate.

5.2.4 Light displacement: it is the vessel's weight, excluding its cargo, ballast, fuel, and everything it needs to navigate.

5.3 Dead weight: it is the cargo's weight only.

5.4 Draft

5.4.1 Draft (C): it is the submerged distance from the vessel's keel to the load line.

5.4.2 Mean draft (C_M): it is the algebraic sum of the draft aft and the draft forward divided by 2.

5.4.3 Draft amidship: it is the readout of the draft in the vessel's mid section.

5.5 Even keel: it is the condition when the draft forward and the draft aft are the same; in other words, the keel rests along the same horizontal plane.

5.6 Trim: it is the difference between the draft forward and the draft aft. The draft forward could either be larger or smaller than the draft aft, but a larger draft aft is desired for better maneuverability and is required under the conditions of this standard.

5.7 Freeboard (D): it is the distance of the vessel's side between the load line and the main deck.

5.8 Center

5.8.1 Center of Gravity (KG): it is the point in the vessel where all forces exert pressure on it.

5.8.2 Center of Flotation (KF): it is the point in the vessel where it balances when it is afloat.

5.8.3 Center of Buoyancy (KB): it is the center of gravity in the vessel's submerged part.

5.8.4 Metacenter (M): it is a point in the vessel where the vertical line of the buoyancy line intercepts the center line.

5.9 Metacentric height (GM): it is the distance between the center of gravity and the metacenter. This is the distance that controls the vessel's stability.

5.10 Center line (L_C): it is the imaginary line that runs from bow to stern, bisecting the vessel in two equal parts.

5.11 Heel: it is the inclination of a vessel caused by the cargo or another external force. It could be corrected by distributing the cargo adequately or using the ballast to compensate the cargo weight.

5.12 Length Overall (LOA): it is the distance between the bow and the stern.

5.13 Length between perpendiculars (L_P): it is the distance of imaginary lines perpendicular to the keel from the first perpendicular in the bow to the line that crosses the center of the rudder shaft.

5.14 Breadth (B): it is the transversal distance from side to side, in other words, from port to starboard measured at the vessel's mid section.

5.15 Tons per inch of immersion (TPI): it is the amount of tons necessary to sink the vessel one inch.

5.16 Tons per centimeter of immersion (TPC): it is the amount of tons necessary to sink the vessel one centimeter.

5.17 Moment: a force external to the vessel created by a weight by a distance to the vessel's center of gravity measured in ton-foot or ton-cm.

5.17.1 Moment to change the trim 1 inch (MT1): it is the force in ton-foot required to change the trim 1 inch.

5.17.2 Moment to change the trim 1 centimeter (MTC): it is the force in ton-cm to change the trim 1 centimeter.

5.17.3 Moment of inertia (I): it is the force required for the vessel to lose its point of equilibrium.

5.18 Clear surface: it is the clear surface over the cargo in tanks and storage rooms where liquid or loose cargo can move due to the vessel's oscillatory movement.

5.19 Oscillation period (R_P): it is the time in seconds a vessel takes to oscillate from one side to the other and return; in other words, from port to starboard and back to port.

5.20 Plimsoll mark or freeboard mark: it is the mark in the vessel's mid section that indicates the vessel's maximum drafts during various seasons and areas of navigation.

5.21 Block coefficient (C_b): it is the number assigned to vessels to determine their displacement according to the shape of their hulls. This number is found in the book of stability. For smaller vessels, this coefficient is approximately 0.6.

6.0 GENERAL

This Standard assumes that the nature and stowage of the cargo, ballast, and others is such that they guarantee enough stability to the vessel and avoid excessive structural efforts.

To obtain stability under any stowage and draft conditions, it is required to estimate the stability components for such conditions in order to find the vessel's GM as an important figure. The GM determines if the vessel's stability is good, rigid, or smooth. It is worth mentioning that a rigid stability – in other words, with a high GM – is dangerous, because the bindings that fasten the cargo could break loose. In addition, navigation is uncomfortable, because the vessel does not oscillate smoothly, but tends to return to its point of equilibrium abruptly. A smooth stability implies that the vessel has a low GM, which puts the vessel in danger because its oscillations are too slow and take too long to reach its point of equilibrium, where an external force could make the vessel turn over.

See the annexes of this standard.

7.0 RESPONSABILITIES

The responsibilities to guarantee compliance with this standard are outlined in the ACP Safety Manual, Section 1, paragraph 1.5.

8.0 CONSULTATIONS

8.1 All information on or clarifications of the content or application of this standard shall be requested in writing to the Maritime Safety Unit.

8.2 All technical information or clarifications of the content or application of this standard shall in turn be consulted to the Fleet and Equipment Maintenance Division (OPM) through the Naval Engineering and Architecture section.

9.0 EXCEPTIONS

Deviations or temporary exceptions to achieve compliance with this standard shall be requested in writing to the Maritime Safety Unit.

10.0 DURATION

This standard shall remain valid until it is changed or revised.

11.0 BIBLIOGRAPHIC REFERENCES

11.1 International Conference on Load Lines, 1966 and amended 1988; Parts 166 to 199.

11.2 Studies on Vessel and Stability Theory.

11.3 Decrees from the Maritime Authority of Panama:

11.3.1 Decree 18 of May 30th, 1984, Official Gazette No. 20,163 of October 16th, 1984.

11.3.2 Decree 45 of December 21st, 1981, Official Gazette No. 19,488 of January 20th, 1982.

11.3.3 Decree 61 of October 23rd, 1979, Official Gazette No. 18,939 of November 1st, 1979.

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Annex 1

Rule 1 (Hull Strength)

1. For ACP, it is enough for the hull's overall structural force to be adequate for the draft corresponding to the assigned freeboard.

Rule 2 (Application)

1. Propelled vessels, barges, or other non-propelled vessels shall be assigned a freeboard pursuant to Rule 7 of this Annex.
2. Vessels designed to feature sails, whether they are their only propelling mechanism or a supplementary mechanism, and tugboats shall also be assigned a freeboard.

Rule 3 (Mark from the authority that assigns a freeboard)

1. The ACP mark through which cargo lines are assigned could be indicated to the side of the maximum cargo ring, above the horizontal line that goes through the ring.
2. This mark shall consist of no more than 4 letters or initials that identify the name of the authority that assigned it, and each letter shall be 115 millimeters high and 75 millimeters wide.

Rule 4 (Details of the freeboard mark)

1. The maximum cargo line consists of a ring with a 300-millimeter external diameter and 25 millimeters wide, and it is intercepted by a horizontal line that is 450 millimeters high and 25 millimeters wide, in which the line's top side goes through the middle of the ring. The middle of the ring shall be placed in the vessel's mid section at a distance equivalent to the vessel's summer draft vertically measured under the main deck.
2. Vessels shall feature two maximum draft lines: the tropical fresh water draft called TF and the tropical water draft called T. The difference between maximum drafts is due to the change in salt and fresh waters made by vessels in canal waters.
3. The ring, the lines, and the letters shall be painted white over a dark background or black over a light background, and they shall be clearly marked on both sides of the vessel at the satisfaction of the ACP.

Rule 5 (Verification of marks)

1. The certificate of compliance shall not be handed to the vessel until an ACP official inspects and guarantees that the vessel complies with this standard.

Rule 6 (Information to be provided to the captain)

1. The captain of each vessel shall be provided enough information to allow him to load and unload or fill ballast, so that the vessel shall not make unnecessary efforts, taking into account other regulations that may apply according to the vessel's special features.
2. The captain who does not have enough information on the vessel's stability as required by international agreements shall be provided the information useful for the vessel's stability under different service conditions. The ACP shall also be given a copy of it.

Rule 7 (Minimum freeboard)

1. The minimum freeboard shall be derived from the $D = \frac{L}{15}$ formula:
2. The tropical freeboard shall be the summer freeboard minus 0.02 of the summer draft, measured from the keel to the center of the freeboard mark ring.
3. Considering other regulations, boats for pilots and linehandlers shall have a minimum freeboard of 1.1 meter.
4. The fresh water freeboard shall be obtained by deducting (Δ)/ 40 TPC from the salt water summer draft.
5. When the displacement in the summer cargo floatation cannot be determined accurately, the deduction shall be one forty-eighth $\frac{1}{48}$ of the summer draft, measured from the high point of the keel to the center of the freeboard mark ring.

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Annex 2

Rule 8

1. All vessels shall have painted in their hulls a flotation line with a predetermined trim to guarantee compliance with a good stability with its ballast displacement.

Rule 9

1. All vessels shall comply with what is outlined in their certificates of inspection and in this standard.

Rule 10

1. Vessels that carry cargo shall have onboard a sheet of stability for such vessels, appropriately filled out, given its cargo condition and guaranteeing their cargo safety and stability.

Rule 11

1. All boat operators, ship captains, and their respective supervisors shall know this standard in order to inspect and find stowage solutions to keep a safe stability for their vessels.

Rule 12

1. All vessels shall carry a book of stability on board, showing the figures of the various stability components for different conditions and drafts described in the vessels' hydrostatic curves.

Rule 13

1. All vessels shall keep a safe and reliable stability at all times.

Rule 14

1. Vessels with or without cranes shall carry loading and unloading procedures on board.
2. These procedures guarantee the vessel's stability while it is being loaded or unloaded.

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Annex 3

This standard describes the formulas needed to determine a vessel's stability, which is determined by the relationship between the vertical distance from the metacenter (KM) and the center of gravity (KG).

$$KM = KG + GM \qquad \text{and} \qquad KM = KB + BM$$

In order to obtain a vessel's center of gravity (KG):

1. The KG of each weight, cargo, fuel tank, water tank, compartment, tanks, and storage container of the vessels needs to be obtained.

2. Multiply these weights by the distance of their position with regard to the vessel's original KG.

3. Add up all the weights, including the vessel's weight.

4. Add up all the moments, including the vessel's original moment.

5. Divide the moments by the vessel's displacement in order to obtain the final center of gravity (KG_F).

$$KG = \frac{Moments}{\Delta} \qquad \text{o} \qquad KG = \frac{\therefore Moments}{\Delta}$$

whereby $\Delta = L_f B f C_M C_b \delta$, L_f being the length of the load line, B_f being the breadth of the load line, C_b the block coefficient, and δ the water density. The displacement (Δ) is equal to the vessel's weight.

In order to obtain a vessel's center of buoyancy (KB):

The center of buoyancy is obtained with the formula $KB = \frac{1}{3}\left(\frac{5C_M}{2} - \frac{V}{A}\right)$, whereby:

C_M = the mean draft, V= the volume of displacement, and A= the water plane area.

Smaller vessels tend to have a block coefficient (C_b) = 0.6. In order to obtain the block coefficient (C_b), we use the formula $C_b = \frac{V}{LBC}$, whereby the volume of displacement, in the metric system, is equal to the vessel's displacement times the water density; in other words: $V = \Delta x \delta$. In the English system, the volume $V = \Delta x 35$ for salt water and $V = \Delta x 36$ for fresh water.
L= the vessel's length, B= the vessel's breadth, and C= the draft

The water plane area (A_{wl}) equals $A_{wl} = L_f B_f C_b$, measures taken at the load line. It could also be obtained using the formulas:

$A_{wl} = TPIx420$ **in the English system** or $A_{wl} = TPCx97.561$ **in the metric system**

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The TPI and TPC are obtained directly from the vessel's hydrostatic table or book of stability, or they can be obtained using the following formulas:

$$TPI = L_f B_f C_b x 1 footx\delta \quad \text{or} \quad TPC = L_f B_f C_b x 0.01 mx\delta$$

For a barge, the block coefficient is 1.0, which determines that the KB for a barge is $KB = \frac{C_M}{2}$ and the $BM = \frac{B}{12C_M}$, B being the vessel's breadth and C_M being the mean draft.

The metacentric height (GM) of a vessel may be obtained through the "Rolling Period" or the oscillation period of the vessel. For instance:

$GM = \left(\frac{0.44xB}{t}\right)^2$ **in the English system** and $GM = \left(\frac{0.79697xB}{t}\right)^2$ **in the metric system**

t being the time in seconds a side's oscillation takes to return to the same side (port-starboard-port).

If the oscillation period is long, it indicates that the GM is low, which makes the vessel unstable or loose and puts the vessel in danger. On the contrary, if the oscillation period is short, the GM is too high, which makes the vessel more rigid and navigation too rough. In addition, the bindings of the cargo could break loose and imperil the navigation.

In order to obtain the height of the center of buoyancy (BM), we use the following formula:

$BM = \frac{I}{V}$, whereby I is the vessel's moment of inertia and V is the volume of the displacement. The moment of inertia is obtained by multiplying $I = LBk$, L being the vessel's length, B the breadth, and k a constant of the vessel. Such a constant is based upon the water plane area coefficient. In order to obtain the water plane coefficient (C_{wl}), we have that $C_{wl} = \frac{L_f B_f C_b}{LB}$.

Depending on the water plane area coefficient, then k =

- 0.60→k= 0.028
- 0.65→k= 0.035
- 0.70→k= 0.042
- 0.75→k= 0.048
- 0.80→k= 0.055
- 0.85→k= 0.062

With these formulas, we find the stability of smaller vessels easily and quickly in order to guarantee the stability and safety of ACP vessels and those that transit its waters.

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Annex 4

Standard of stability for a floater in protected waters

At no time shall a portion of the deck accessible to people on a floater or pontoon vessel extend beyond the external port and starboard edges of each pontoon or beyond the frontal and back port and starboard edges.

A pontoon vessel or floater with 2 or more pontoons or a deck located 150 mm (6") above each pontoon shall comply with the standards of stability approved by the Maritime Safety Unit (OPXI-S).

A pontoon vessel or floater shall pass a stability test, in which the simulated weight of passengers and crew and other weights are originally placed in the middle, so that the par's length and lower extreme are minimal.

A pontoon vessel or floater has an acceptable minimal level of initial transversal and longitudinal stability if it meets the following criteria:

Transversal stability with a simulated load or weight located as far out as possible at the end of the deck at the port and starboard with a minimum initial freeboard. The area of the transversal section exposed to the surface or remaining from the pontoon shall be equal to or larger than the area of the submerged transversal section produced by the movement of the load or weight.

Longitudinal stability with a simulated load located in the middle, toward the port or starboard. Whichever of the two positions is farther away from the initial position of the load, the pontoon's top section shall not be submerged at any time.