Magee

VS-4-B

COPY

September, 1942

STABILITY OF SHIPS

Passenger heel requirements

The stability of the vessel shall be sufficient to meet the following conditions:

(1) When the vessel is heeled to immerse the total freeboard, but not to exceed 14 degrees, the righting moment should at least be equal to the following:

2/3 (weight of passengers)x(center of gravity of 1/2 deck area)

(2) For an open boat, where heel beyond the deck edge will cause flooding of the hull, the required righting moment of the vessel when heeled to immerse the total freeboard should be about twice the value given in the above condition (1).

Passengers are assumed to weigh 140# each or 1/16 of a long ton. The crew is assumed fixed at its station and does not contribute to the heeling moment.

For a first approximation, the arm to the center of gravity of 1/2 the deck area can be taken as 1/4 of the beam and the righting moment as:

Δ x GM x Tan θ.

In general, passengers should be distributed vertically in proportion to the available deck areas.

Wind heel requirements

The stability of the vessel shall be sufficient to meet the following condition:

(1) When the vessel is heeled to immerse 1/2 the total freeboard, but not to exceed 14 degrees, the available GM should at least be equal to the following:

$$\frac{\text{Wind pressure x Exposed area x Arm}}{\text{Displacement x Tan } \theta}$$

The wind pressure, which varies with the length of the vessel and the waters traversed, can be obtained from the attached wind pressure chart. The arm is taken as the vertical distance between the center of gravity of the exposed area and 1/2 the mean draft.

Use total fbd for passenger heel

Use 1/2 fbd for wind heel

Use 2/3 fbd for truck or auto heel on ferries when these are running aboard

U.S. PASSENGER HEEL CRITERIA

BCS
8/16/65

FORMULA DERIVATION

$$GM_{req} = \frac{N\,b}{24\,\Delta \tan\theta}$$

where: N = No. of passengers
b = Dist. from ℄ to centroid of pass. area on one side of ℄.
θ = ∡ of heel to deck edge OR 14°, whichever is less.

Assumptions:

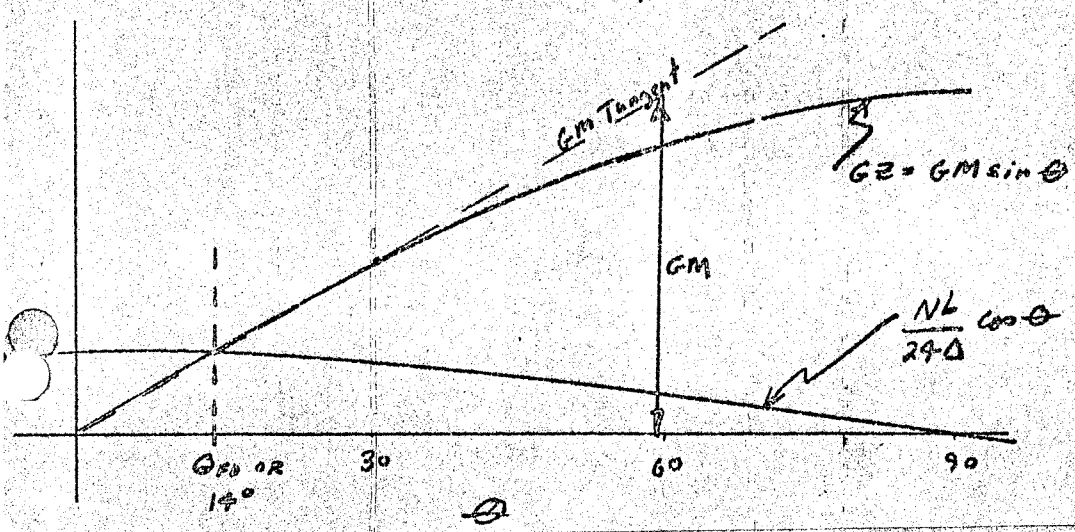
1) wt. of passenger = 140#, OR 16 pax/TON
2) Statistics: use 2/3 of passenger wt. = 93#, OR 24 pax/TON
3) $GZ = GM \sin\theta$ {valid at small angles, is conservative if there is any form gain}

$$\text{Heeling Moment} = (\text{wt. of Pax}) \times (\text{lever}) = \frac{N}{24}(b) \quad \text{FT-TONS}$$

$$\text{Lever} = \frac{H.M.}{\Delta}\cos\theta = \frac{Nb}{24\Delta}\cos\theta$$

Set GZ = Lever: $GM \sin\theta = \frac{Nb}{24\Delta}\cos\theta$

$$\therefore GM = \frac{Nb}{24\Delta \tan\theta}$$



6 August 1957
U. S. Coast Guard
MII Division

Vessels Fitted With Superstructure - Maximum Permissible Freeboard for Use in Determining "tan θ" in "Weather Criteria" Formula (TENTATIVE)

Note: Superstructure must extend from shell to shell P & S, and have adequate strength, tightness and closures.

(1.) Without superstructure: $\tan\theta = \frac{f/2}{B/2} = f/B$ (not to exceed tan 14°, i.e. 0.25)

where "B" = mld beam ℄ at freeboard deck
and "f" = freeboard ℄ from operating W.L. to top of deck at si

(2.) With superstructure of height "k" for full length of vessel, the freeboa "f" to freeboard deck may be increased by a height "h" where "h" is equa to or less than "k"

Then $\tan\theta = \frac{\frac{f+h}{2}}{B/2} = \frac{f+h}{B}$ (not to exceed tan 14°, i.e. 0.25)

Then from $\frac{f+h}{B} = .25$ maximum

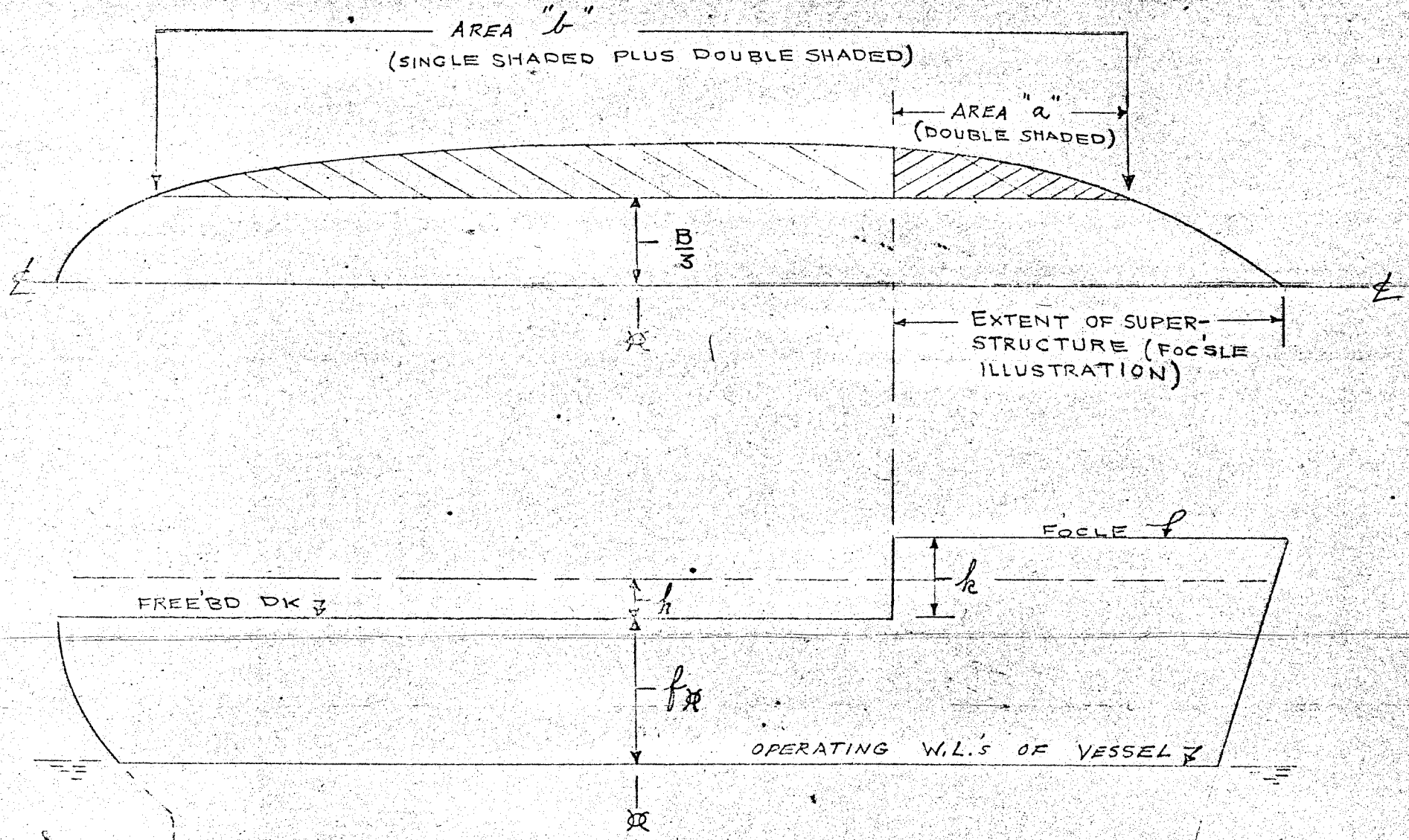
The permissible freeboard addition "h" (max.) = (B/4-f)

(3.) With superstructure of less than full length of vessel, the freeboard addition "h" is limited by two considerations. The first is relative length of superstructure. The second is the transverse distribution of the superstructure volume relative to that of the main hull below. These two items are combined in the factor "$\frac{a}{b}$" which represents the applicable percentage of total superstructure effectiveness as given in (2.) above.

Therefore, the maximum permissible freeboard addition = $\frac{a}{b}(h) = \frac{a}{b}(B/4-f)$,

the total maximum permissible freeboard is $f+(a/b)(B/4-f)$, and the maximum permissible tan θ that can be used is $\frac{f+(a/b)(B/4-f)}{B}$.

Note: Areas "a" and "b", as determined in accordance with sketches on page 2, are measured on the freeboard deck. No area within the 2/3 "B" of the vessel transversely shall be included in such area


AREA "b"
(SINGLE SHADED PLUS DOUBLE SHADED)
AREA "a"
(DOUBLE SHADED)
B/3
EXTENT OF SUPER-STRUCTURE (FOC'SLE ILLUSTRATION)
FOCLE f
k
FREE'BD DK
h
f
OPERATING W.L.'S OF VESSEL

C/2

NRT-5
Hull Scientific Section
20 September 1963

INSTRUCTIONS (TENTATIVE) FOR ASSESSING PASSENGER VESSEL STABILITY FOR REGATTA VIEWING PURPOSES ON PROTECTED WATERS.

1. For normal passenger heel criteria 46 CFR 74.10-10, the passenger heeling moment involved assumes two thirds of the passengers at the geometrical center of the deck area (on one side of the centerline) which is available to passengers. Also, passenger weight is considered at 140# each, which corresponds to 16 persons per long ton.

$$\text{therefore} \qquad H.M. = \frac{2}{3}\,\frac{N}{16} \times b = \frac{Nb}{24}$$

2. It is apparent from the above that when a regatta viewing passenger heeling moment is involved in lieu of the above equation must be modified to take into consideration the following:

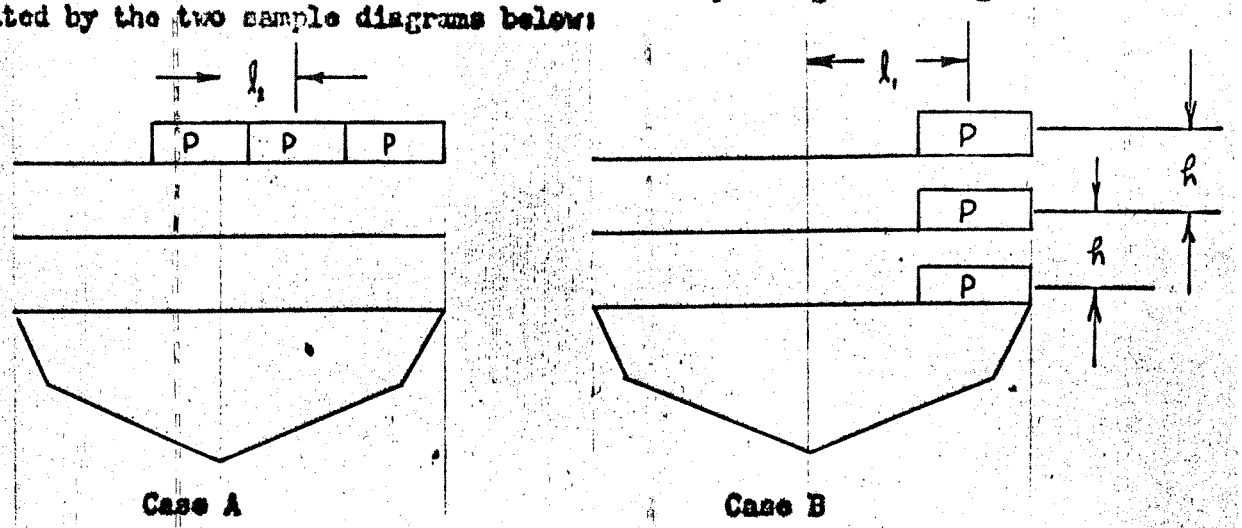
(a) The passengers are each heavier; use 160# i.e. 14 persons per ton.

(b) The passengers are going to crowd to the best viewing location. Since this crowding is uncontrolled, the worst combination must be assumed.

(c) The effect of (b) alone can introduce two factors which increase the heeling moment over the statistical moment shown above. First, since <u>all</u> the passengers are crowding, a factor of 1.5 is involved. Secondly, since the crowding is to viewing areas the distance of the passengers from the centerline can introduce a factor in the order of 1.5 to 2.

3. The factors mentioned above are not employed directly but in the manner illustrated below. Based upon past investigations, the above considerations indicated that, as a "rule of thumb", 1/2 of the vessel's normal protected water passenger allowance was a conservative and satisfactory value for regatta viewing on such waters. For most of the cases investigated, the normal passenger criterion was the governing criterion prior to regatta study. Also it should be noted that protected water regatta requirements are investigated apart from other requirements. The heel angles are limited to those permitted by normal passenger criterion. The significant item in the regatta viewing study is to find the maximum number of passengers the vessel can safely carry (without restriction on a deck by deck basis) under conditions of combined vertical loading and maximum practicable transverse loading (i.e. heeling moment). See limiting cases A and B below.

4. For multi-deck vessels with a given number of passengers (in regatta service) we have possible combinations of crowded passenger loading as indicated by the two sample diagrams below:



(a) Case A is the same as Case B except that in Case A the passengers on the two lower decks have been shifted upwards and inboard (due to diminishing outboard space). Comparison of the two cases indicates:

1. Case A has greater vertical moment and less available G.M.
   Case A also has less transverse passenger moment and less required G.M.

2. Case B has less vertical moment and greater available G.M.
   Case B also has greater transverse passenger moment and greater required G.M.

(b) Case A increase in vertical moment compared to Case B equals δM_v

i.e. $(Pxh + Px\,2h = 3\,Ph)$ in this case

and available GM loss $= \dfrac{\delta M_v}{\Delta}$

(c) Case A has a reduction in transverse passenger moment compared to Case B equal to δM_t

i.e. $3(Pl_1 - Pl_2)$ in this case

and required GM reduction $= \dfrac{\delta M_t}{\Delta \tan \theta}$

where $\tan \theta = \dfrac{f}{B/2}$ with cut off at tan 14°

(d) Case A is the governing case when the loss in available GM exceeds the reduction in required GM, i.e. when:

δK_v is greater than $\frac{\Delta t \, \delta}{\tan \theta}$ Note: Δ in denominators of both terms has been omitted.

OTHERWISE CASE B GOVERNS

(e) For calculations, passenger load distribution (by decks) and passenger heeling moment is that which results from assuming rail crowding at 3 sq.ft. per person in longitudinal rows adjacent to rail viewing areas. (In Case B, the same number of rows is assumed on each deck.)

(f) When the governing case has been determined for a given passenger loading, comparison of available GM and required GM (both as applicable to the case) at departure and arrival, will determine adequacy of stability for regatta service with that passenger total. It may be necessary to repeat the procedure with different passenger totals to arrive at the total which is satisfactory. The following must be met:

$$\text{Available GM (governing case)} = \text{Req'd GM} = \frac{\text{Pass heel mom. (Governing case)}}{\Delta \tan \theta}$$

Broad shoal draft hull correction, as applicable, should be computed, in this type service, over 1.25 times the angle of heel permitted or 16° whichever is less. Note, where permitted angle is to deck edge, 25% increase in the angle puts the water over the deck edge. Tight superstructure is considered water excluding hull for this purpose.

5. The above comparison also applies to a 2 deck vessel except that two passenger blocks (each of weight "P") in lieu of three are involved. In application, the simplified features indicated will generally not be present. The deck heights will generally not be a constant value "h". The T.C.G. of passengers (l_1 and l_2) will be influenced by distance from centerline to rail on the various decks and the variation in passenger weight P in the various decks. The weight P on any given deck will depend upon the actual rail viewing length on such deck and the assumption (in case B) of equal viewing rows of passengers on the various decks.

6. Regatta passenger load shall not be greater than that determined as mentioned. This load shall be permitted without any limitation on number of passengers per deck. However, in no case shall regatta viewing passenger load exceed the number permitted by weather criteria or damaged stability criteria as applicable.

7. The instructions in paragraphs (1) thru (6) above apply to PROTECTED WATERS only.