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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

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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.

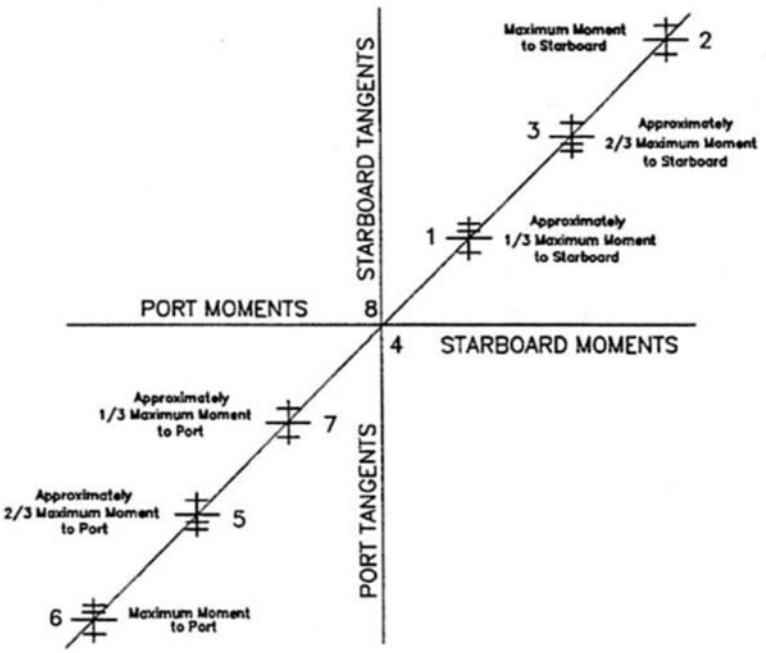

FIG. 1 Typical Incline Plot

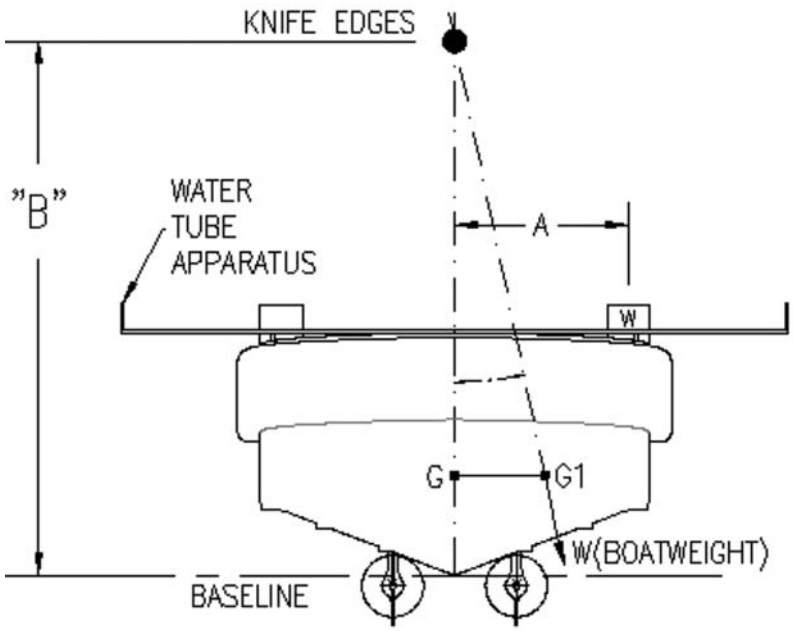

FIG. 2 Measurement of KM, GM & KG

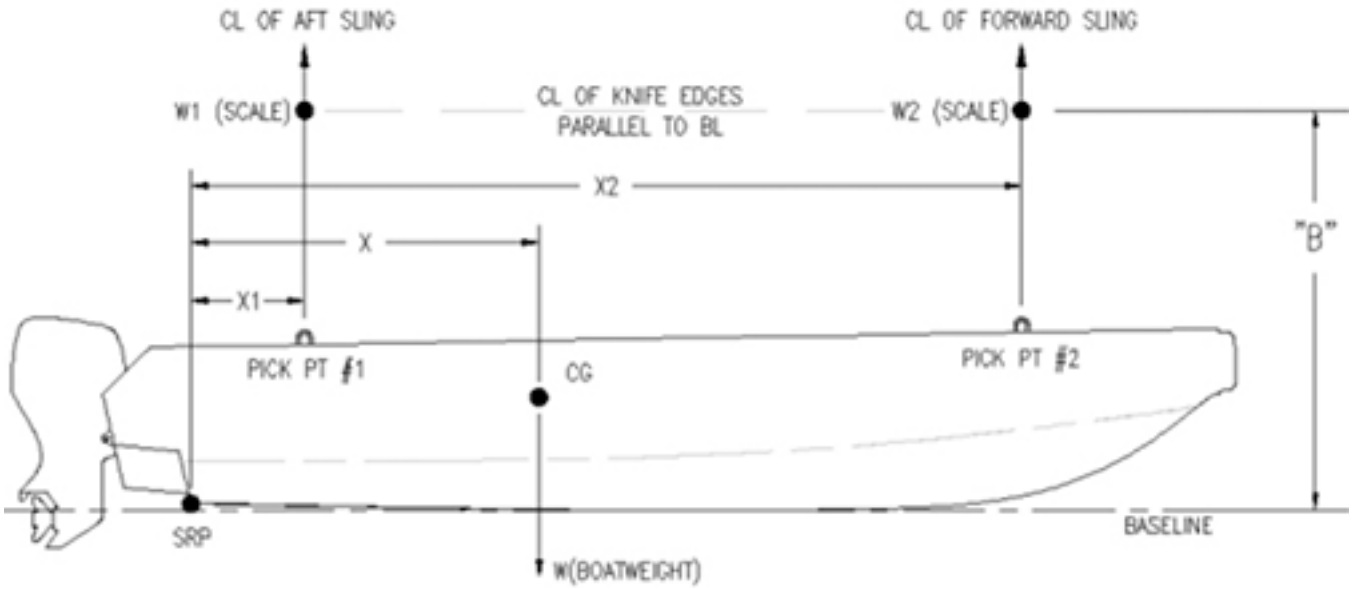

FIG. 3 Relationships of Pick Points and Center of Gravity

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