

Stability for Working Captains

To quote the CAPCA website . . .

It's no secret that stability shortcomings have accounted for a hefty share of accidents involving commercial vessels. But how can you tell whether your boat really is as stable as it should be? And, if it isn't, what can you do to overcome the problem and pass U.S. Coast Guard stability tests? Captain Iver Franzen, a naval architect and expert in this field, offers a plain-English rundown on the stability issue, with practical advice for skippers of small- or medium-sized vessels.

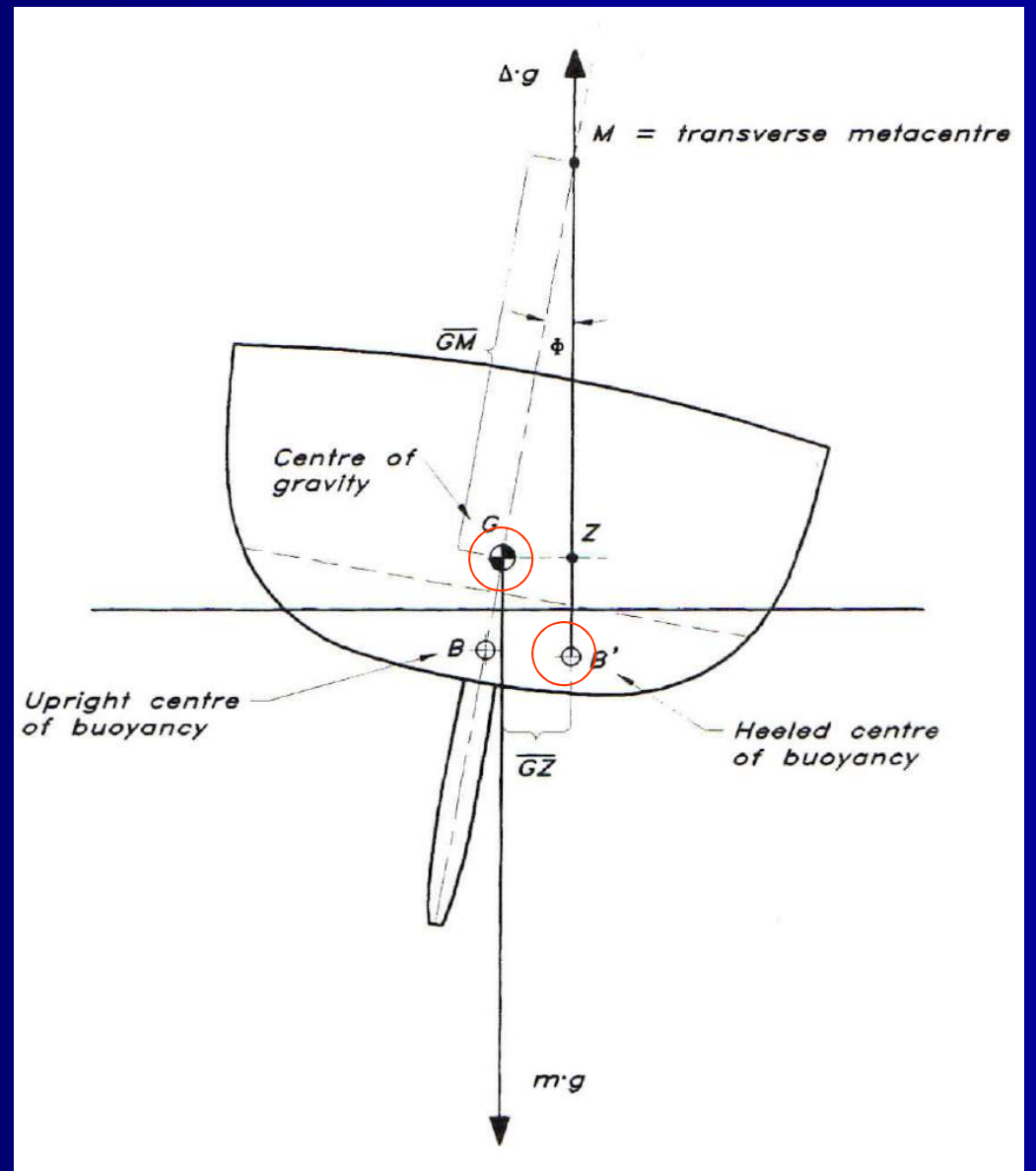
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Stability for Working Captains

- Stability Basics
- Stability Letters
- Stability Testing
 - Casualties
- Quick & Easy Stability Check
 - Questions (answers, maybe)

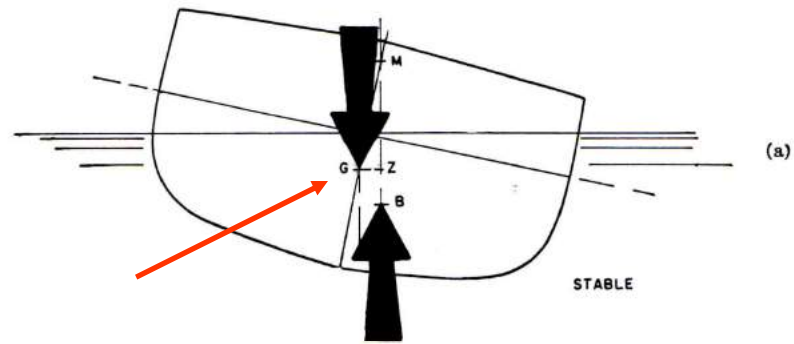
Stability Basics:

- Whole textbooks have been written just on stability, but . . .
- The important thing to remember is that the Center of Buoyancy must remain outboard of the Center of Gravity.
- Or, the Center of Gravity must remain inboard of the Center of Buoyancy.

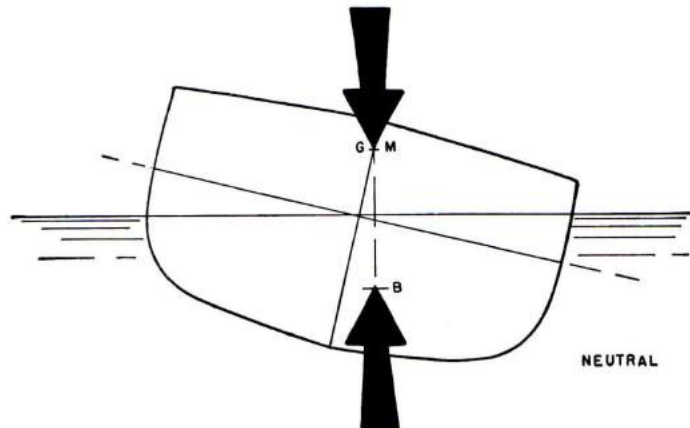


GZ = horizontal distance between Center of Gravity & Center of Buoyancy. Considered "Positive" as shown here = good!

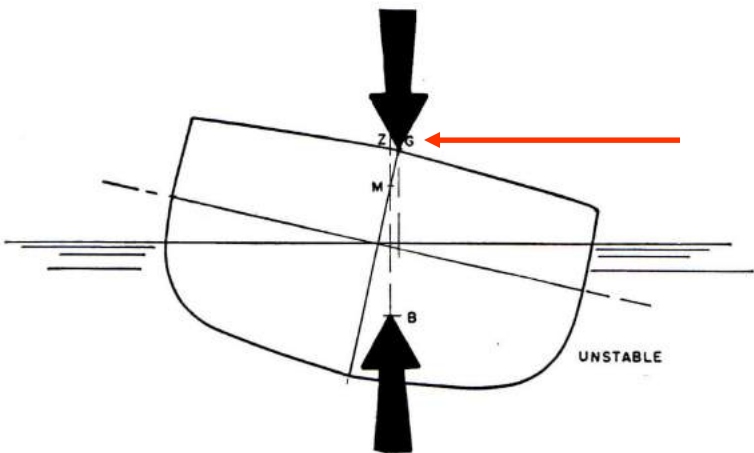
$$\mathbf{GZ} = \mathbf{GM} \sin\phi, \text{ therefore, } \mathbf{GM} = \mathbf{GZ} / \sin\phi$$



(a)



(b)

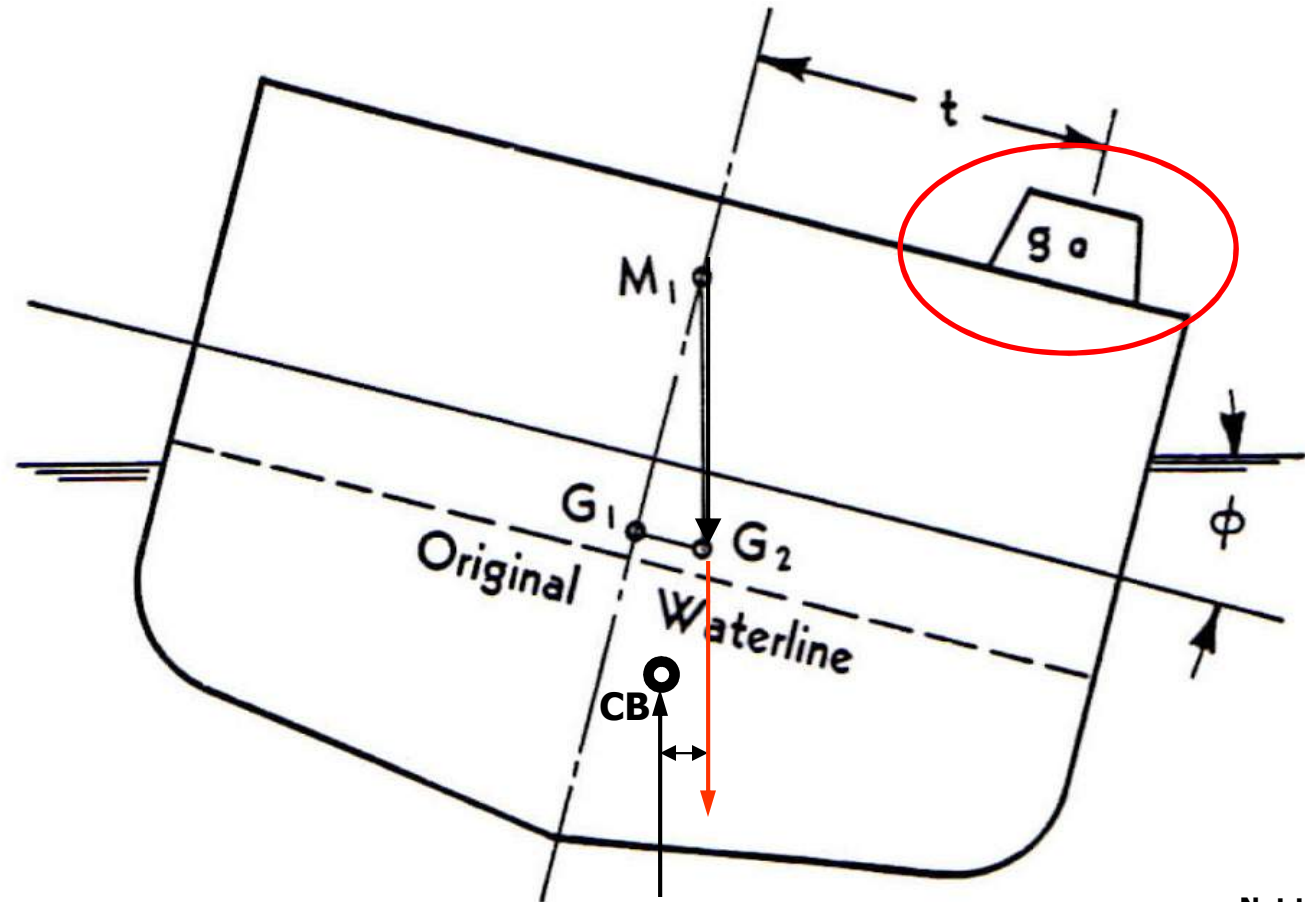


(c)

Stable vs Unstable

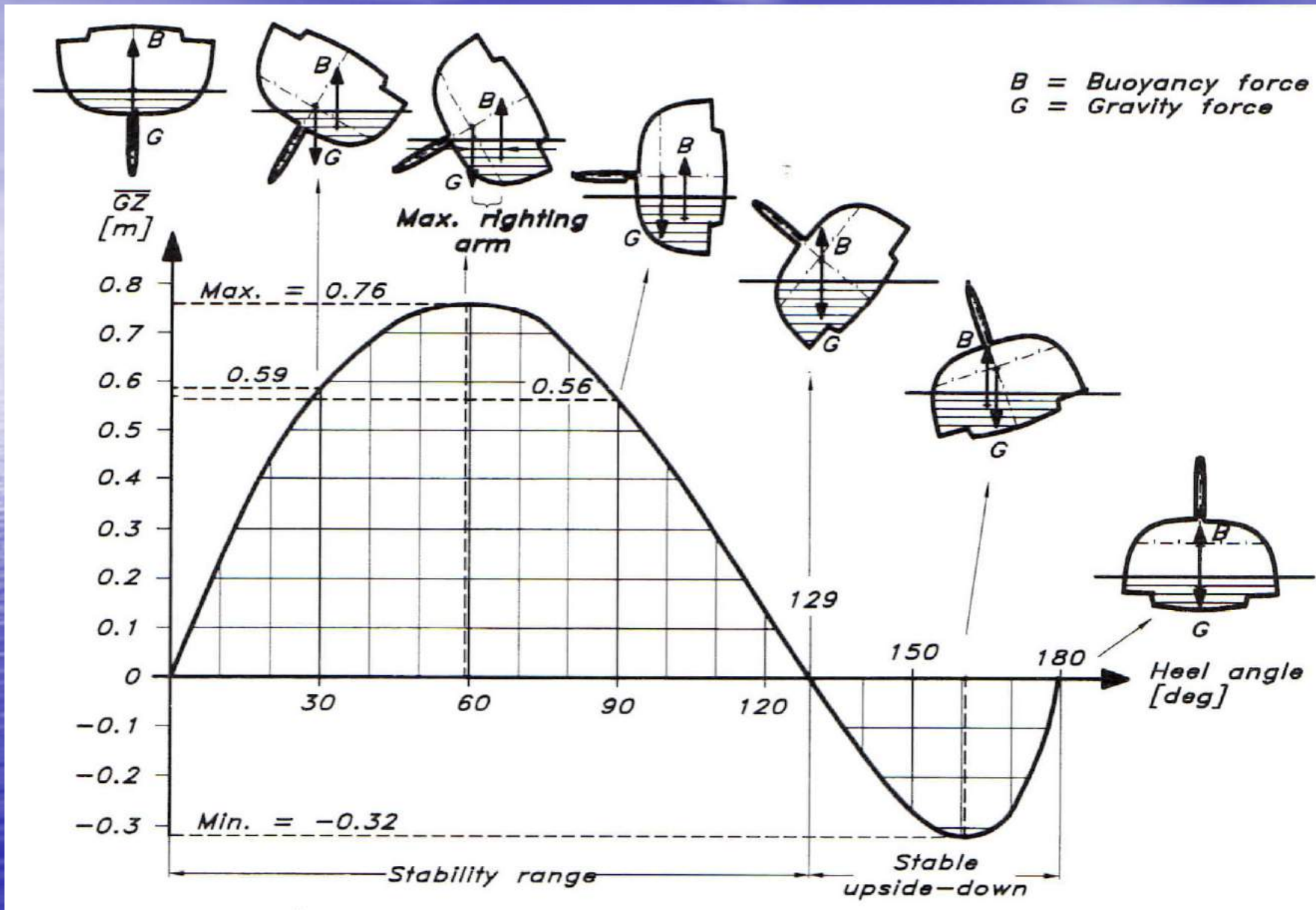
- The top image shows a stable condition.
- The middle image is a neutral condition.
- The bottom image shows an unstable condition. Why?

Off-Center Weight



- A weight put or moved off-center, for example a gaggle of passengers rushing to one side to look at . . . , creates a new Center of Gravity - G_2 .
- If that new Center of Gravity, G_2 , happens to be outboard of the Center of Buoyancy (CB) . . . what happens?

Typical Righting Arm (GZ) Curve for a Sailing Vessel



- Any questions about stability before moving on to . . . Stability Letters?

Stability Letters

- These are important, but have been accused of not being helpful.
- Efforts have been underway to have them provide more guidance, especially operational, especially for sailing vessels.
- In the meantime, there's actually useful information, and some items not indicated on the COI, but must be paid attention to.
- Such as, sail combinations allowed, # of pax allowed on an upper deck, etc.

U.S. Department of
Homeland Security



United States
Coast Guard

Commanding Officer
United States Coast Guard
Marine Safety Center

2100 2nd St., SW
Washington, DC 20593
Staff Symbol: MSC-1
Phone: (202) 475-3401
Fax: (202) 475-3920
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STABILITY LETTER

16710/P003609
Ser H1-0702623
August 23, 2007

Master, KALMAR NYCKEL, O.N. 1066008
Allen C. Rawl, Inc. Hull No. ACR13001J598
89'2" (L.WL) x 24'11" x 16' Auxiliary Sailing Small Passenger Vessel (T)

You are responsible for maintaining this vessel in a satisfactory stability condition at all times.

A stability test, witnessed by the U.S. Coast Guard, was conducted on KALMAR NYCKEL, O.N. 1066008, at Portsmouth, Virginia, on June 6, 2007. On the basis of that test, stability calculations have been performed. Results indicate that the stability of KALMAR NYCKEL, as presently outfitted and equipped, is satisfactory for operation on Protected Waters, provided that the following restrictions are observed.

SUBDIVISION

When operated as indicated below, calculations indicate that this vessel will remain afloat with any one major compartment flooded (one-compartment subdivision). A major compartment is the total space between any two adjacent Main Transverse Watertight Bulkheads (MTWB's). For this vessel, these MTWB's are located, referenced aft of the bow, at 13 feet 6 inches, 31 feet 6 inches, 58 feet 5 inches, and 68 feet 2-1/2 inches.

DAMAGE SURVIVAL

Calculations indicate this vessel will stay upright (no more than 7 degrees of list under ideal conditions) after side damage when the side damage is limited to any one major compartment and not more than 5 feet 0 inches inboard from the side of the hull. To maintain the vessel upright after flooding (damage), the heeling forces imposed by wind, wave, and passenger movements must be minimized.

OPERATING RESTRICTIONS

1. **ROUTE:** Operations on Protected Waters is permitted. Since the route and is based upon other considerations in addition to stability, you are cautioned that the route may be further limited to that specified on the Certificate of Inspection.
2. **PERSONNEL:** A maximum of 80 persons may be carried. Since the personnel capacity is based upon other considerations in addition to stability, you are cautioned that the number of persons carried may be further limited to that specified on the Certificate of Inspection.
3. **SAILS:** The sails which may be set are limited to the following combinations, in accordance with the approved sail plan, bearing the U. S. Coast Guard Marine Safety Center approval stamp dated August 23, 1999. That plan must be maintained on board the vessel in a suitable location at all times:



Stability Letters, continued

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Subj: KALMAR NYCKEL, O.N. 1066008; STABILITY LETTER

- a. When both Main Topsail and Fore Topsail are not set, all other sails may be set.
- b. When Main Topsail is set, any of the following combinations may be set:
1. Sprintsail, Sprit Topsail, Fore Course (Lower), Mizzen Topsail, and Mizzen (Lower).
 2. Sprintsail, Sprit Topsail, Fore Topsail, and Mizzen (Lower).
 3. Sprintsail, Sprit Topsail, Fore Topsail, and Mizzen Topsail.
 4. Fore Topsail, Mizzen Topsail, and Mizzen (Lower).
- c. When Fore Topsail is set, any of the following combinations may be set:
1. Sprintsail, Sprit Topsail, Fore Course (Lower), Main Course (Lower), Mizzen Topsail, and Mizzen (Lower).
 2. Sprintsail, Sprit Topsail, Main Topsail, and Mizzen (Lower).
 3. Sprintsail, Sprit Topsail, Main Topsail, and Mizzen Topsail.
 4. Main Topsail, Mizzen Topsail, and Mizzen (Lower).
4. **DRAFT:** The vessel's scribed load waterline at the bow and stern is located 2 inches below the 12 foot design waterline. The scribed waterline corresponds to the limiting draft of 11 feet 10 inches above the baseline and it shall not be submerged under any conditions of trim.
5. **WATERTIGHT BULKHEADS:** No watertight bulkheads shall be removed or altered without the authorization and supervision of the cognizant Officer in Charge, Marine Inspection (OCMI). The doors in the watertight bulkheads located 31 feet 6 inches, 58 feet 5 inches, and 68 feet 2-1/2 inches aft of the bow are acceptable and shall be kept closed when under way.
6. **TANKS:** Any cross-connections between port and starboard tank pairs shall be kept closed at all times when underway.
7. **HULL OPENINGS:** Any openings that could allow water to enter the hull should be kept closed when rough weather or sea conditions exist or are anticipated.
8. **DECK CARGO:** No deck cargo may be carried.
9. **WEIGHT CHANGES:** This stability letter has been issued based upon the following light ship parameters:
- | | | |
|--------------|--------|-------------------------|
| Displacement | 278.08 | Long Tons |
| VCG | 11.47 | Feet Above the Baseline |
| LCG | 47.64 | Feet Aft of the Bow |

Any alteration resulting in a change in these parameters will invalidate this stability letter. No fixed ballast or other such weights shall be added, removed, altered and/or relocated without the



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authorization and supervision of the cognizant OCMI. The vessel is fitted with fixed ballast located as shown on the itemized ballast listing, attached as enclosure (1).

10. **BILGES:** The vessel's bilges and voids shall be kept pumped to minimum content at all times consistent with pollution prevention requirements.

11. **FREEING PORTS:** Deck freeing ports and drains shall be maintained operable and completely unobstructed at all times.

12. **LIST:** You should make every effort to determine the cause of any list of the vessel before taking corrective action.

This stability letter shall be posted under glass or other suitable transparent material onboard the vessel so that all pages are visible. It supersedes any stability information previously issued to the vessel.

S. P. MCGEE
Lieutenant Commander, U.S. Coast Guard
By direction

Encl: (1) Lead Ballast Listing for KALMAR NYCKEL, bearing U. S. Coast Guard Marine Safety

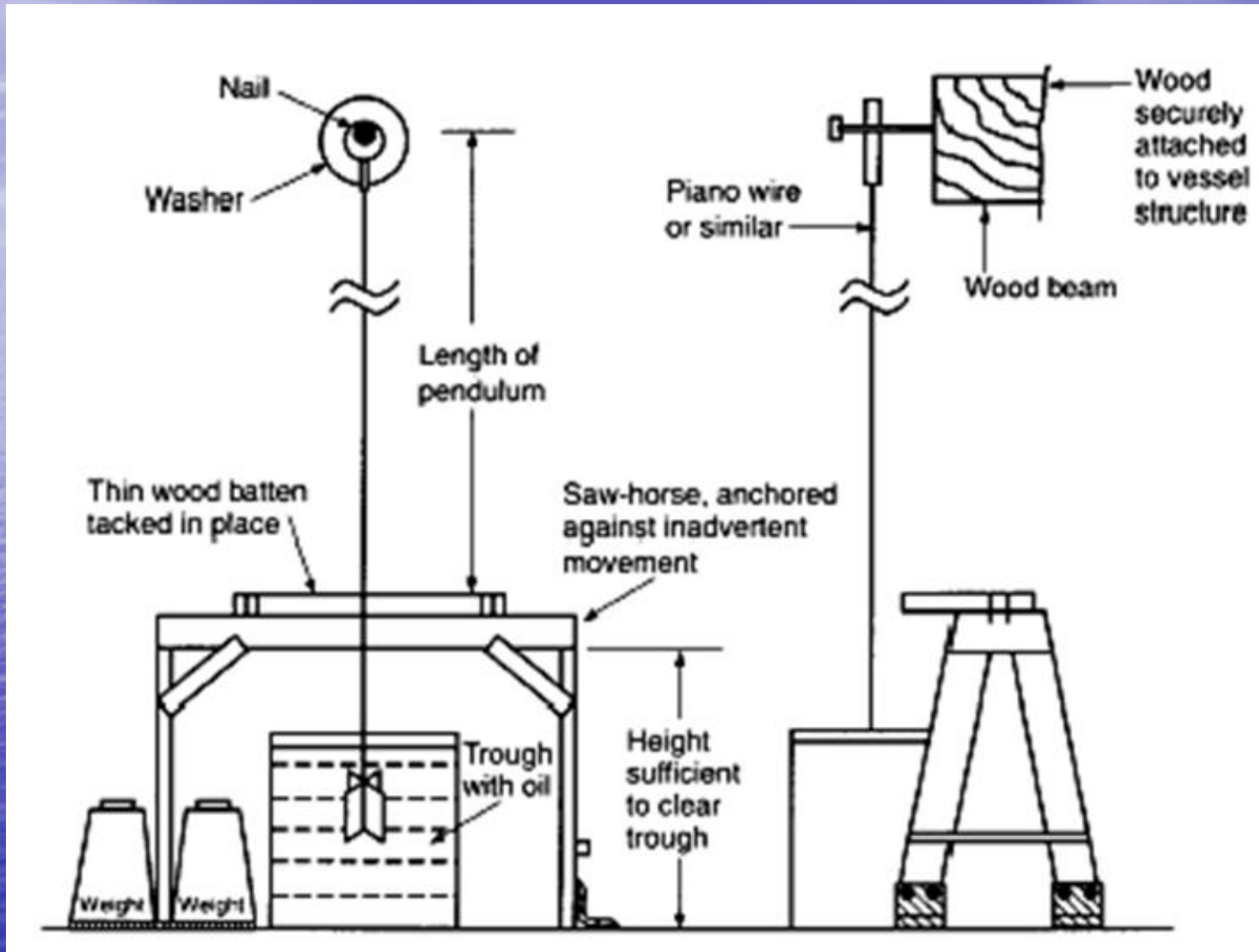
Center Approval Stamp dated August 23, 2007

So, how does that Stability Letter come about?



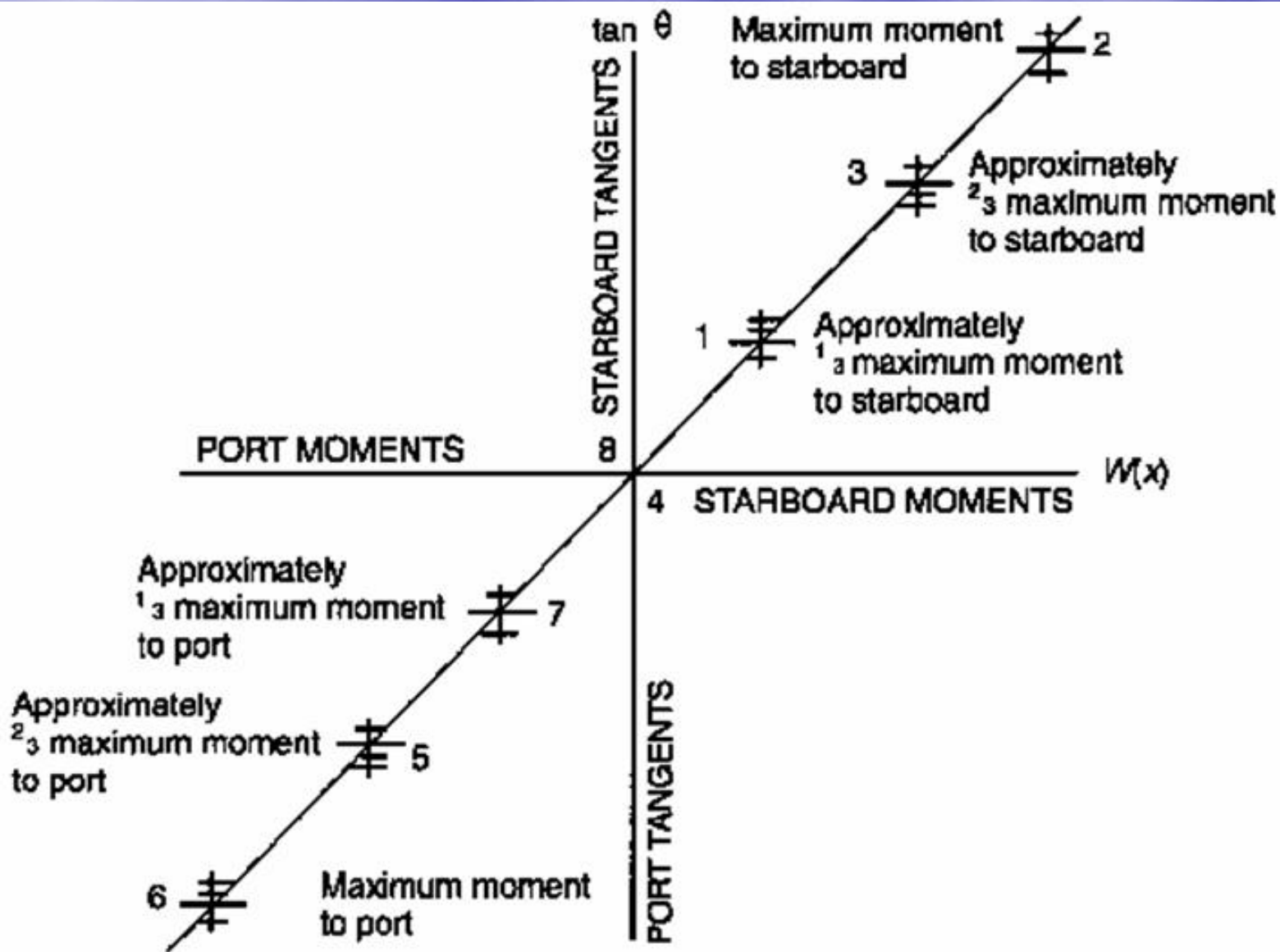
The Stability Test – either a Simplified Test (SST), or the dreaded Incline Test.

Pendulum Apparatus for an Incline Test



- 3 required, but can also use water tubes, or 1 or 2 electronic inclinometers plus 1 or 2 pendulums/tubes.

On-site Results Plot of the Incline Test



TANGENT =
 Pendulum
 Deflection
 ÷
 Pendulum
 Length.

MOMENT =
 Weights
 moved
 ×
 Distance
 moved.

Then . . .

- When the Plot is accepted by the USCG witness as OK, the GM of the vessel can then be determined right away:
[1 / ((tan/mom) x displ.)].
- Back at the office, calculations are done on the hull shape to determine her metacentric height, KM, plus Displacement, etc.
- Subtract GM from KM and you get the KG, or the vessel's actual Vertical Center of Gravity (also often referred to as VCG).
- It is this KG # that becomes one of the primary ingredients in the various Subchapter "S" calculations to determine her stability: 46CFR 170.170, 170.173, 171.050, 171.052, 171.055, 171.057, 171.080.
- After review and acceptance by the USCG at headquarters (MSC), they then issue the Stability Letter.

Remember, this Letter precedes and forms the foundation for the COI, and all pages must be posted under glass along with the COI (or an acceptable variation thereof).

Simplified Stability Test - SST

- Much simpler proof test that gives a pass/fail answer on the spot.
- Still involves moving weights on board, the amount being equal to the # of pax you want to carry.
- However, no pendulums, and the only freeboard measurement is at the lowest point to determine the "immersion mark."
- Those vessels which are allowed to do the SST:
 - Not more than 65', and
 - Carry not more than 150 pax domestic, and
 - Carry not more than 12 pax international, and
 - For a sailing vessel, does not sail at night, and
 - The stability is otherwise not in question by the OCMI.
- All others must do the Incline Test (or a Deadweight Survey with a very conservatively estimated VCG) and the subsequent "Sub-S" calculations.

Questions before moving on to Casualties?

3 Notable Stability Casualties:

- LADY D – Pontoon water taxi in Baltimore Harbor. Valid Stability Letter and COI, yet was capsized by a high gust of wind preceding the arrival of a front. Maneuverability was partly to blame as she was unable to come more quickly head-to-wind. Pax slid to leeward, exacerbating the problem to the extreme.
- ETHAN ALLEN – Tour boat on Lake George. Permitted to operate by the State of NY, but no Stability Letter. Vessel was caught broadside by a large boat wake, heeled, pax slid to low side exacerbating heel, and she ultimately capsized.

In both cases it was determined that while there was partial fault of the operators, that they were also overloaded was not their fault. The NTSB determined that the weight/person #s being used in the "Sub-S" stability calculations had become obsolete. Under the old rules, it was 140lb/person for protected waters, and 165 lb/person beyond. The CDC was consulted, and the FAA immediately raised their # to 174 lb/person. For the USCG, it is now 185 lb/person in all waters.

- 34' Silverton, new owner, Oyster Bay capsized, 4th of July 2012. 3 children dead. Grossly overloaded with 27 people aboard, and many up on the flybridge. From a stability perspective, the KG got way too high, so that the smallest heel immediately put the Center of Gravity outboard of the Center of Buoyancy.

Quick & Easy Estimation of GM

by measuring the Roll Period

$$GM = \left(.44 \times \text{Beam}' / T_{\text{sec}} \right)^2$$

So, a boat with a 14' beam, with a roll period of, say, 3.5 seconds, will have a GM of . . .

$$.44 \times 14 = 6.16$$

$$\text{then } \div 3.5 = 1.76$$

$$\text{then squared, GM} = \underline{3.09 \text{ feet}}$$

(from Skene's:)

Harbor vessels & tugs -

$$GM = 15-18''$$

Small power cruisers -

$$GM = 2' - 2' 6''$$

Shoal-draft river boats [& cats] -

$$GM = 12'$$

(Cumberland Star)

Sailing vessels (private & high freeboard) -

$$GM = 3' - 4' 6''$$

(Lady MD - 7 feet)

Questions?

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