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An American National Standard

Standard Guide for Conducting Small Boat Stability Test (Deadweight Survey and Air Inclining Experiment) to Determine Lightcraft Weight and Centers of Gravity of a Small Craft[1]

This standard is issued under the fixed designation F3052; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Small craft operators, builders, buyers, accident investigators and others may be required to determine the centers of gravity for their craft in order to apply stability criteria or perform other analyses. The conventional in-water stability test can be difficult to perform accurately on small craft, so an in-air inclining experiment may be specified. However, there are no guidelines available to help standardize and explain the process.

This guide provides the marine industry with an understanding of an Air-Incline stability test for small craft. It contains procedures to ensure that valid results are obtained with precision at a minimal cost to owners, shipyards and the government. The guide is not intended to direct a person(s) in the actual calculations of the lightcraft weight and centers of gravity, but to be a guide to the recommended procedures required to gather accurate data for use in the calculation of the lightcraft characteristics.

A complete understanding and documentation of proper procedures to conduct a stability test is paramount to confirm that the results gathered during the test can be examined for accuracy, especially by third parties subsequently reviewing the data. This guide is recommended to be used for all small craft capable of being lifted safely with forward and aft pick points capable of enduring additional inclining weights to be used for the stability test.

1. Scope

1.1 This guide covers the determination of a small boat's lightcraft characteristics. The air incline stability test can be considered two separate tasks; a deadweight survey and an air-inclining experiment. The stability test is recommended, but not required, for all small craft upon their construction completion and/or after major conversions where stability information is required. It is typically conducted indoors and an enclosed facility to protect the vessels from unprotected environmental conditions.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1321 Guide for Conducting a Stability Test (Lightweight Survey and Inclining Experiment) to Determine the Light Ship Displacement and Centers of Gravity of a Vessel

3. Terminology

3.1 *Definitions:*

3.1.1 *inclining experiment*—comprises moving a series of known weights in a transverse direction and then measuring the resulting change in the equilibrium heel angle of the craft. This information is used to calculate the vessel's vertical center of gravity.

3.1.2 *lightcraft*—a small craft, or boat in the lightest condition ("Condition 1") is a boat complete in all respects without consumables, stores, cargo crew and effects and without any

[1] This practice is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.01 on Structures.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

liquids on board except machinery fluids, such as lubricants and hydraulics at operating levels. The lightcraft should be as defined in the craft procurement or other specifications, or in the operating manual, as to outfit permanently aboard, etc.

3.1.3 *deadweight survey*—comprises weighing the vessel at two longitudinal points to determine the total weight and longitudinal center of gravity of the craft, then auditing all items found on board to be added, deducted or relocated on the craft at the time of the stability test so the observed condition of the small craft can be adjusted to the specified lightcraft condition. All loose items or outfit equipment (that is, anchor, anchor warp, dock lines, fire extinguishers, etc.) found on board should be removed completely from the craft and weighed separately on a calibrated scale.

3.1.4 *keel (baseline)*—the datum point used for measuring the vertical location of the pivot points and subsequently defining the vertical location of the weights involved in the test. It is often the lowest point of the craft hull, but may be defined as any convenient point, provided it is consistent within the experiment, consistent with any other documentation such as the drawings or weight estimate, and well documented.

3.1.5 *Stern Reference Point (SRP)*—the intersection of the transom and the keel (baseline) of the boat or as otherwise defined in the documentation, but should be clearly defined and documented in the test report, and should be verified by physical measurement at the time of the test relative to the lift points. The SRP is where all relative locations of outfit and centers of gravity should be referenced in Fig. 3.

3.1.6 *X1*—longitudinal distance from stern reference point (SRP) to aft pick point.

3.1.7 *X2*—longitudinal distance from stern reference point (SRP) to forward pick point.

3.1.8 *X*—longitudinal distance from stern reference point (SRP) to longitudinal center of gravity of the boat.

3.1.9 *W1*—weight in pounds at the aft pick point.

3.1.10 *W2*—weight in pounds at the forward pick point.

3.1.11 *W*—*W*1 + *W*2, is total weight of the boat.

3.1.12 *B*—vertical distance from SRP to pick points and roll axis/centerline of knife edges.

3.1.13 *LCG*—longitudinal center of gravity measured from the SRP.

3.1.14 *VCG*—vertical center of gravity measured from the baseline.

3.1.15 *Tan* θ—tangent angle of deflection.

4. Significance and Use

4.1 From the lightcraft characteristics, calculations of the stability characteristics of the small craft for all load conditions can determine compliance to applicable stability criteria or provide mass properties information for other analyses or investigations. Accurate results from an air incline stability test may therefore determine future survival of the boat, the crew and compliment. If the small craft is not 100 % complete or there is fuel or other liquids in a tank that is supposed to be clean and dry then the person leading the stability test must determine the acceptability of all variances from the guide based on the ability to correct for these variances analytically. A complete understanding of the principles behind the stability test and knowledge of the factors that affect the results is therefore necessary.

4.2 The results of the stability test typically supersede the corresponding values in the weight estimate for any subsequent use in ascertaining compliance to stability or weight control criteria and may be used in weight margin adjudication.

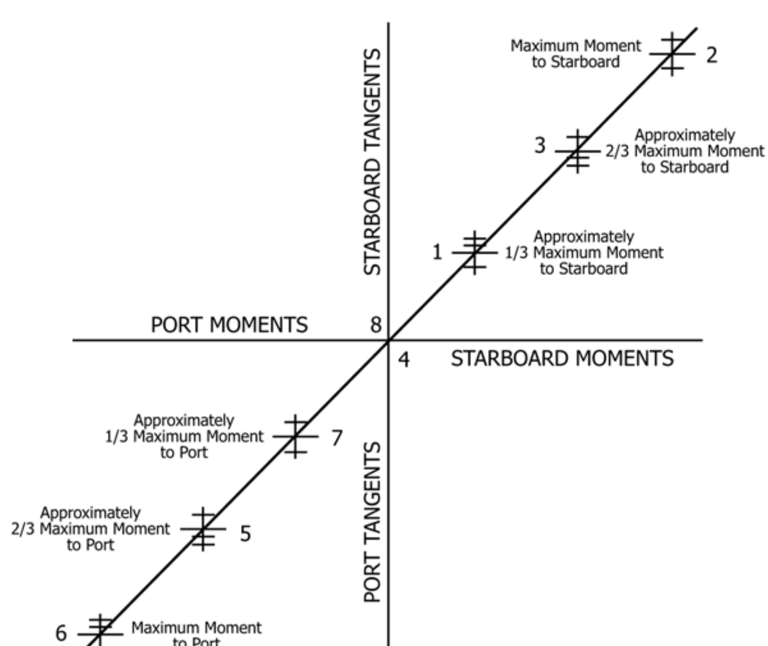


FIG. 1 Typical Incline Plot

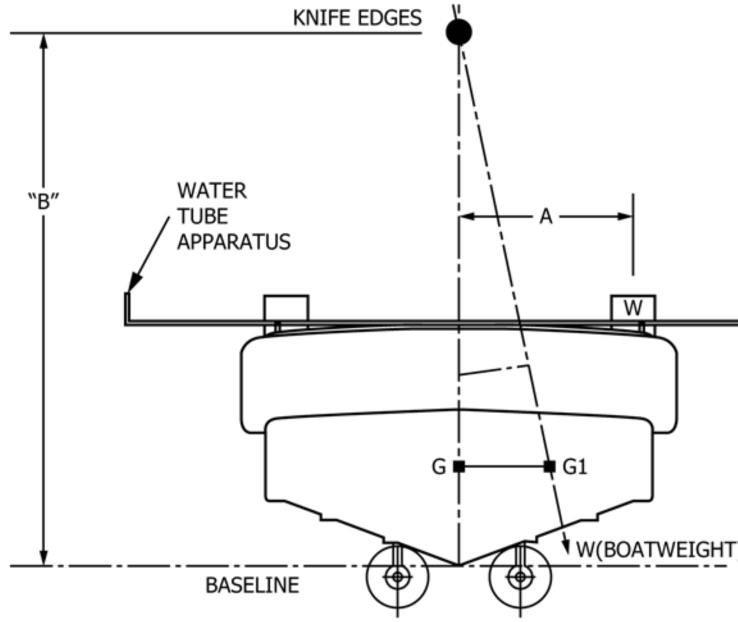


FIG. 2 Measurement of KM, GM & KG

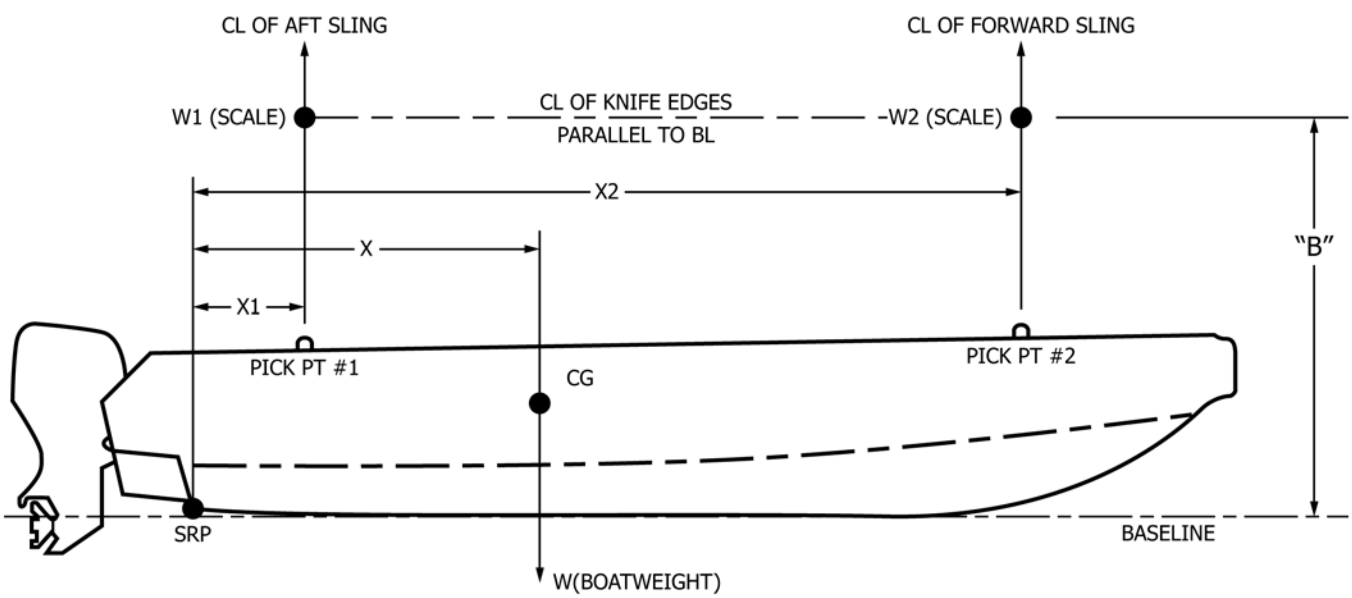


FIG. 3 Relationships of Pick Points and Center of Gravity

5. Theory

5.1 This test is analogous to the standard in-water inclining test of Guide F1321 and the basic concepts are similar, but the information determined by the readings of the scale(s) and the location of the pivot point are substituted for the hydrostatic properties of the floating vessel in an in-water inclining experiment. Similar terms are used in some cases based on this analogy, but these terms should not be confused with those derived from hydrostatic data.

5.2 *The Metacenter*—The transverse metacenter "M" is the point around which the boat swings through small angles of inclination (typically 0° to 5°). This is the point at which transverse movement is not constrained relative to the craft hull. For example, as shown in Fig. 5, the lift straps constrain the lower shackle from moving transversely relative to the craft hull, but there is no such constraint on the upper shackle, so the lower shackle pivots on the contact surface between the upper and lower shackles and the metacenter is at their mutual contact point, The height of "M" above "K" is known as "KM". The location of M is fixed over the range of angles of inclination during the stability test. The intersection between the bearing surfaces of the shackles is known as the "*knife-edge*". It is imperative that this height, "KM", be exactly parallel between the forward and aft pick points and the baseline of the boat. Note also that one source of error in this experiment is inaccurate or inconsistent location of the pivot

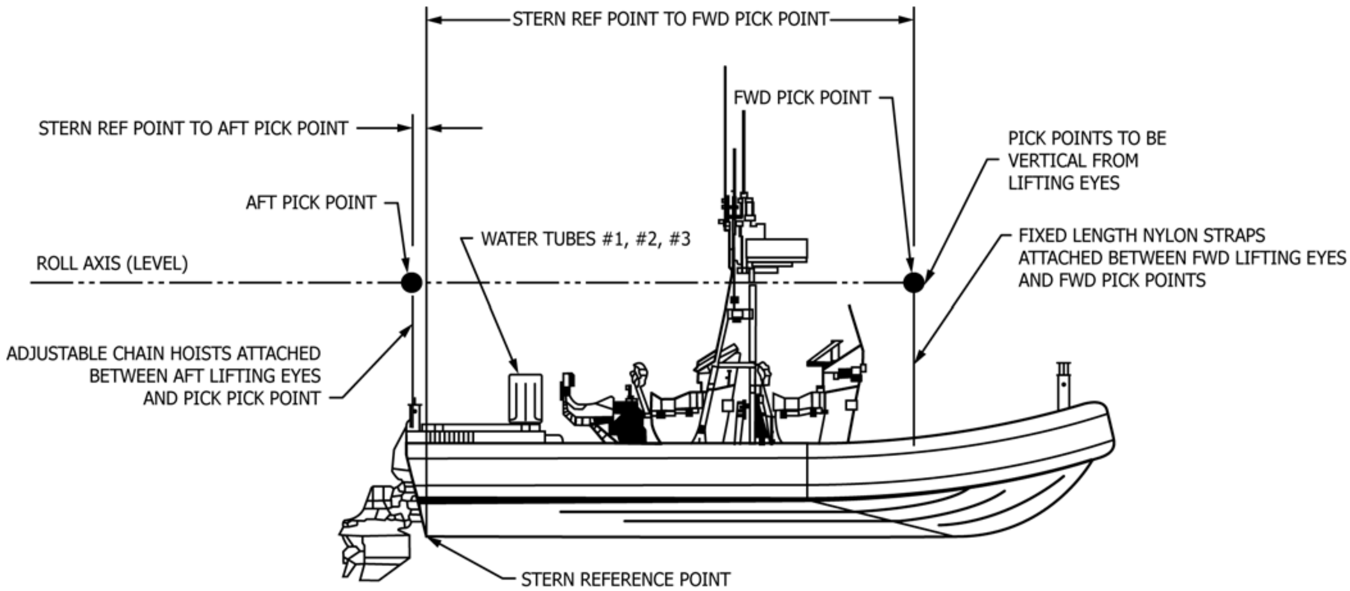


FIG. 4 Typical Lifting Arrangement with Pick Point References and Water Tube Location

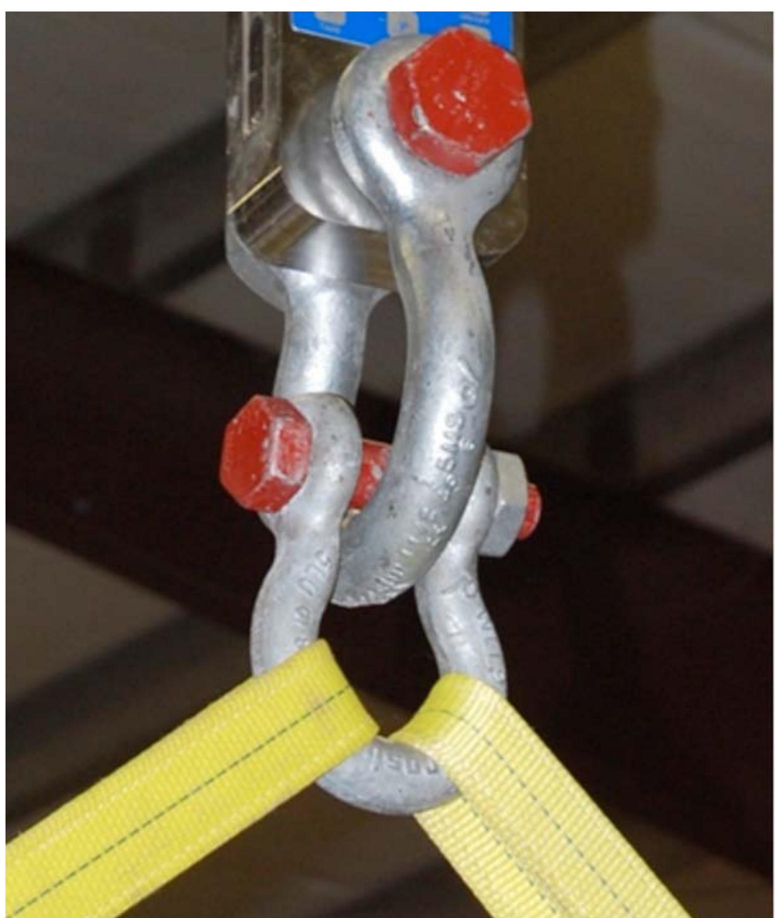


FIG. 5 Improvised "Knife-Edge" Configuration (forward and aft) Pick Points

point. It is important the system from the craft hull to the pivot point be effectively rigid in the transverse plane and the pivot point itself be completely free to rotate through the full range of observed angles of inclination without any binding.

5.3 *Metacentric Height*—The vertical distance between the center of gravity "G" and "M" is called the metacentric height, "GM". At small angles of inclination, GM is equal to the initial slope of the righting arm "GZ" curve and is calculated based on the relationship:

$$GZ = GM\sin\theta \quad (1)$$

GM is a measure of stiffness in roll that can be calculated during the air inclining experiment. Moving a weight "*w*" across the deck a distance "*A*" will cause a shift in the overall center of gravity "GG_1" of the small craft equal to:

$$GG_1 = \left(\frac{(w)(A)}{W}\right) \quad (2)$$

and parallel to the movement of "*w*". The small craft will list over to a new equilibrium heel angle. Because the angle of inclination during the stability test is small, the shift of "*G*" can be approximated by:

$$GM_1 = \left(\frac{(w)(A)}{W(\tan\ \theta)}\right) \quad (3)$$

Because the GM and weight remain constant throughout the entire air inclining experiment, the ratio in Eq 3 will remain constant. A series of weight shifts will result in a plot of tangents at the corresponding moments. This ratio is the slope of the best represented straight line drawn through the plotted points as shown in Fig. 1. The line does not necessarily pass through the origin or any other particular point, for no single point is more significant than any other point. Therefore, a linear regression analysis should be used to fit a straight line through the points.

5.4 *Calculating the Height of the Center of Gravity Above the Keel*—KM remains constant throughout the entire stability test and is represented as "*B*", see Fig. 2. The metacentric height, GM, as calculated in Eq 3, is determined from the inclining experiment. The difference between KM and GM is the center of gravity, KG. Therefore, the center of gravity above the keel is:

$$KG = B - GG1\cos\theta$$
$$KG = B - \frac{wA}{W}\cos\theta \quad (4)$$

5.5 *Calculating the Weight of the Boat*—The weight of the boat is obtained by adding the two calibrated scale readings, W1 + W2, Fig. 3. The distance "*X*" of the longitudinal center of gravity from the stern reference point (SRP) is calculated by taking the moments:

$$W1X1 + W2X2 = W(X) \quad (5)$$

$$X = \frac{W1X1 + W2X2}{W} \quad (6)$$

5.6 *Measuring the Angle of Inclination*—Each incidence where an inclining weight, "*w*", is shifted a distance, "*x*", the boat will settle to some final equilibrium heel angle, "θ". To accurately measure this angle, pendulums, a digital inclinometer, a set of water tubes, pendulums or any combinations thereof can be used. At least three independent means of measuring the angle should be used.

5.7 When pendulums are used, the two sides of the triangle defined by the pendulum are measured, "*Y*", is the length of the pendulum from the pivot point to the ruled batten and "*Z*' is the distance the pendulum deflects from the initial reference position along the ruled batten where transverse deflections are measured. Tangent "θ" is then calculated, see Fig. 6:

$$\tan\theta = Z/Y \quad (7)$$

Plotting the readings during the stability test will aid in the discovery of a bad shift in weight or deflection. Since Eq 1 should be constant, the incline plot theoretically should be a straight line. Deviations from a straight line are indicators that there are other moments acting adversely on the craft or the height of "*B*" is not the same at the fore and after sling pick points. These errors should be identified and corrected and the weight shift repeated until a straight line can be achieved.

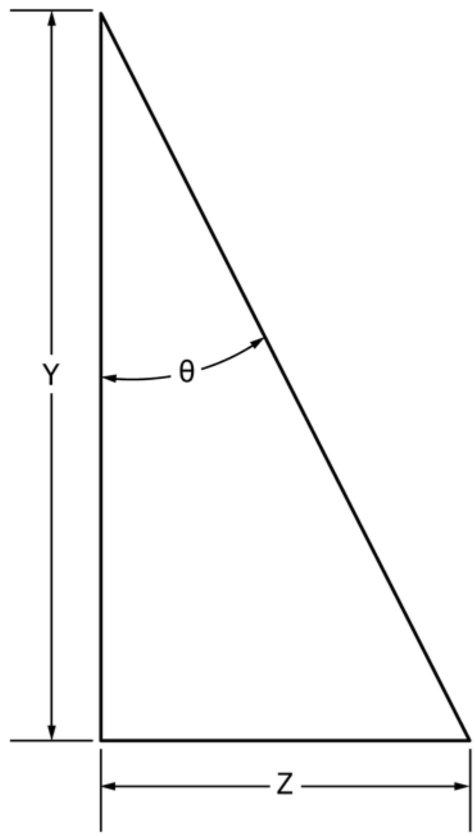
5.8 *Free Surface*—During the stability test, the inclining of the vessel should result solely from the movement of the inclining weights. It should not be inhibited or exaggerated by unknown moments of shifting of liquids or on board components so all such liquids or other weights should be removed or documented so that they can be corrected for during the analysis. Note also that any free surface has the effect of reducing the observed roll stiffness of the system, because it is similar to an additional inclining weight. This means that free surface effects have the effect of raising the observed KG and therefore are subtracted from the observed KG resulting in a lower lightcraft KG.

5.8.1 *Tankage during the Air-Inclining*—There should not be any liquids on board with the exception of machinery fluids, such as lubricants and hydraulics at operating levels as defined in the specified lightcraft condition. Unless the exact weight and distance of liquid shifted can be precisely calculated, the GM from Eq 1 will be in error. Free surface should be minimized by emptying the tanks completely and making sure all bilges are dry. The shifting of fluids within tanks due to the entrapment of air or pocketing within a complex tank causes considerable errors in the computation of the GM. Note especially that tanks near to empty or full may exhibit heeling moments that vary with the inclining angle as the fluid in the tank touches the top of the tank or as part of the bottom of a tank goes dry. These varying moments severely degrade the accuracy of the test, so tank loads that may produce these effects should be avoided.

6. Preparations for the Stability Tests

6.1 *General Condition of the Small Craft*—The boat should be as complete as possible at the time of the stability test. The boat will be inspected and any standing water and loose items of "outfit" (anchor, anchor warp, dock lines, fire extinguishers, etc.) found on board should be removed completely or stored securely as specified in any procurement documentation or operator's manuals if they are defined as part of lightcraft in that documentation. Seacocks and drainage pipes should be dry. The exterior of the hull(s) should be clean and dry. Fig. 4 is an example of a typical lifting arrangement diagram used in an air incline stability test.

6.1.1 The small craft should have structurally sufficient lifting points forward and aft or should be lifted by slings or by



$$\tan \Theta = Z/Y$$
$$\tan 4° = 6 \text{ in.}/Y$$
$$Y = 6 \text{ in.}/\tan 4°$$
$$Y = 6 \text{ in.}/0.0699$$
$$Y = 87 \text{ in.}$$
$$\tan 3° = 6 \text{ in.}/Y$$
$$Y = 6 \text{ in.}/\tan 3°$$
$$Y = 6 \text{ in.}/0.0524$$
$$Y = 114 \text{ in.}$$
$$\tan 2° = 6 \text{ in.}/Y$$
$$Y = 6 \text{ in.}/\tan 2°$$
$$Y = 6 \text{ in.}/0.0349$$
$$Y = 172 \text{ in.}$$

FIG. 6 Angle of Inclination versus Pendulum Length

rigid frames designed for the purpose. The lift means should not shift in any respect during the test. Slings should be marked at the contact point with the hull or secured by tape to the hull such that any slipping can be readily observed.

6.1.2 The boat should be suspended by slings or other hoisting gear forward and aft. Each sling should be vertical and should connect to a "knife-edge" defining the metacenter. The arrangement of shackles, as shown in Fig. 5 is a typical such configuration. The slings should be adjusted so that the craft baseline is level within one inch over the length of the craft and parallel with the forward and aft metacenters or knife edges, which should also be level within one inch. In Fig. 3, the height of "B" must be equal at the forward and aft pick points within one inch. At each pick point, there should be a calibrated scale with a rated capacity greater than that of the total estimated weight of the boat. It is possible to use one scale and a link of the same length (within ⅛ in.) instead of two scales. In this case, the craft should be lifted twice, once with the scale in the forward position and the link aft and once with the positions reversed, but the requirements above for level positions of the metacenters should be verified in both lifts. The subsequent inclining process may be done with the link and scale in either position. The scale(s) should have a current calibration certificate, which should be copied and recorded on the test documentation.

6.2 *Tankage*—All tank(s) should be empty and clean. Alternatively, the fuel tank(s) can be pressed full or 100 %.

6.2.1 *Pressed Tanks*—Tanks that are completely full with no voids caused by trim, heel or inadequate venting. Anything less than 100 % is unacceptable. 98 % condition regarded for full operational purposes is unacceptable. The craft should be rolled side to side to eliminate entrapped air before starting the air incline. Special care should be taken when pressing fuel tanks to prevent accidental over flow or pollution.

6.2.2 *Empty Tanks*—It is generally not sufficient to pump tanks until suction is lost. All attempts should be made to ensure a tank(s) are empty prior to the stability test. This may require physical inspection through a manhole or other means such as a video bore scope.

6.2.3 *Slack Tanks*—Half full tank(s) are undesirable during the stability test and are susceptible to errors in the air inclination plot.

6.3 *Test Weights*—The total weight used should be sufficient to provide a minimum inclination of 1 degree and a maximum of 4 degrees of list.

6.3.1 A means to estimate the amount of weight needed is as follows:

6.3.1.1 Measure the maximum athwartships distance, *x*, available on deck to shift incline weights.

6.3.1.2 Take the combined weight readings from the fore and aft scales used for the experiment.

6.3.1.3 Estimate a reasonable GM of the boat (as defined by this test, not the hydrostatic GM), typically, this is no less than 1.5 feet. This can be done by using the KG from the construction weight estimate compared to the metacenter as defined by the height B in Fig. 3. In the absence of a weight estimate, KG is generally near the sheerline.

6.3.1.4 Calculate the total incline weight, *w*, required to heel the boat within the limits of inclination in 6.3.

$$w = \left(\frac{(G\ M)(\tan\theta)(W)}{(x)} \right) \tag{8}$$

where:

θ = the desired angle of inclination between 1 and 4 degrees.

6.3.2 It is prudent to have additional weights readily accessible to compensate for any inaccuracies.

6.3.3 Test weights should be compact and easily moveable by personnel or crane and in such configuration that the vertical centers can be accurately determined. Mark each weight accordingly with an identification number and weight. One means of accurately determining the effective centers of the weights and making them convenient to handle without requiring anyone to get onto the boat is to suspend the weights from the boat gunwales. The accuracy of the process can be improved by providing a definite point of suspension, such as a hook from a beam placed on the boat or an angle on the side of the hull that the suspension strap passes over. The center of gravity of the weight is then the point of suspension. If suspended weights are used, verify that they are free to swing transversely throughout the range of inclining angles.

6.3.4 At least three inclined positions should be done from level in each direction (port and starboard). This requires three weights or groups of weights of roughly equal size, on each side, that can be moved separately for each "move" or position, for a total of six weights or weight groups.

6.3.5 Test weights should be certified using a certified scale. Performing the weighing close to the time of the stability test will ensure accuracy.

6.3.6 An additional crane, not one being used for the stability test, or some other means, such as a forklift may be required during the stability test to shift test weights in a safe and efficient manner.

6.3.7 Consider where the test weights will reside on the deck of the boat during weight movements. If deck strength is a concern, check the scantlings below the deck to determine if the existing scantlings can support the additional weight.

6.3.8 Test weight centers of gravity should be at the same vertical and longitudinal location in both the original and shifted positions.

6.4 *Pendulums:*

6.4.1 Pendulums should be arranged to be conveniently situated, in any location on the boat, longitudinally and transversely, and importantly where personnel can accurately read them without disturbing the boat, typically aft of the transom of the boat or forward of the bow. No pendulum or any other means of measuring angle should require a person aboard the boat. No pendulum or any other means of measuring angle should require a person be under the boat, and no person should be under the boat while suspended as any part of this procedure. It also is preferable that no person be required to board the boat once it is suspended.

6.4.2 The pendulum(s) should be long enough to give a measured deflection of at least 4–6 in. to each side, and a precision equivalent to a ⅛ in. deflection of an eight foot pendulum. Generally this requires a pendulum length of about 8–10 feet. A longer pendulum produces more accurate results, however, may take more time to settle down which in this case the accuracy of the results may be questionable. With smaller boats, increasing the weight as prescribed in 6.3 will increase the heel thus utilizing a shorter length pendulum. As shown in Fig. 6, pendulums must be at least 87 in. long to get at least 6 in. of deflection to either side without exceeding the 4 degree maximum heel.

6.4.3 The pendulums are fixed to a point on the craft, as is the batten used to record deflections. The damping trough should be below the batten and may be on the boat or on the floor, but if it is on the floor its weight and its free surface effect need not be deducted from the craft weight condition. Note that he damping trough is not connected to the battens or the pendulum, so it may be moved as required to ensure that the bob doesn't contact the sides of the trough. This also means that the trough need not be of any particular shape as long as it allows the bob to be free from contact with the sides; a regular round bucket is generally acceptable.

6.4.4 A weighted winged pendulum bob (such as two angles connected at their heels) should be immersed in a trough filled with a liquid to dampen oscillations after each weight movement. Liquid detergent generally works well. The trough should be deep enough to prevent the pendulum bob from touching the bottom.

6.4.5 Battens used to record the readings should be smooth, easy to read and securely fixed in position so that an inadvertent contact will not create a bad reading. They should be marked with a horizontal datum line that defines the lower point of the vertical height of the pendulum. The battens should be aligned close, but not touching the pendulum. The deflection used to calculate the inclining angle comprises the location of the pendulum string where it crosses the datum line of the batten. This is recorded on battens which may comprise a scale for noting the deflections or a mark able surface. If necessary, a mirror or other reflective surface one or behind the batten may be used to visually align the pendulum line and its image and thereby correct for any error due to misalignment.

6.5 *Water Tubes:*

6.5.1 Water tubes may be substituted for pendulums; however, at least one pendulum must be used for the test.

6.5.2 At a minimum, three (3) water tubes should be arranged to allow personnel to read and record deflections caused by the weight shift during the stability test on either side of the boat. Like the pendulum, the greater the span between the vertical ends of the water tube apparatus, the higher the deflection readings when shifting the weight. Water tubes should be arranged to give equivalent measurement precision as a pendulum. Water tubes should be located forward, midship and aft.

6.5.3 The flexible water tubes should be long enough to lay freely athwartships on the boat and extend vertically on the ends of an apparatus, see Fig. 7. The tubes should not come in contact with the ground.

6.5.4 Make sure the water tube is free of any air bubbles. Trapped air bubbles will cause an error in the deflection readings. Generally, when using three water tubes in parallel with one another, different colored dye is added to each water tube to allow personnel recording the deflections to do so without discrepancy. This also ensures that the port and starboard legs of the tube are correctly matched. Note that a stopcock on each end of each tube allows them to be moved or otherwise inclined without loss of the fluid, but verify that the stopcocks are fully open during each measurement.

6.5.5 Rulers or battens should be fixed to the vertical ends of the water tube apparatus to easily read the deflection in the water tube, as shown in Fig. 8. Measurements of the deflections recorded must be readable to 1⁄16 in. and a minimum of 6 in. of deflection must be attained above and below the zero point on each side of the vessel.

6.5.6 The water tube apparatus is usually located in an unobstructed section of the boat deck where it can pass freely from side to side. Note that the tube connecting the water levels may run freely vertically and fore and aft, etc. as convenient provided that no point on the tube is higher than the measurement area and that no air pockets are formed.

6.6 *Digital Inclinometers:*

6.6.1 A calibrated digital inclinometer may be used for quick reference validation and not to substitute the pendulums or water tubes. They should be located with the active axis athwartships and in an unobstructed area easily viewed by personnel to record. They should have a precision equivalent to at least ±0.01 degrees and an accuracy of ±0.05 degrees. If the reading does not stabilize at a single number, an average of at least five maximum-minimum swings (therefore, ten readings) should be recorded for each weight movement.

6.6.2 Manufacturer's data or certification for the inclinometer must also be submitted.

6.7 *Laser Level:*

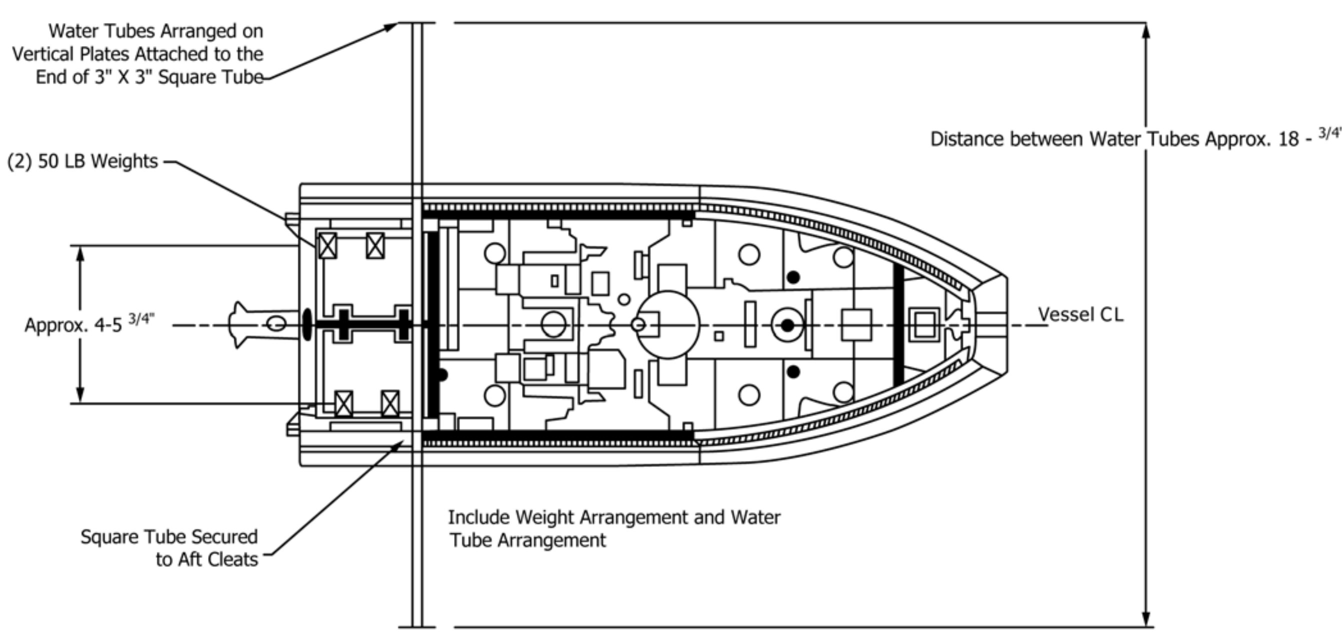


FIG. 7 Typical Water Tube Arrangements

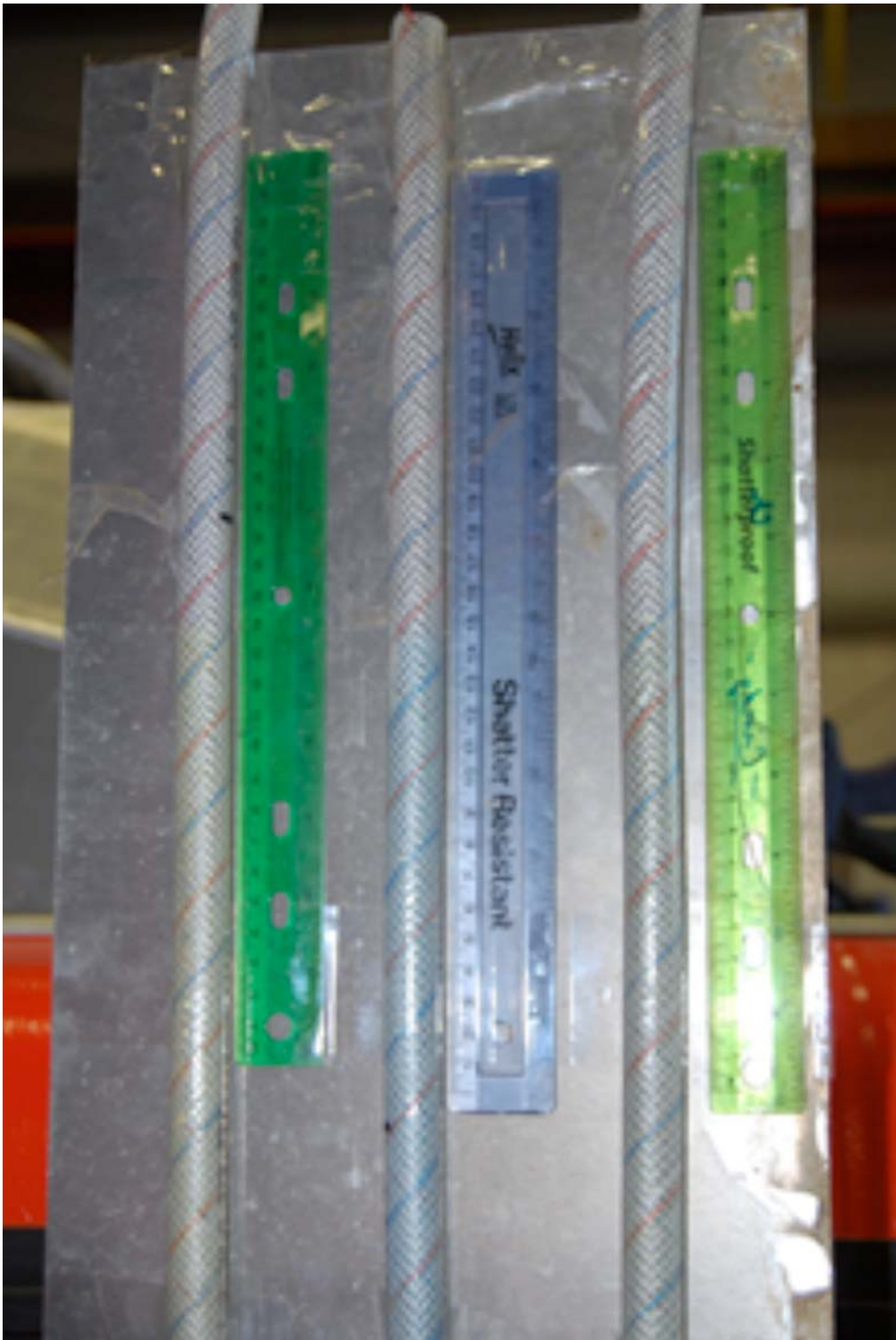


FIG. 8 Typical Water Tube Deflection Recording Station

6.7.1 A laser level can be used during a stability test to check for even trim of the boat.

6.7.2 A laser transit can be used to assure the knife-edge pick points and the boat baseline are level and parallel.

6.7.3 A laser level or optical transit can be used for determining the inclination of the boat. If used this should be only one of at least three independent means of determining the inclination of the boat and should be shown by calculation to give equivalent precision to 0.1 % slope.

6.8 *List and Trim*—The most crucial procedure for the stability test is to ensure that the boat should be as close as possible to even trim and list hanging from fore and aft cranes. A water tube or laser transit can be used to ensure the boat is level and that the fore and aft pick/lift points are the exact distance from the baseline. With inclining weights in the initial position, up to ½ ° of list is acceptable. If the list exceeds the acceptable limit, use leveling weights to put the vessel at an acceptable condition.

6.9 *Communication Arrangements:*

6.9.1 One person at a central location within the stability test facility should have ultimate control over all personnel involved with the test.

6.9.2 If necessary, efficient two-way communications between central control and weight handlers and central control and data collectors.

6.9.3 Ultimately, the stability test should be administered indoors in an enclosed facility with no less than two cranes to avoid any environmental effects (that is, wind, rain, etc.) during the test; however, if an enclosed facility cannot be provided, a test can be satisfactorily administered outdoors in calm conditions (that is, no wind, no rain, etc.). The test leader should determine the results satisfactory by monitoring the plot and noting any major deflections or errors.

6.10 *General:*

6.10.1 If the person administering the test desires to substitute inclinometers or other measuring devices for pendulums or water tubes, they should complete prior testing of the measuring devices to verify their accuracy. It is recommended that such devices be used in conjunction with at least one pendulum or water tube as mentioned in 6.4 of this guide instead of using only other devices and no pendulum or water tubes.

6.11 *Additional Requirements:*

6.11.1 Annex A1 contains additional requirements that must be met, if U.S. Coast Guard approval of the stability test is needed.

6.11.2 Annex A2 contains additional requirements that must be met for stability tests on U.S. Navy vessels.

7. Plans and Required Equipment

7.1 *Plans*—The person in charge of the air inclining should have available a copy of the following at the time of the stability test:

7.1.1 General arrangement plan;

7.1.2 Outboard/Inboard profile;

7.1.3 Midship section;

7.1.4 Capacity plan (if available) showing capacities and centers of gravity of tanks and so forth.

7.2 *Equipment*—Besides the physical equipment necessary, the following are necessary to the person in charge of the air incline procedure:

7.2.1 Sufficient number of engineering scales or equivalent devices for measuring pendulum and water tube deflections;

7.2.2 Sufficient number of pencils to mark deflections and/or record deflections;

7.2.3 Chalk for marking various positions of the incline weights;

7.2.4 A sufficiently long measuring tape (steel, 100 ft) for measuring the movement of the inclining weights;

7.2.5 Duct tape;

7.2.6 Ladders to access the hull when lifted;

7.2.7 Digital camera;

7.2.7.1 It is important to record where and the timing of when a photograph was taken to avoid any discrepancies later when generating the final report.

7.2.8 Flashlight;

7.2.9 Calculator;

7.2.10 Permanent marker;

7.2.11 Graph paper to plot inclining moments, sufficient number of pads of paper to record information and/or a single computer station configured to track the air inclining results;

7.2.12 At least two (2) calibrated scales rated to accept the total estimated weight of the craft;

7.2.13 At least two (2) adjustable chain hoists or other means of adjusting the length of the lift gear between the boat and the knife edge if the craft has dedicated lift points that are appropriate for this test;

7.2.14 Assortment of shackles to provide extra length of straps if needed;

7.2.15 If the craft does not have appropriate lift points, two (2) nylon slings rated at the capacity of one of the scales and slings of adequate length (that is, approximately 30 ft) fitted with means to adjust the sling length so that the required level and parallel relationships of the craft and the lift points may be achieved. Note that the adjustment means must be in the sling such that the spread of the sling legs is maintained as shown in Fig. 5. This ensures that the knife edge is the true pivot point. The adjustable means should not be between the point where the two legs come together and the knife edge.

7.2.16 Other means of connecting the craft to the knife edge, such as dedicated rigid frames, may be used provided they are vertical, achieve the required level and parallel relationship, are of well-known weight and center, and achieve the required restraint of the lower component of the knife edge relative to the craft.

8. Procedure

8.1 *Safety*—First and foremost, throughout the entire air inclining procedure, it is advised NOT to go under a suspended craft.

8.2 Bring the lift gear taut without lifting the craft. Verify the location and vertical measurement of the lift points, knife edges, weight locations, etc. relative to the SRP. Verify the transverse measurements of the weight shifts.

8.3 Lift the craft in the as-inclined condition with all inclining equipment aboard and set up in position and with the weights in their initial position.

8.3.1 Verify the level and parallel condition. Note the scale reading(s). Photograph the craft showing the entire craft from several views, with close up views of the weights and the scale reading(s).

8.3.2 If only one scale is used, interchange the scale and link and repeat as per 8.3.1.

8.3.3 Use this data to compute the total weight and longitudinal center of the craft as inclined.

8.4 With the craft lifted and ready as per 8.3.1, ensure all means for measuring inclining angle are active and ready (stopcocks open, pendulum bobs free, digital devices on and active, etc.). Note the initial reading of the means for measuring inclining angle.

8.5 Move one weight across the craft to its new position on the opposite side, and allow the craft to settle.

8.5.1 Note the inclining angle on all of the angle measurement devices. Compute the moment induced by the weight move and the tangent of the angle achieved on each device (note that a digital reading in percent of slope is by definition 100 times the tangent). Plot these points or enter them into software on a computer that displays graphics of the moment-tangent relationship and observe the position of the three angle readings and the line from them back to the origin. Note that the commercial software specifically for performing inclining experiments may be available, most spreadsheets can readily be set up to perform and display all of the calculations required for an in-air inclining experiment because craft hydrostatic data is not needed. It is also advisable to photograph the weight(s) in their as-moved condition to allow subsequent verification of the weight moved and its position in case of questions or lost data.

8.6 Move a second weight across the craft so that two weights are on the same side, and repeat the process of 8.5.1, again observing the line formed. If feasible, perform a least squares fit to the data and note the R^2 value at this and each following step.

8.7 Move a third weight across the craft so that three additional weights are on one side. Repeat the process of 8.5.1.

8.8 If additional weight moves are desired to one side, continue until the all of the weights have been moved to one side.

8.9 Move each weight back to its original position one at a time and repeat 8.5.1 and return the craft to its original configuration. It is not necessary that the weights be moved in the same order.

8.10 Move one weight (that was on the original low side, and therefore has not yet been moved) across the boat to the opposite side, and repeat 8.5.1. Continue to plot and observe the points resulting from each step, looking for anomalies. Repeat any suspicious moves.

8.11 Continue in steps until all weights are on the opposite side.

8.12 Move the weights back to their original position in steps.

8.13 Observe the final plot, any available statistics and the line resulting from the statistical analysis, if available. Repeat any suspicious points, or make slightly different moves that surround the points (that is, if a suspicious move comprised weights 1 and 2, try 1 and 3 instead). In general an R^2 of more than 0.998 is readily achievable. An ANOVA analysis will also show the actual probable error for various levels of confidence.

8.14 If a least squares analysis was done, the result will be an linear equation of the form:

$$\text{Tangent} = m*\text{Moment} + B \quad (9)$$

where:

B = the vertical offset from the line at zero moment, and
m = the slope of the line.

The corrected GM to be used is:

$$GM_{corr} = (1/m)/Weight \quad (10)$$

8.15 If the person leading the stability test is confident that the survey will maintain the boat in an acceptable condition, then the air inclining experiment and deadweight survey maybe conducted in any order. It is very important that a level of consistency of weight condition be maintained throughout the entire stability test. Appendix X1 contains a stability test check list that can be used to make a quick check that the procedure is correctly followed.

8.16 The person conducting the stability test should arrive well in advance of the scheduled time of the test to ensure that the boat is properly prepared for the test and ensure those assisting with the procedure are well informed of the process. Safety precautions should be reviewed with those handling the incline weights. A walk-through of the boat should be conducted to check that tanks are empty and clean or pressed 100 %, and that the hull is clean and dry. Loose outfit gear should be either removed or secured on board and documented. Pendulums and water tubes should be properly secured in place. Incline weights should be on board and in place in their initial positions and a crane or other method should be available to shift weights during the test. Before commencing the stability test, the person in charge should:

8.16.1 Make a thorough overall survey of the boat to ensure the boat is complete enough to conduct the stability test and all outfit items are off the boat. This survey should be photographically documented with a digital camera and the photos should be included in the report.

8.16.2 Survey the boat to identify all items that need to be added, removed or relocated on the boat to bring the boat to a lightcraft condition. Each item must be clearly identified by weight and location from the SRP. The inclining weights, pendulums, water tubes and digital inclinometers, any temporary equipment are all among the weights to be removed to achieve the lightcraft condition. Any tanks containing liquids must be accurately accounted for and recorded. Appendix X1 is an example of a typical entry from a survey.

8.16.2.1 It is recognized that the weight of some items on board, or that are to be added may have to be estimated. If this necessary, it is in the best interest of safety to be on the conservative side when estimating, so the following rules of thumb should be applied:

(1) Estimation of added weights:

(a) Estimate high for items to be added high on the boat and low for items low in the boat.

(2) Estimation of removed weights:

(a) Estimate low for items to be removed high on the boat and high for items low in the boat.

(3) Estimation of relocated weights:

(a) Estimate high for items to be relocated to a higher point in the boat and low for items relocated lower in the boat.

8.17 *Initial Preparation:*

8.17.1 Boat is delivered to the facility. The fuel tank(s) should preferably be empty.

8.17.2 Facility personnel to provide a clean area to conduct the incline, free of debris and other obstructions that would prevent a successful test. Facility personnel to also provide high-reach ladders or other equipment to allow personnel to have access to the boat once it is in the air.

8.17.3 Locate indoor (preferably) facility to conduct inclining experiment.

8.17.4 Begin preparations for incline. Provide weights as needed. Go over with facility personnel requirements for the gantry or other cranes, and the requirements to level the boat and the pick points once it is hanging from the cranes.

8.17.5 Visually inspect boat, noting equipment to be added, removed, or relocated. Inspect fuel tank to ensure it is at full capacity. Inspect bilges for dryness. Inspect lifting points.

8.18 *Weighing and Incline Procedure:*

8.18.1 Review with facility personnel requirements for leveling the boat using the cranes and electronic transit.

8.18.2 Assemble lifting straps or other hoisting gear and load cells in preparation for lifting boat. Lift boat from lifting eyes and using the electronic transit and any needed shackles level the boat and the pick points with the baseline.

8.18.3 Perform inclining preparations by setting up water tubes and inclining equipment, and marking locations of weights.

8.18.4 Perform incline experiment.

8.19 *Preparation Instructions for Facility Personnel:*

8.19.1 Provide clean area in an enclosed facility for the incline procedure. The area should be clear of debris and other obstructions.

8.19.2 Provide gantry crane and other crane to hoist boat into the air.

8.19.3 Provide strapping, shackles, etc. for hoisting boat. See Fig. 3 and Fig. 4 for recommended strap arrangement.

8.19.4 Provide (2) adjustable chain hoists.

8.19.5 Provide electronic transit to assure pick points of boat are level.

8.19.6 Provide (2) calibrated load cells for weighing the boat, each to be not less than 5,000 lb. capacity.

8.20 *Preparation Instructions for Engineering Personnel:*

8.20.1 Provide water tubes to measure boat inclination.

8.20.2 Provide water tube to assure fore-aft pick points of boat are level with each other.

8.20.3 Provide long board for measuring between plane of pick points and ground.

8.21 *Procedures for Air Incline Test:*

8.21.1 *Before Hoisting Boat:*

8.21.1.1 Position boat under gantry crane as needed. Prepare hoisting straps and attach load cells.

8.21.1.2 Perform deadweight survey. Ensure boat is complete in every respect and that bilges, sumps, and voids are dry. Record weights for items to be added, removed, or relocated. Remove any loose gear completely off the boat to prevent shifting during the experiment.

8.21.1.3 Sound fuel tank. Ensure that the tank(s) are completely dry, clean and empty.

8.21.1.4 Locate positions for inclining weights and load required weights onto boat. Label each weight as required and record their locations.

8.21.1.5 Locate position for stern reference point (SRP).

8.21.1.6 Prepare water tubes to load onto boat after it is hoisted.

8.21.1.7 Prepare high-reaches, or ladders as needed to access boat after it is hoisted.

8.21.2 *Hoisting and Leveling the Boat:*

8.21.2.1 Attach lifting straps to lifting eyes located in boat. Attach adjustable chain hoists between aft lifting eyes and load cells so that the vessel can be positioned as required. Attach load cells to straps. See Fig. 2 and Fig. 3 for recommended arrangement.

8.21.2.2 Lift the boat so the keel is about 3 in. above the trailer blocks. While maintaining the height of the pick point of forward strap, adjust the aft strap using adjustable chain hoists so that the pick point between the forward strap and the aft strap are level and the deck of the boat is also level, Fig. 3. Use the transit to assure the points are level. A water tube can be used to verify the electronic transit readings. The vessel should be freely hanging and pick points vertical from vessel's lifting rings, Fig. 3.

8.21.2.3 Position transverse water tube assembly in a location not to obstruct the weight shift process during the stability test, Fig. 4.

8.21.2.4 Perform a preliminary weight movement by moving all inclining weights to one side of the craft. After weights are moved the net deflection of the water tubes should be about 5–7 inches. This will assure the experiment will give expected results. If needed adjust weight movements/amount to attain required heeling angle.

8.21.3 *Conducting Air Inclining Experiment/Weight Survey:*

8.21.3.1 To acquire the stern reference point use the long board to measure the vertical distance from a suitable point on the ground to the height of the pick point/roll axis. Measure up from the ground to a point located at the base of the transom. This will be the stern reference point. The difference between these two heights is 'B', Fig. 4.

8.21.3.2 Record craft weight as measured by the load cells on the forward and aft pick points.

8.21.3.3 Record longitudinal distance to the forward and aft pick points from stern reference point.

8.21.3.4 During the test after weights are moved from one side of the vessel to the other, allow the craft to settle out before recording the water tube deflections. One person will read the port side; another person will read the starboard side. When recording the water tube deflections do not disturb the vessel. Also, when recording the water tube deflections take measurement from the center of the meniscus.

8.21.3.5 As test progresses plot moments and tangents to develop a suitable plot line. Redo any points that fall outside of an acceptable range.

8.21.3.6 At the end of the incline procedure weigh all test equipment and record as weights to remove. Record weights of lifting straps and enter them as weights to remove.

9. Calculations

9.1 *Condition 0, As Inclined:*

9.1.1 Upon completion of the test resolve weight, VCG and LCG for the 'As Inclined' Condition 0.

9.2 *Condition 1, Lightcraft:*

9.2.1 Deduct incline weights, water tube weights, hoisting straps, fuel, and any other extraneous weights that will not be included in the defined lightcraft Condition. Add any weights not yet aboard to be included in lightcraft such as components not yet installed.

9.3 *Full Load:*

9.3.1 Add weights of full crew, equipment, passengers, (or others aboard such as migrants or survivors), cargo, stores and fuel to lightship weight (Condition 1) to calculate a full load condition. This is generally the heaviest condition that the craft will be operated in.

9.4 *Minimum Operations:*

9.4.1 Add weights of minimum crew, equipment, return condition fuel and stores to lightship weight (Condition 1) to calculate a minimum load condition. This is generally the lightest condition that the craft will be operated in.

9.5 Other specific weight conditions may be required by the owner or operator of the boat, or by specific regulatory authorities as required by the procurement documents, regulations or mission needs, such as a hoisting condition. These may be generated by the addition of the appropriate weights to lightcraft condition.

10. Report

10.1 Unless otherwise specified by the organization requiring the test, the report may be in any format as desired by the testing organization provided it provides all of the information required by this specification, a selection of the required photographs to verify the various configurations of the boat, the calculations and resultant statistics and plots and a narrative of the test.

10.2 Appendix X2 contains sample data sheets to record data during stability tests. It is suggested that these sheets be used so no data is misplaced and that data is clear, concise and consistent in form and content.

10.3 Alternatively, all calculations performed during the inclining and in preparation of the report may be carried out by a suitable computer program. Output generated by such a program may be used for presentation of all or partial data and calculations included in the test report if it is clear, concise, well documented and generally consistent in form and content with the forms in Appendix X2.

11. Precision and Bias

11.1 The accuracy of the stability test is directly related to the accuracy of the measuring conditions at the time of the test. Many factors can influence the reliability of the information gained. Ideally, conditions for the stability test are easily controlled when the test is conducted indoors in an environmentally controlled facility. The test can be conducted outside using the same equipment mentioned in Section 7, however, other factors (that is, wind, rain, snow, etc.) may have an adverse effect on the results and overall control of the air inclining experiment may be compromised. The precision used to read deflection measurements does not guarantee the resulting overall accuracy of the test. If all procedures in this guide are followed, the test results should have satisfactory accuracy.

ANNEXES

(Mandatory Information)

A1. UNITED STATES COAST GUARD APPROVAL OF THE STABILITY TEST ON COMMERCIAL VESSELS THE FOLLOWING ADDITIONAL REQUIREMENTS SHOULD BE FOLLOWED

(In Amplification of the regulations)

A1.1 *Prior Notification to the Coast Guard Marine Safety Center*—Written notification of the test must be sent to the Coast Guard Marine Safety Center (MSC) at least two weeks before the test. The MSC will make arrangements for an acceptable representative to witness the test.

A1.1.1 *Details of Notification*—Written notification should provide the following information:

A1.1.1.1 Identification of the vessel by name and shipyard hull number, if applicable.

A1.1.1.2 Date, time, and location of the test.

A1.1.1.3 Inclining weight data.

(a) Type,
(b) Amount (number of units and weight of each),
(c) Certification,
(d) Method of handling (that is, sliding rail or crane), and
(e) Anticipated maximum angle of heel to each side.

A1.1.1.4 *Pendulums*—Approximate location and length. (If a shipyard/naval architect desires to substitute inclinometers or other measuring devices for one or two of the three required pendulums, prior approval must be obtained from the MSC. The MSC might require that the devices be used in addition to the pendulums on one or more inclining's to verify their accuracy before allowing actual substitution for a pendulum.)

A1.1.1.5 Approximate trim.

A1.1.1.6 Condition of tanks.

A1.1.1.7 Estimated weights to deduct, to complete, and to relocate to place the vessel in its true light ship condition.

A1.1.1.8 Detailed description of any computer software to be used to aid in calculations during the inclining.

A1.1.1.9 Name and phone number of the person responsible for conducting the test.

A1.2 Each of the test weights must be certified by a weigh master's document and a copy provided to the Coast Guard representative. For small vessels, capped drums, completely filled with water, may be used. In such cases, the weight should be verified in the presence of the Coast Guard representative using a recently calibrated scale.

A1.3 An estimate of work items that will be outstanding at the time of the stability test should be included as part of any test procedure submitted to the MSC. This is required so that the Coast Guard representative can advise the shipyard/naval architect if in their opinion the vessel will not be sufficiently complete to conduct the stability test and that it should be rescheduled. If the condition of the vessel is not accurately depicted in the test procedure and at the time of the stability test the Coast Guard witness considers that the vessel is in such condition that an accurate stability test cannot be conducted, the witness may refuse to accept the test and require that a test be conducted at a later date. If the combined aggregate total of the weight to add and remove, neglecting any tankage and essential personnel, exceeds 2.0 % of the light ship weight, the vessel may be consider not properly prepared and the survey may be postponed and/or the survey results may be rejected.

A1.4 Before departing the vessel, the person conducting the test and the Coast Guard representative should initial each sheet as an indication of their concurrence with the recorded data.

A1.5 A copy of the data should be forwarded to the MSC along with the stability test report.

A1.6 When completed, three copies of the stability test report should be submitted to the MSC for approval.

A1.7 The Coast Guard may alter or limit acceptance of any provision in this guide.

A1.8 When the American Bureau of Shipping is representing the Coast Guard during a stability test, the words, American Bureau of Shipping, should be substituted for the words, Coast Guard, and for the words, Marine Safety Center, in this annex.

A2. UNITED STATES NAVY (USN) VESSELS THE FOLLOWING ADDITIONAL REQUIREMENTS SHOULD BE FOLLOWED

A2.1 The inclining experiment should be performed in accordance with the requirements set forth in Naval Ship's Technical Manual, and as modified below. The stability test report should be prepared on the forms described in the above technical manual.

A2.2 Photographs of topside arrangements including weather decks is required to document topside installations. Photographs of each draft mark reading are also required.

A2.3 A comprehensive survey of all compartments, tanks, and voids is required to determine the weight and center of gravity (vertical, longitudinal, and transverse) of all consumable loads, including personnel, ammunition, provisions, general stores, and liquids.

A2.4 Inclining weights are moved transversely to produce at least two inclinations to port and two to starboard.

A2.5 Significant items of weight that are considered part of the lightship displacement but are subject to change or are readily removable are listed, as part of the report, by weight and center of gravity. These items include boats, armament, ballast, salvage gear, and yellow gear.

A2.6 The transverse center of gravity, TCG, must be determined for all ships.

A2.7 In presentation of incline results, incline plots are to be arranged such that the slope of the incline plot can be directly substituted into the *GM* equation as shown below.

$$GM_t = \left(\frac{slope}{W}\right) \quad \text{(A2.1)}$$

where slope of the line from the incline plot equals the (rise/run). Heeling moments must be on the ordinate and tangents must be on the abscissa. Fig. A2.1 gives an example of an acceptable plot.

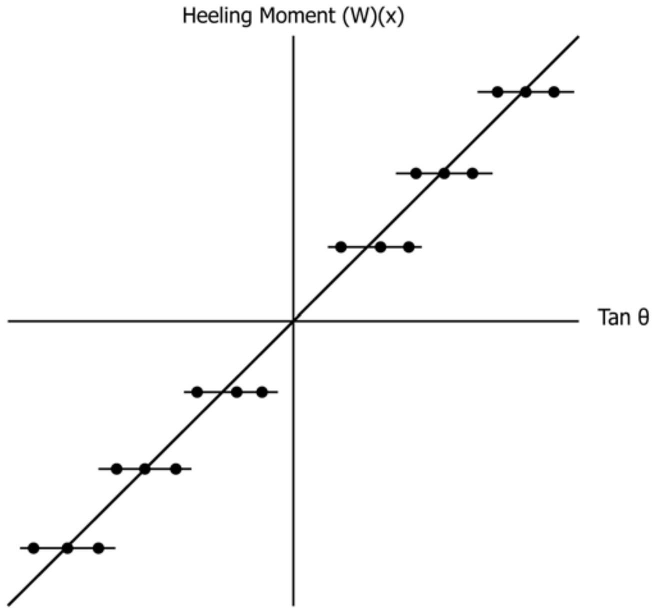


FIG. A2.1 Acceptable Orientation for Incline Plots on U.S. Navy Vessels

APPENDIXES

(Nonmandatory Information)

X1. STABILITY TEST CHECK LIST

X1.1 *Pre-Inclining*:

(1) ____ Boat is complete or nearly so.

(a) No major structural sections or major items of equipment to be added or removed.

(b) No tanks with liquids not shown in the air inclining procedure.

(c) No extraneous outfit on board the boat.

(2) ____ All empty tanks should be opened and checked for cleanliness. All tank levels should be recorded.

(3) ____ Weight certificates obtained or the weights used for the inclining actually weighed using certified scales.

(4) ____ Scales used to lift and weigh the boat are certified and have a minimum capacity of 5,000 lbs.

(5) ____ Initial angle of heel is less than 0.5 degrees and the trim is level and parallel to the forward and aft pick points.

X1.2 *Weight Movements*:

(1) ____ Pendulums:

(a) At least one (1) and can be located aft of the transom on a fabricated bracket assembly.

(b) Length of pendulum(s) is measured from the pivot point to the top of the batten.

(c) Fixed pendulum support so it cannot move during stability test.

(d) Thick liquid detergent in a bucket to dampen pendulum movements.

(2) ____ Water Tubes:

(a) At least three (3) and can be located anywhere long the unobstructed portion of the deck athwartships with sufficient overhang for personnel participating with the stability test can record deflections.

(b) Different colored dye added to each of the water tubes to allow for differential readings.

(c) Water tubes are free of any trapped air trapped bubbles.

(d) Water tubes are continuous, without kinks, and not in contact with the ground.

(3) ____ Digital Inclinometer:

(a) Located athwartships and in an unobstructed area easily viewed by personnel to record.

(4) ____ Battens:

(a) Pencil marks placed on battens to record the position of the deflections.

(b) In a fixed location so it cannot move during the stability test.

(c) Battens should never be reset once the air inclining begins and weight movements are being recorded.

(5) ____ Weights:

(a) Record initial position (vertical, transverse, longitudinal distances from the SRP).

(6) ____ Weight Movements:

(a) At least two to each side of the reference position.

(b) Deflections at maximum moment should be at least 6 in. to each side of the initial position.

(c) Maximum angle of heel should not be greater than 5 degrees. A typical angle of heel should be in the range of 1 and 4 degrees.

(d) Moment equals weight times distance moved; calculated and summed for all weights moved for each movement.

(e) Tangent equals deflections divided by length. All values must be in the same units (inches or feet).

(f) During the movement, ensure that:

(i) Deflection readings are not bottoming out or reading past their estimated deflection range.

(ii) For pendulums, there is no contact with the batten.

(g) Plot of moment-tangent curve:

(i) Plot each tangent value calculated for each weight movement. The average of all the deflection readings may be graphed instead of plotting each of the readings only if the tan θ values measured are consistent.

(ii) Plot must be a straight line but it doesn't have to pass through the origin.

(iii) Curved line indicates unaccounted free surface, unparalleled knife edges and baseline or the boat is touching another entity.

X1.3 *Post-Inclining*:

(1) ____ Check "B" to ensure that the knife-edge and baseline are parallel and that there is consistency with the initial measurements.

X1.4 *Survey of Items to Be Added, Removed or Relocated*:

(1) ____ Record weight, vertical, longitudinal and transverse centers of gravity (if required) for each item. Weights are more critical with smaller boats.

(2) ____ Typical weights to add:

(a) Any fuel found in tank(s).

(b) All and any required outfit items.

(3) ____ Typical weights to deduct:

(a) Inclining weights and deflection apparatus setups;

(b) All large and small shackles;

(c) Lifting straps;

(d) Master shackles;

(e) Water leveling bars;

(f) Clamps;

(g) Pendulums;

(h) Water tubes;

(i) Water in tubes;

(j) Rulers;

(k) Chain(s), if necessary;

(l) Weight containment basket(s), if necessary;

(m) If boat is fitted with a foam collar, protection for the collar;

(n) Any fuel and free surface corrections.

X2. SAMPLE DATA SHEETS

X2.1 Figs. X2.1-X2.6 are sample data sheets.

Stability Test Rough Data

Description of Vessel:

Name ______________________________

Type ______________________________

Builder ______________________________

Hull Number ______________________________

Vessel inclined at ______________________________

____

Date ____________ Time ____________

Test conducted by ______________________________

Test witnessed by ______________________________

Description of weather conditions ______________________________

____

Specific gravity of water ______________________________

Temperature of water ______________________________

Weights certified by:

Weigh master (certificate attached) ☐

Reviewing authority ☐

FIG. X2.1 Stability Test Rough Data

Items to be Added

Description	Weight	Vertical Center	Longitudinal Center	Transverse Center (if needed)

TANKS:

Description	Location	Sounding or Ullage	Specific Gravity/Density

FIG. X2.2 Items To Be Added

Items to be Removed

Description	Weight	Vertical Center	Longitudinal Center	Transverse Center (if needed)

TANKS:

Description	Location	Sounding or Ullage	Specific Gravity/Density

FIG. X2.3 Items To Be Removed

Items to be Relocated

			From			To	
Description	Weight	Vertical Center	Longitudinal Center	Transverse Center (if needed)	Vertical Center	Longitudinal Center	Transverse Center (if needed)

FIG. X2.4 Items To Be Relocated

Ship at Time of Stability Test—Condition 0

Pendulums No. Location	Length to Batten (Inches)		Weight No.	Weight (Tons)	Distance from Initial Positions Port (Feet)	Distance from Initial Positions Starboard (Feet)	Moment (Ft-Tons)	Total Inclining Moment Port (Ft-Tons)	Total Inclining Moment Starboard (Ft-Tons)	Pendulum Deflections No.	Pendulum Deflections Port (Inches)	Pendulum Deflections Starboard (Inches)	Tangents Port	Tangents Starboard
1st		1st Trial								1st / 2d / 3d				
2d		2d Trial								1st / 2d / 3d				
3d		3d Trial								1st / 2d / 3d				
		4th Trial								1st / 2d / 3d				
		5th Trial								1st / 2d / 3d				
		6th Trial								1st / 2d / 3d				
		7th Trial								1st / 2d / 3d				
		8th Trial								1st / 2d / 3d				

Inclining Weights

Location ______________

Description ______________

Weight No.	Tons	Initial Position Port (Feet)	Initial Position Starboard (Feet)

FIG. X2.5 Condition 0—Preliminary Report

STABILITY TEST..

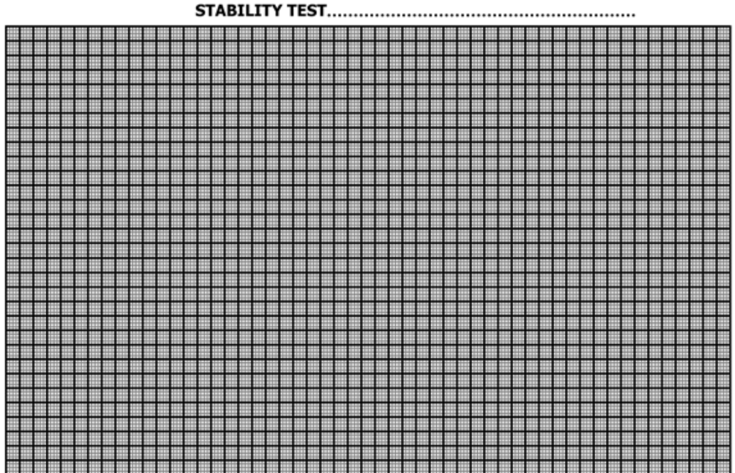


FIG. X2.6 Stability Test Graph—Preliminary Results