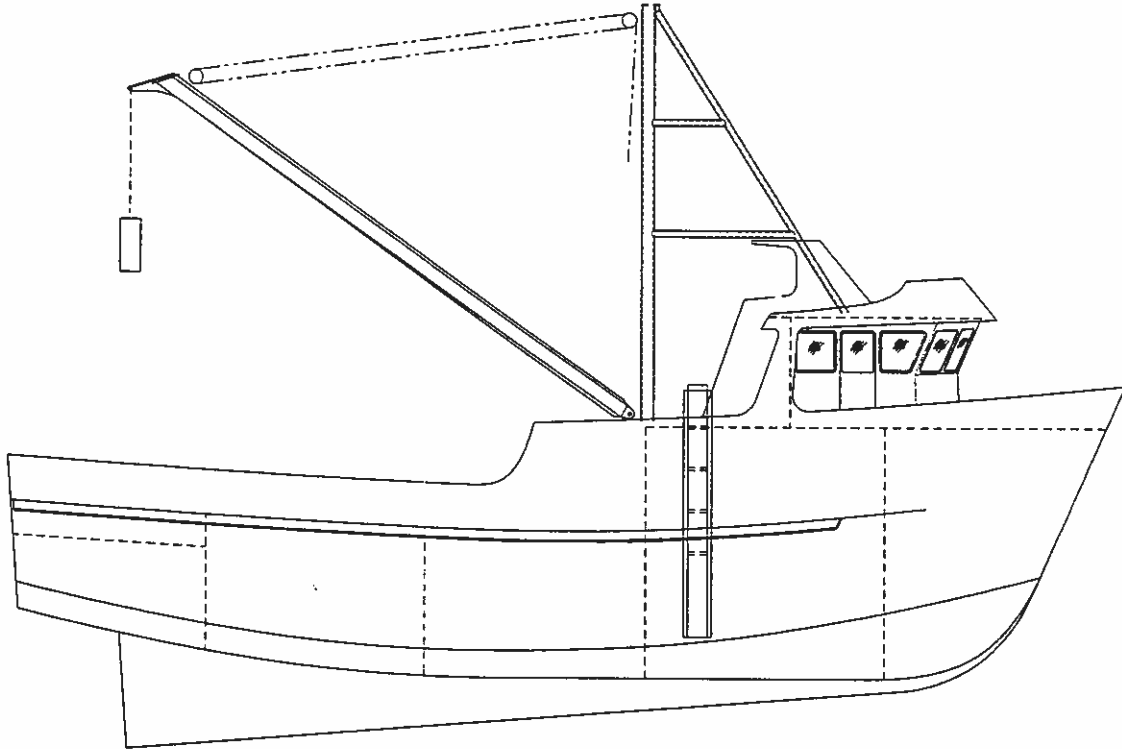


U.S. COAST GUARD INTERACTIVE STABILITY TRAINER
OPERATOR'S MANUAL FOR THE "S.S. SPADE"



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1.0 INTRODUCTION

1.1 General

The Safety and Stability (S.S.) Admiral Class fishing vessel models were developed to educate fishermen, Coast Guard personnel, small industry vessel operators and recreational boaters on the effects of operational decisions on the stability of their vessels. To that end, this document is provided for instruction and reference purposes on using one such model, the USCG Interactive Stability Trainer “S.S. Spade”, to demonstrate various aspects of ship’s stability.

Vessels corresponding to the full scale size of the “Spade” comprise a fleet of nearly 100,000 fishing vessels that are not subject to USCG inspection. Therefore, as an alternative method of promoting safe practices at sea, the USCG will use the “Spade” model, built to 1/16th scale, to provide practical demonstrations of stability to owners and users of similar size fishing vessels. Additionally, results of computer modeling of the full scale “Spade” will complement the “hands-on” model scale demonstrations.

The complete training package contains the following:

- The fishing vessel model, “S.S. Spade”;
- A fiberglass water tank used for demonstration of the model;
- A “waterbed” pump used for pumping water to or from the model’s compartments;
- 2 inclining weights, and;
- 1 lifting weight.

1.2 How to Use This Manual

This manual is divided several key sections, as described below.

Section 2 enables the operator(s) to familiarize themselves with the model itself by presenting a sketch of the “Spade” model, general particulars and full scale equivalents, and a description of the key systems.

Section 3 presents introductory information on inclining the “Spade”, deriving various loading conditions, and demonstrating the vessel against selected criteria, such as “water on deck”, and flooding of the engine room.

Appendix A gives hydrostatic data at various levels of trim, as well as tank capacities of the forward and aft cargo holds.

Appendix B presents full scale stability results for six different stability criteria.

Appendix C gives detailed information on how to incline the “Spade”

2.0 DESCRIPTION

2.1 Vessel Configuration

A sketch of the vessel configuration is presented in Figure 1. The model features the following:

- 4 cargo holds, 2 port and 2 starboard, with a removable centerline (CL) bulkhead and removable hatch covers. The CL bulkhead is used to illustrate the “free surface” effect, as will be explained further on;
- A flooding system, pump included, used to pump water to or from the cargo holds and the engine room. Water in the holds is used to simulate fish cargo, while water in the engine room is used to simulate flooding;
- 2 VCG weights, adjusted vertically in order to alter the vertical center of gravity (VCG);
- A lifting system consisting of a boom and one 9-oz weight, used for lifting weight over the side;
- 2 inclining weights, weighing 9-oz each, used to determine the model’s metacentric height (GM).

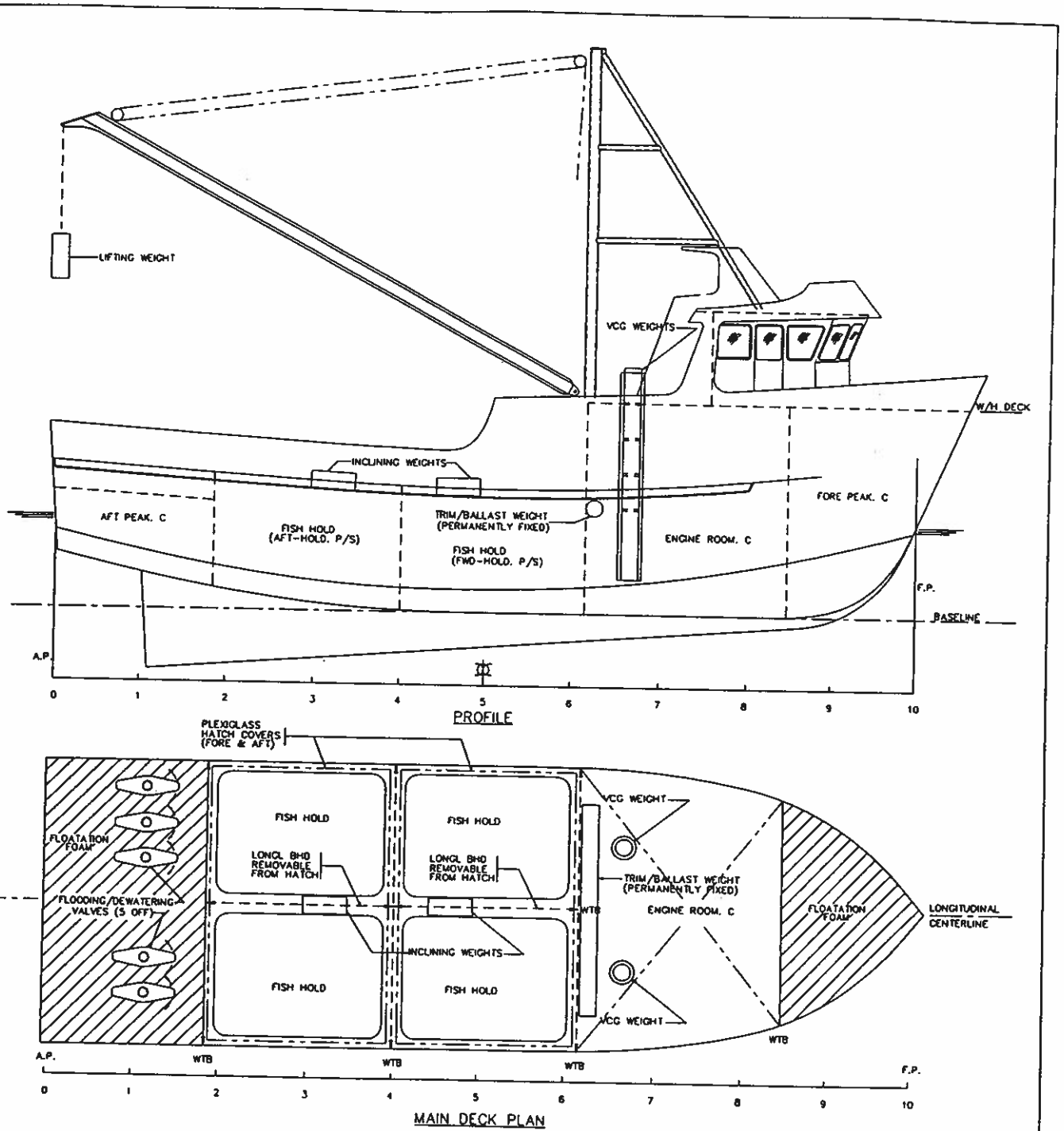
2.2 General Particulars

The general particulars of the vessel, along with its full scale equivalents, are presented in Table 1 below.

Table 1 – General Particulars of Model

| Item | Model Scale | To Convert from Model Scale Value to Full scale Value, Multiply by: | Full scale |
|---|------------------|---|-------------------|
| Length over All (LOA) | 4.42 [Ft] | 16 | 70.69 |
| Length Between Perpendiculars (LBP) | 4.06 [Ft] | 16 | 65.00 |
| Beam (Maximum) | 1.34 [Ft] | 16 | 21.50 |
| Design Draft | 0.54 [Ft] | 16 | 8.61 |
| Displacement | 42.72 [Lbs] | 1.8286 | 78.11 [L.Tons] |
| Longitudinal Center of Gravity (LCG) – Distance Aft of Forward Perpendicular (FP) | 1.77 [Ft] | 16 | 28.32 [Ft] |
| Transverse Center of Gravity (TCG) – Distance off Centerline (CL) | 0.00 [Ft] | 16 | 0.00 [Ft] |
| Vertical Center of Gravity (VCG) - Distance Above Baseline (BL) | 0.68 [Ft] | 16 | 10.88 [Ft] |
| VCG Weights – Used to Alter the Vertical Center of Gravity (VCG) of the Vessel | | | |
| Weight (Quantity =2) | 2 x 2.625 [Lbs] | 1.8286 | 2 x 4.80 [L.Tons] |
| LCG – Distance Aft of FP | 1.344 [Ft] | 16 | 21.50 [Ft] |
| TCG – Distance off CL | 0.00 [Ft] | 16 | 0.00 [Ft] |
| VCG Weights – Vertical Center of Gravity (VCG) Distance Above Baseline (BL) – 5 Positions Available | | | |
| Position 0 | 8.0 [In] | 1.3333 | 10.67 [Ft] |
| Position 1 | 9.75 [In] | 1.3333 | 13.00 [Ft] |
| Position 2 | 11.75 [In] | 1.3333 | 15.67 [Ft] |
| Position 3 | 13.75 [In] | 1.3333 | 18.33 [Ft] |
| Position 4 | 15.75 [In] | 1.3333 | 21.00 [Ft] |
| Note: “Position 0” corresponds to the pin being removed and the weight resting on the bottom of its enclosure. | | | |
| Lifting Weight | | | |
| Lifting Weight Attached to Boom | 0.5625 [Lbs] | 1.8286 | 1.03 [L.Ton] |
| Boom Length | 33.3 [In] | 1.3333 | 44.4 [Ft] |
| Inclining Weight | | | |
| Weight = 9 oz (Quantity = 2) | 2 x 0.5313 [Lbs] | 1.8286 | 2 x 0.971 [L.Ton] |

Figure 1



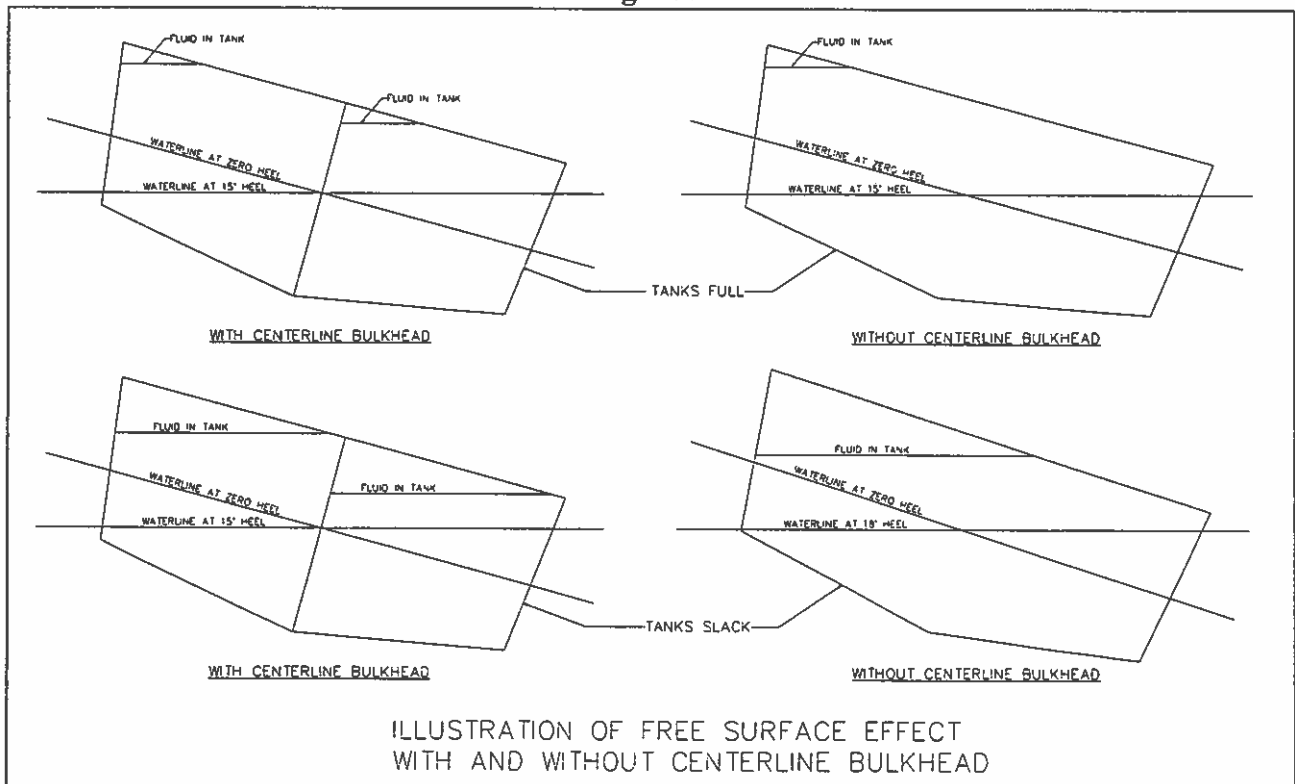
VESSEL CONFIGURATION

(REMOVE INCLINING WTS FOLLOWING INCLINING OF VESSEL)
 (USE LIFTING WT ONLY FOR "LIFTING OVER THE SIDE" DEMONSTRATION)
 (LOCATION OF TRIM/BALLAST WEIGHT MAY VARY IN SOME MODELS)

2.3 Free Surface Effects in the Holds (With and Without Centerline Bulkhead)

Referring to the vessel configuration in Figure 1, it can be seen that the centerline bulkhead creates 4 cargo holds, while its removal reduces that number to 2. Essentially, a hold without a centerline bulkhead allows more fluid in a slack cargo hold to move to one side when the vessel is heeled, as opposed to the case where the vessel has a centerline bulkhead installed. As a result, for the case of no centerline bulkhead, the additional transfer of fluid to one side will cause the model to heel even more, thereby reducing its stability. This free surface effect can be seen in the illustration below, Figure 2. For the slack tanks (bottom pair), more fluid is allowed to move to one side of the vessel when the centerline bulkhead has been removed, causing a slight increase in heel angle. Alternatively, for the nearly full tanks (top pair), the heel angle is the same with or without the centerline bulkhead. These differences will be evident when analyzing the stability criteria listed in the next section.

Figure 2



2.4 Flooding System

The flooding system configuration is presented in Figure 3 below, while photographs of the system are presented in Figures 4 and 5. The flooding system is used to fill the cargo holds and engine room. Filling the cargo holds simulates the cargo of fish, while filling the engine room simulates damage to that compartment. Connecting the flooding system manifold to a hose from a municipal water supply fills these spaces. The pump, mounted to the side of the fiberglass tank, can be used to drain the holds and engine room. The pump can also be used for filling, if required.

Figure 3 – Flooding System

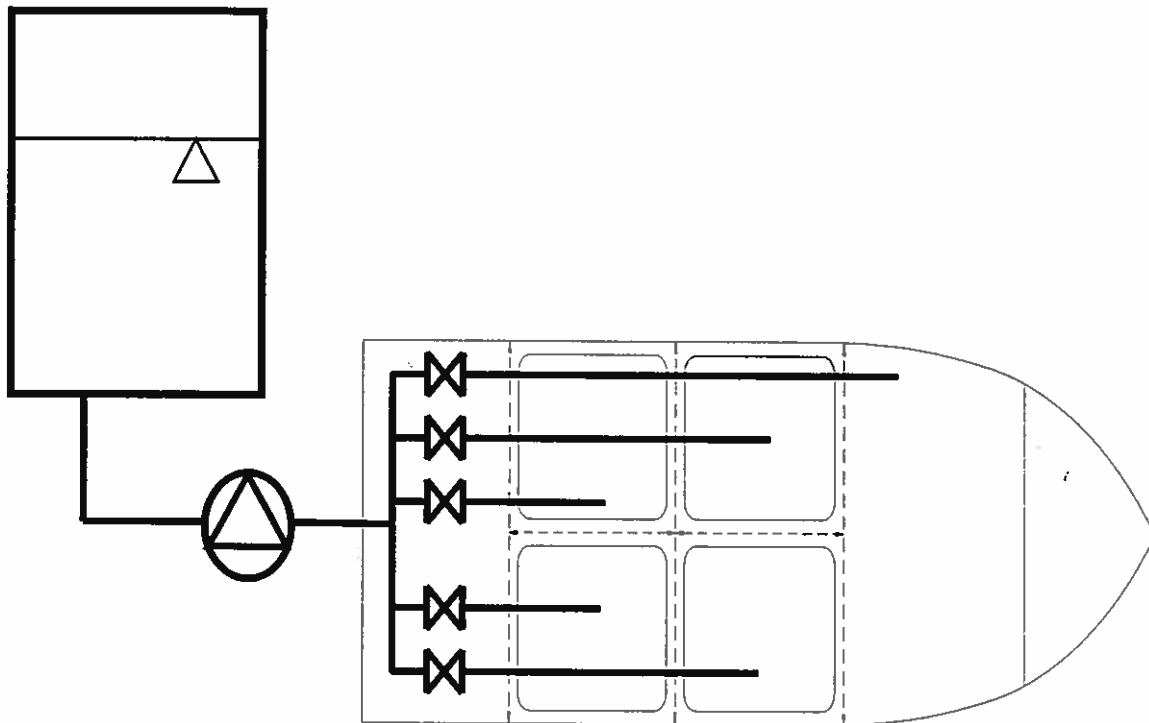


Figure 4 – Flooding System Manifold

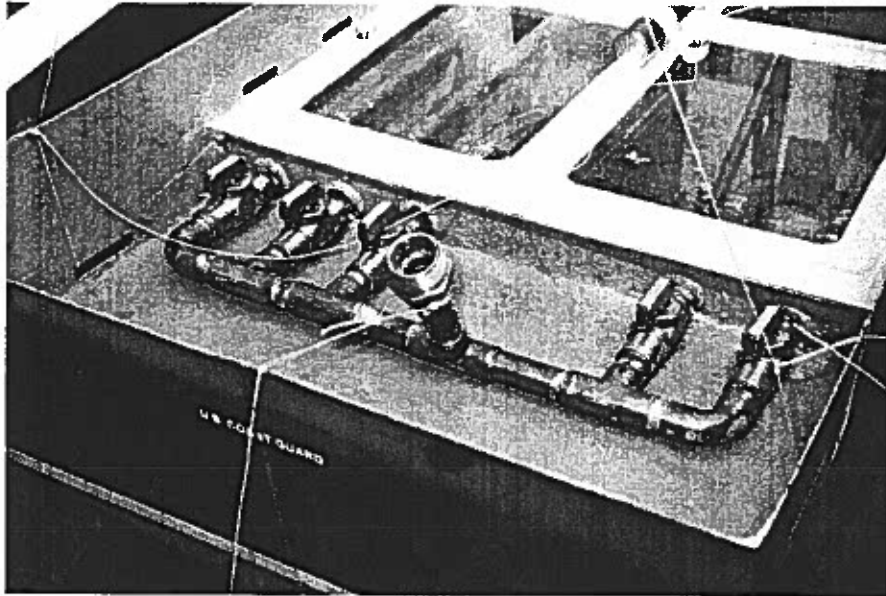
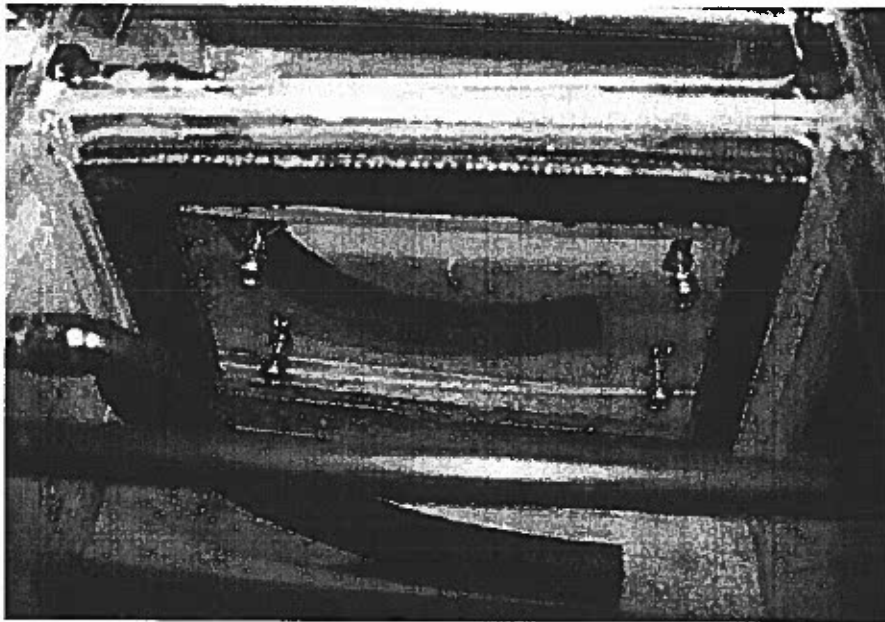


Figure 5 – Hold Flooding System



2.5 VCG Weights

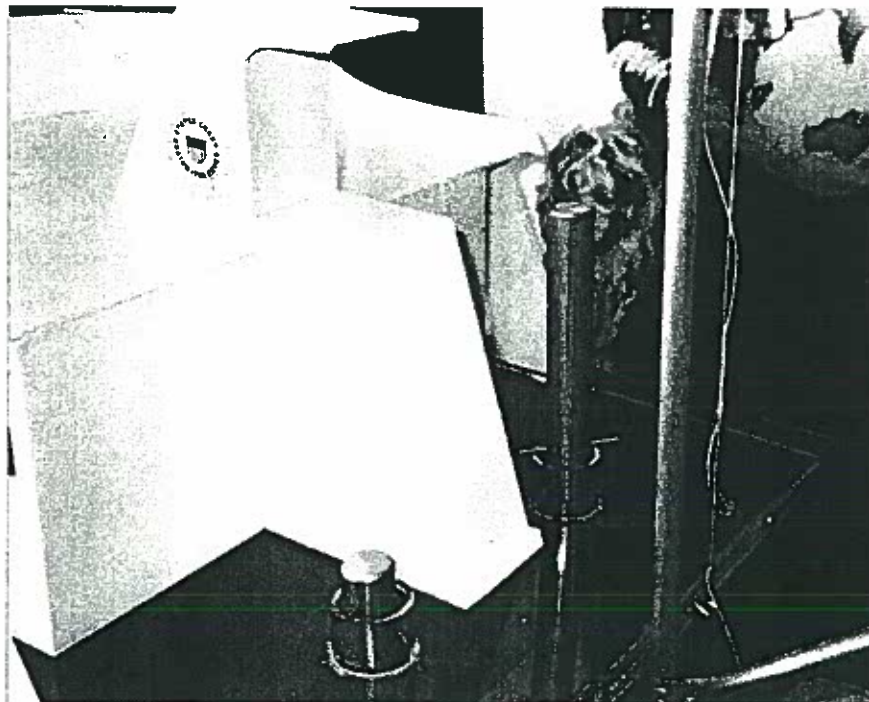
The 2 VCG weights can be adjusted vertically to increase or decrease the vertical center of gravity (VCG) of the vessel. Increasing the VCG makes the vessel unstable or “tipsy”. One characteristic of an unstable vessel can be observed when the vessel rolls. The more unstable the vessel, the longer it will take for the vessel to roll back to its upright position.

The VCG weights are housed in plastic tubes, and are situated on the aft end of the wheelhouse deck. These weights can be moved to 5 different positions. In their lowest position, “Position 0”, the weights are resting on the bottom of the plastic tube. For the 4 higher positions, each weight has 4 drilled holes, to which a pin is inserted in order to maintain the higher position. Some examples of full scale VCG increases are depicted in Table 2 below. A photograph of the VCG weights is presented in Figure 6 below.

Table 2 – Sample Causes of VCG Increases

| Position of VCG Weights | Weight Shift or Addition | Sample Causes of VCG Increases |
|-------------------------|---|--|
| Position 0 | N/A | <ul style="list-style-type: none"> • Standard Configuration |
| Position 1 | 3.5 Long tons | <ul style="list-style-type: none"> • Movement of crab pots from hold to main deck |
| Position 2 | 5.5 Long tons | <ul style="list-style-type: none"> • Movement of net from hold to drum |
| Position 3 | 5.5 Long tons + 1 Long tons + 4.5 Long Tons | <ul style="list-style-type: none"> • Movement of net from hold to drum, plus • Movement of equipment from hold to wheelhouse deck, plus • Icing of vessel, 1 inch thickness |
| Position 4 | 5.5 Long tons + 1 Long tons + 4.5 Long Tons | <ul style="list-style-type: none"> • Movement of net from hold to 7 Ft above main deck, plus • Movement of equipment from hold to wheelhouse deck, plus • Icing of vessel, 1 inch thickness |

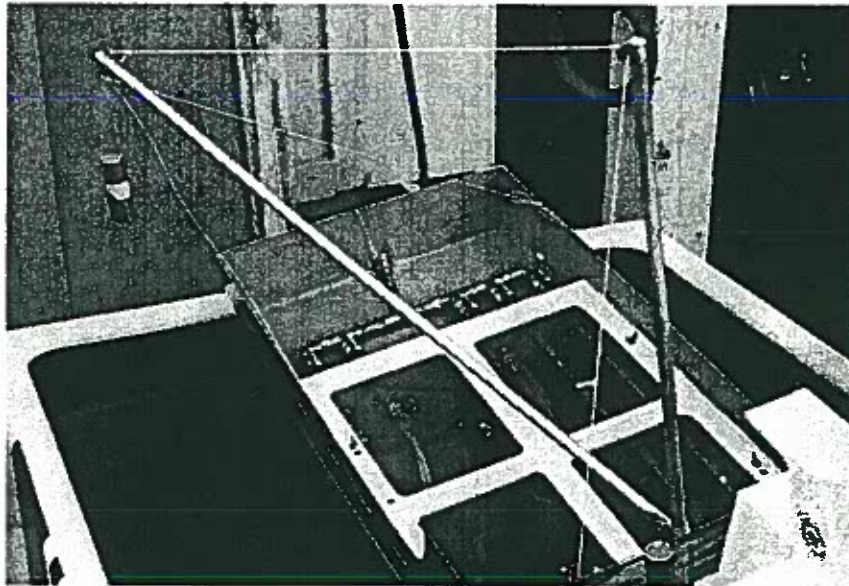
Figure 6 – VCG Weights



2.6 Lifting System

The vessel's boom is used for lifting a weight over the side. The end of the boom has a hook for attaching a weight, while its position is fixed by attaching 2 strings to the end of the boom. The strings are tied at the other ends to cleats on the deck, that is, wing nuts for securing the cargo hatches, which will double as cleats for securing the boom. Loosening the wing nuts, wrapping the strings around the screws that the wing nuts are attached to, and then re-tightening the wing nuts, secures the string. A photograph of the lifting system is presented in Figure 7.

Figure 7 – Lifting System



2.7 Inclining Weights

The inclining weights are used to incline the vessel, that is, to determine the vessel's metacentric height (GM). This is basically an intermediate step that is required to determine the vessel's vertical center of gravity (VCG). Once determined, the VCG is used to derive all of the various loading conditions, such as full cargo and half cargo.

Additional information on inclining the vessel to determine the GM is presented in Section 3. Inclining results and step by step instructions for repeating the procedure are presented in Appendix C.

3.0 OPERATING INSTRUCTIONS

3.1 General

Various aspects of ship's stability will be demonstrated by carrying out the following tasks:

- Inclining the "Spade";
- Deriving the loading conditions, and;
- Demonstrating the "Spade" in accordance with selected stability criteria.

3.2 Inclining the "Spade"

As mentioned earlier, the inclining of the "Spade" is carried out in order to determine the vessel's GM, and subsequently, its VCG. This has already been done for the "Spade", and the results are presented in Appendix C. Step by step instructions are also presented in Appendix C so that operators can repeat the inclining, and hence verify the results. The instructions have been prepared assuming that the operator understands some of the underlying principles associated with this task.

3.3 Loading Conditions

There are 4 loading conditions, derived by filling the 4 cargo holds with water, in the manner described in Table 3 below. The operators will have to use their judgment in estimating the percentage loading. Nonetheless, minor variations from the values described below will not significantly affect the expected results.

Table 3 – Description of Loading Conditions

| Loading Condition | Aft Holds (% Loading) | Fwd Holds (% Loading) |
|-------------------------------------|------------------------------|------------------------------|
| 1. Full Load | 98 | 98 |
| 2. 50% Load (w/ Small Free Surface) | 10 | 98 |
| 3. 50% Load (w/ Large Free Surface) | 50 | 50 |
| 4. 5% Load | 0 | 10 |

By combining the 4 conditions above with the 5 positions of the VCG weights, a total of 20 different loading conditions can be demonstrated at model scale. Additionally, the 20 conditions are analyzed in 2 ways, with and without the presence of the centerline bulkhead. All of these conditions will be used to observe the vessel's stability characteristics in accordance with the stability criteria of Section 3.3 below.

In order to have significant free surface, the tanks would require loading similar to Loading Condition 3 of Table 3 above, that is, all holds only partially loaded. Although a prudent operator would never load a vessel in this manner, it is only included here to demonstrate the effects of an extreme free surface.

3.4 Demonstrating the “Spade” in Accordance with Selected Stability Criteria

In order to validate model-scale demonstrations of ship’s stability, the full scale (actual size) “Spade” has been computer modeled and its stability characteristics analyzed and assessed against applicable U.S. Coast Guard stability regulations. As noted earlier, the “Spade” does not have to comply with these regulations. However, comparison with them provides a relative method of assessing the vessel’s survivability under various loading and environmental conditions. Additionally, the full scale data provides a means of determining how realistic a model scale loading condition is, and, enables USCG personnel to predict the model scale stability characteristics in advance of conducting the demonstration.

Full scale analysis also includes additional stability criteria, which cannot be readily demonstrated at model scale. Thus, the range of stability criteria to be demonstrated, whether at model-scale, full scale, or both, are presented in Table 4 below.

Table 4 – Stability Criteria at Model and Full Scale

| Stability Criterion and Applicable U.S. Coast Guard Regulation | Model Scale [Yes/No] | Computerized Full scale [Yes/No] |
|---|-----------------------------|---|
| 1. Intact Righting Energy – 46 CFR 28.570 | No | Yes |
| 2. Severe Wind and Roll – 46 CFR 28.575 | No | Yes |
| 3. Water on Deck – 46 CFR 28.565 | Yes | Yes |
| 4. Lifting of Heavy Weights over the Side - 46 CFR 28.545 | Yes | Yes |
| 5. Unintentional Flooding (Damage to ER) - 46 CFR 28.580 | Yes | Yes |
| 6. Unintentional Flooding (Damage to Lazerette) - 46 CFR 28.580 | No | Yes |

It is noted that icing of the vessel, in accordance with 46 CFR 28.550, is not included in the above list. Since the analysis of icing entails increasing the weight and vertical center of gravity (VCG) of each loading condition, this criterion is implicitly included in the range of displacements and VCG’s used in this analysis.

It is further noted that flooding of the model’s lazerette is not possible, since that compartment is filled with foam. However, full scale computer modeling of this scenario was completed.

A description of each stability criterion and discussion on expected results are presented below. Full scale results are presented in Appendix B.

1. Intact Righting Energy – 46 CFR 28.570 (Full Scale Only)

This criterion requires a vessel to have a righting arm curve that exhibits minimum values in terms of righting energy (area under the curve), righting lever, and minimum GM.

Referring to Appendix B, it can be seen that the two “50% Load” cases exhibit the best stability characteristics, while the “5% Load” cases exhibit the worst. However, these results are opposite to what one would expect, since one of the “50% Load” cases has significantly more free surface than both the “5%” and “Full Load” cases. Therefore, a more detailed explanation of the results is presented below.

The relative magnitude of the stability characteristics for Loading Conditions 1 (Full Load), 2 and 3 (50% Load), and 4 (10% Load) are best explained by presenting some of the intermediate stability characteristics used in determining the final values. These are presented in Table 5 below.

Table 5

| Loading Condition (VCG Wt in Pos'n 0) | Mean Draft [Ft] | Trim [Ft] | GM [Ft] | KM [Ft] | KG (VCG) [Ft] | Free Surface @0°[Ft] | Free Surface @15°[Ft] | Free Surface @30°[Ft] |
|---|-----------------------|--------------|------------|------------|---------------------|----------------------------|-----------------------------|-----------------------------|
| 1 – Full Load | 7.91 | 1.01 Aft | 2.39 | 10.44 | 7.35 | 0.70 | 0.03 | 0.01 |
| 2 – 50% Load (Small FSM) | 6.25 | 3.38 Fwd | 2.40 | 10.85 | 7.82 | 0.63 | 0.30 | 0.18 |
| 3 – 50% Load (Large FSM) | 6.04 | 0.52 Fwd | 2.96 | 11.22 | 7.26 | 1.00 | 1.11 | 1.55 |
| 4 - 10% Load | 4.26 | 3.72 Fwd | 1.58 | 12.30 | 10.05 | 0.67 | 0.54 | 0.29 |
| GM = KM – KG(VCG) – Free Surface @0° | | | | | | | | |

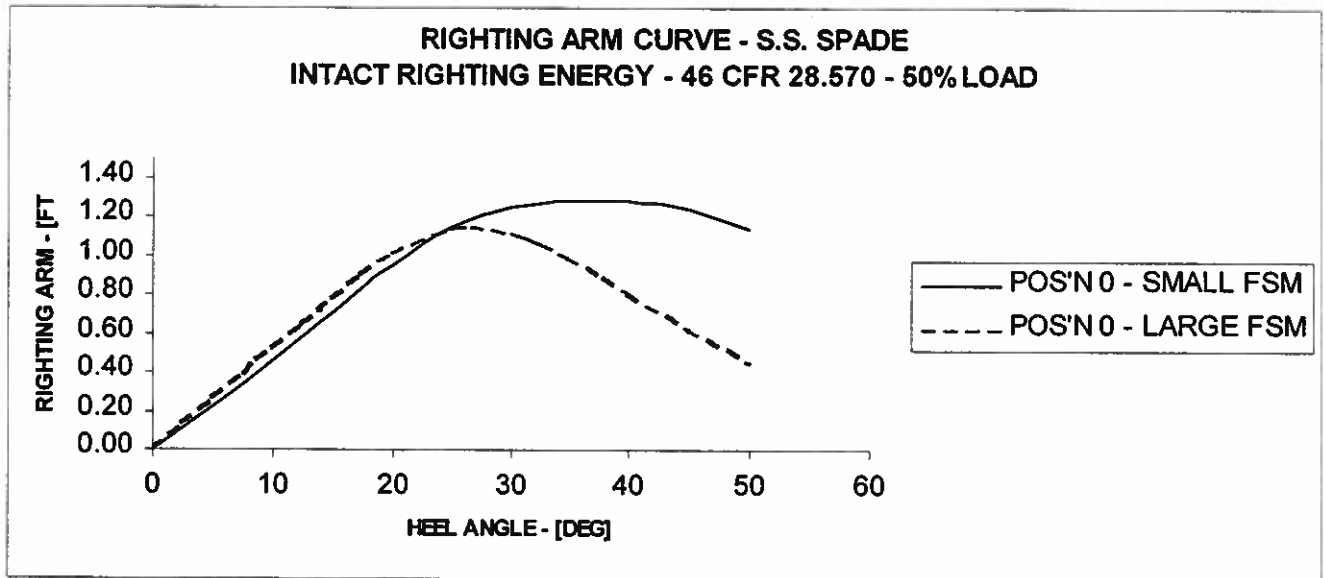
Using the formula in Table 5 above to derive GM, it can be seen that a vessel’s stability (GM) increases as the KM increases, the VCG decreases, and as the Free Surface decreases. For example, even though Loading Condition 3 has a worse free surface than Condition 1, its values for KM and VCG are better, thereby resulting in a larger GM. Again, it is noted that Condition 3 is not a prudent method of loading the vessel.

The same comparison as above, also applies between Conditions 3 and 2, where a better KM and VCG cause Condition 3 to have a higher GM than Condition 2. However, referring to their righting arm curves in Appendix B, Condition 2 has better stability characteristics at higher angles of heel. This is because, per Table 5 above, at higher angles of heel, Condition 3, with all holds loaded to 50%, has increased free surface. Condition 2, with two of the four holds loaded to 98%, has a reduction in its free surface. A comparison of the righting arm curves for Conditions 2 and 3 in Table 5 is presented in Figure 8 below.

Comparison between Conditions 3 and 4 yield the following results. Condition 3 has a worse KM and free surface, but a much lower VCG. The combination of all three results in Condition 3 having better stability characteristics than Condition 4.

Again referring to Appendix B, it can also be seen that when comparing the cases with and without a centerline (CL) bulkhead, the “50% Load” case with the large free surface, Condition 3, causes capsize when the CL bulkhead has been removed.

Figure 8



2. Severe Wind and Roll – 46 CFR 28.575 (Full Scale Only)

The vessel is expected to have sufficient righting energy to overcome the heeling moment produced by the action of the wind on the vessel’s “sail area”. It must also have sufficient energy to absorb a rolling motion caused by wave action.

By referring to the full scale results of this criterion in Appendix B, the stability of the Load Conditions can be rated as, from best to worst:

1. Load Condition 2, “50% Load (Small FSM)”;
2. Load Condition 3, “50% Load (Large FSM)”;
3. Load Condition 1, “Full Load”;
4. Load Condition 4, “5% Load”, capsizes.

This trend is similar to the explanation in the first criterion, “Intact Righting Energy – 46 CFR 28.570”. It is noted that Condition 4 has a larger wind force as a result of its excess freeboard.

3. Water on Deck – 46 CFR 28.565 (Model and Full Scale)

This criterion illustrates the effect of water trapped in the deck well. It can be illustrated by filling the deck well with water until it starts to run off. It is noted that in order to fill the deck well the freeing ports need to be plugged, perhaps with heavy tape that can easily be removed following the demonstration.

By referring to the full scale results of this criterion in Appendix B, the stability of the Load Conditions can be rated as, from best to worst:

1. Load Condition 2, “50% Load (Small FSM)”;
2. Load Condition 4, “5% Load”, capsizes;
3. Load Condition 3, “50% Load (Large FSM)”, capsizes;
4. Load Condition 1, “Full Load”, capsizes.

In the computer simulation, the amount of water that accumulates in the deck well is defined by the boundaries of the deck well, and, a horizontal plane that cuts through the lowest point on the deck well’s bulwark. The lowest point on the bulwark is located immediately aft of the foc’sle deck. From that point and proceeding aft, the height of the bulwark gradually increases. Therefore, the accumulation of water on deck is maximized when the forward trim is minimal. Consequently, capsize occurs for Loading Conditions 1 (Full Load) and 3 (50% Load, Large FSM) because these two conditions, which both have aft trim, take on a large amount of water, 68 tons and 57 tons respectively. Conditions 2 and 4, which both have forward trim, take on about the same amount of water, 37 tons and 35 tons respectively. However, because Condition 4 has less GM than Condition 2, its stability characteristics with water on deck are significantly reduced, resulting in capsize.

For Condition 2, the angles of loll occur at about 12 to 13°.

4. Lifting of Heavy Weights over the Side – 46 CFR 28.545 (Model and Full Scale)

This criterion can be illustrated by attaching the lifting weight to the boom, thereby imposing a heeling moment upon the vessel, as well as raising the vessel’s VCG. As mentioned previously, the wing nuts used to secure the cargo hatches are also designed to act as cleats, to which the boom’s strings are secured.

The heeling moment is defined as the product of the attached weight and the horizontal distance between the weight and the longitudinal centerline (See Figure 9). That is,

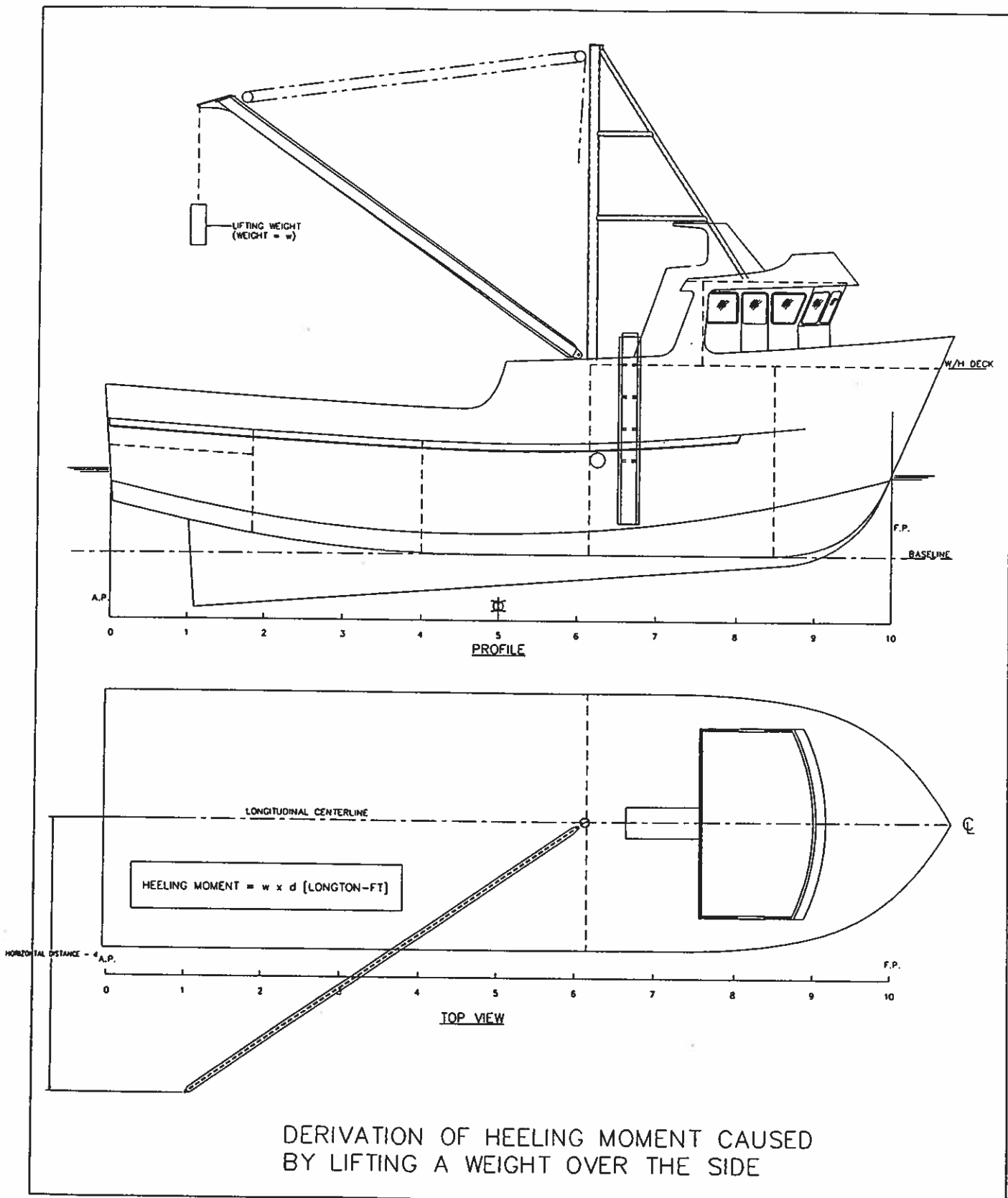
$$HM = w d,$$

where: HM = imposed heeling moment [LT-Ft];

w = suspended weight [LT];

d = projected horizontal distance (lever arm), perpendicular to longitudinal centerline [Ft].

Figure 9



The heeling moment used in the analysis of the full size “Spade” is about 24 LT-Ft. It corresponds, approximately, to the configuration in Figure 9, and was derived with a lever arm of 23.0 feet and a weight of 1.03 LT. Other combinations of weight and distance can be used. For the full scale loading conditions depicted in Appendix B, the vessel exhibits heel angles between 3 and 12°. It is noted that 46 CFR 28.545 limits the heel angle to 10°.

By referring to the full scale results of this criterion in Appendix B, the stability of the Load Conditions can be rated as, from best to worst:

1. Load Condition 2, “50% Load (Small FSM)”;
2. Load Condition 3, “50% Load (Large FSM)”;
3. Load Condition 1, “Full Load”;
4. Load Condition 4, “5% Load” (Capsizes at higher VCG weight settings).

This trend is similar to the explanation in the first criterion, “Intact Righting Energy – 46 CFR 28.570”.

5. Unintentional Flooding (Damage to Engine Room) – 46 CFR 28.580 (Model and Full Scale)

This criterion is illustrated by using the flooding system to fill the engine room with water, or by progressive flooding through the sluice hole in the after engine room bulkhead. In order to comply, the vessel must exhibit a minimum allowable righting arm and range of stability, as well as a maximum allowable equilibrium heel angle.

By referring to the full scale results of this criterion in Appendix B, the stability of the Load Conditions can be rated as, from best to worst:

1. Load Condition 2, “50% Load (Small FSM)”;
2. Load Condition 3, “50% Load (Large FSM)”;
3. Load Condition 1, “Full Load”;
4. Load Condition 4, “5% Load” (Capsizes at higher VCG weight settings).

This trend is similar to the explanation in the first criterion, “Intact Righting Energy – 46 CFR 28.570”.

It is also noted that removal of the centerline (CL) bulkhead for the case of Load Condition 3, “50% Load (Large FSM)”, causes capsize, even though the same case with the CL bulkhead installed exhibits stability characteristics in excess of the minimum requirements.

6. Unintentional Flooding (Damage to Lazerette) – 46 CFR 28.580 (Full Scale Only)

This criterion is computer modeled at full scale only by damaging the lazerette, thereby allowing it to flood. The vessel must comply with the requirements of Stability Criteria No.5 above.

For comparison purposes, intact hydrostatic properties for the four Load Conditions analyzed are presented in Table 6.

Table 6

| Loading Condition (VCG Wt in Pos'n 0) | Mean Draft [Ft] | Trim [Ft] | GM [Ft] | KM [Ft] | KG (VCG) [Ft] | Free Surface @0°[Ft] | Free Surface @15°[Ft] | Free Surface @30°[Ft] |
|---|-----------------------|--------------|------------|------------|---------------------|----------------------------|-----------------------------|-----------------------------|
| 1 – Full Load | | | | | | | | |
| | CAPSIZE | | | | | | | |
| 2 – 50% Load (Small FSM) | 6.79 | 0.23 Fwd | 1.33 | 9.98 | 7.82 | 0.83 | 0.30 | 0.16 |
| 3 – 50% Load (Large FSM) | 6.60 | 5.13 Aft | 1.77 | 10.04 | 7.27 | 1.00 | 1.12 | 1.57 |
| 4 – 10% Load | 4.33 | 3.53 Fwd | 1.55 | 12.28 | 10.05 | 0.68 | 0.55 | 0.28 |
| GM = KM – KG(VCG) – Free Surface @0° | | | | | | | | |

By referring to the full scale results of this criterion in Appendix B, the stability of the Load Conditions can be rated as, from best to worst:

1. Load Condition 2, “50% Load (Small FSM)”;
2. Load Condition 3, “50% Load (Large FSM)”;
5. Load Condition 4, “5% Load”;
6. Load Condition 1, “Full Load”, capsizes.

By contrast, for Stability Criteria No’s 1 (Intact Righting Energy), 2 (Severe Wind and Roll), 4 (Lifting Over the Side) and 5 (Damage to Engine Room), the order, from best to worst, is: Load Condition 2, 3, 1 and 4. Thus, Load Condition 4 has moved from fourth place for the other criteria to third place for this criterion. This is because Condition 1, which had an initial aft trim of 1.01 feet, experienced even more aft trim following damage to the lazerette, thereby lowering its KM enough to cause capsize.

It is also noted that removal of the centerline (CL) bulkhead for the case of Load Condition 3, “50% Load (Large FSM)”, causes capsize.

APPENDIX A

HYDROSTATIC TABLES AND TANK CAPACITIES – SHIP SCALE

HYDROSTATIC PROPERTIES
Trim: Fwd 4.00/65.00, No Heel, VCG = 0.00

| LCF | Displacement | Buoyancy-Ctr. | | Weight/ | Moment/ | | | |
|-------|--------------|---------------|------|---------|---------|---------|------|-------|
| Draft | Weight (LT) | LCB | VCB | Inch | LCF | IN trim | KML | KMT |
| 5.000 | 100.45 | 28.58a | 3.08 | 2.41 | 31.81a | 8.76 | 67.9 | 11.50 |
| 5.200 | 107.03 | 28.80a | 3.20 | 2.46 | 32.22a | 9.26 | 67.3 | 11.37 |
| 5.400 | 113.47 | 29.01a | 3.32 | 2.50 | 32.47a | 9.72 | 66.7 | 11.19 |
| 5.600 | 120.06 | 29.21a | 3.44 | 2.55 | 32.76a | 10.23 | 66.3 | 11.05 |
| 5.800 | 126.87 | 29.41a | 3.57 | 2.60 | 33.09a | 10.81 | 66.3 | 10.97 |
| 6.000 | 133.92 | 29.62a | 3.69 | 2.66 | 33.46a | 11.46 | 66.6 | 10.95 |
| 6.200 | 140.82 | 29.82a | 3.81 | 2.70 | 33.68a | 11.95 | 66.1 | 10.85 |
| 6.400 | 147.82 | 30.01a | 3.93 | 2.74 | 33.93a | 12.49 | 65.8 | 10.76 |
| 6.600 | 154.92 | 30.19a | 4.05 | 2.78 | 34.16a | 13.02 | 65.4 | 10.72 |
| 6.800 | 162.11 | 30.37a | 4.16 | 2.83 | 34.39a | 13.55 | 65.1 | 10.72 |
| 7.000 | 169.12 | 30.54a | 4.28 | 2.86 | 34.48a | 13.91 | 64.0 | 10.69 |
| 7.200 | 176.07 | 30.70a | 4.39 | 2.88 | 34.52a | 14.21 | 62.8 | 10.64 |
| 7.400 | 183.07 | 30.85a | 4.50 | 2.90 | 34.56a | 14.51 | 61.7 | 10.61 |
| 7.600 | 190.13 | 30.98a | 4.61 | 2.92 | 34.59a | 14.81 | 60.6 | 10.60 |
| 7.800 | 197.24 | 31.11a | 4.73 | 2.95 | 34.63a | 15.11 | 59.7 | 10.60 |
| 8.000 | 204.22 | 31.23a | 4.83 | 2.96 | 34.59a | 15.31 | 58.4 | 10.57 |
| 8.200 | 211.22 | 31.34a | 4.94 | 2.97 | 34.54a | 15.50 | 57.1 | 10.54 |
| 8.400 | 218.25 | 31.44a | 5.05 | 2.99 | 34.49a | 15.70 | 56.0 | 10.52 |
| 8.600 | 225.32 | 31.54a | 5.16 | 3.00 | 34.44a | 15.90 | 54.9 | 10.51 |
| 8.800 | 232.96 | 31.64a | 5.28 | 2.90 | 34.70a | 16.00 | 53.5 | 10.29 |
| 9.000 | 240.21 | 31.73a | 5.39 | 2.81 | 34.89a | 16.15 | 52.3 | 10.09 |

Distances in FEET.-----Specific Gravity = 1.025.-----Moment in Ft-LT.
 Trim is per 65.00Ft

Draft is from base plane.

HYDROSTATIC PROPERTIES
Trim: Fwd 1.00/65.00, No Heel, VCG = 0.00

| LCF | Displacement | Buoyancy-Ctr. | | Weight/ | Moment/ | | | |
|-------|--------------|---------------|------|---------|---------|---------|------|-------|
| Draft | Weight (LT) | LCB | VCB | Inch | LCF | IN trim | KML | KMT |
| 5.000 | 103.91 | 32.02a | 3.02 | 2.60 | 34.82a | 10.85 | 81.4 | 11.93 |
| 5.200 | 110.33 | 32.19a | 3.14 | 2.65 | 35.04a | 11.32 | 80.0 | 11.73 |
| 5.400 | 116.84 | 32.35a | 3.26 | 2.69 | 35.25a | 11.79 | 78.7 | 11.59 |
| 5.600 | 123.45 | 32.50a | 3.38 | 2.73 | 35.44a | 12.24 | 77.3 | 11.50 |
| 5.800 | 130.05 | 32.65a | 3.50 | 2.75 | 35.47a | 12.51 | 75.0 | 11.33 |
| 6.000 | 136.70 | 32.78a | 3.62 | 2.77 | 35.50a | 12.79 | 73.0 | 11.19 |
| 6.200 | 143.41 | 32.91a | 3.73 | 2.79 | 35.53a | 13.07 | 71.1 | 11.08 |
| 6.400 | 150.18 | 33.02a | 3.85 | 2.82 | 35.55a | 13.36 | 69.4 | 11.00 |
| 6.600 | 156.95 | 33.13a | 3.96 | 2.83 | 35.54a | 13.46 | 66.9 | 10.88 |
| 6.800 | 163.72 | 33.23a | 4.08 | 2.84 | 35.49a | 13.63 | 65.0 | 10.78 |
| 7.000 | 170.53 | 33.32a | 4.19 | 2.85 | 35.44a | 13.81 | 63.2 | 10.69 |
| 7.200 | 177.36 | 33.40a | 4.30 | 2.87 | 35.38a | 13.99 | 61.5 | 10.62 |
| 7.400 | 184.23 | 33.47a | 4.42 | 2.88 | 35.33a | 14.17 | 60.0 | 10.56 |
| 7.600 | 191.14 | 33.54a | 4.53 | 2.89 | 35.28a | 14.35 | 58.5 | 10.51 |
| 7.800 | 198.07 | 33.60a | 4.64 | 2.91 | 35.23a | 14.53 | 57.2 | 10.47 |
| 8.000 | 205.04 | 33.65a | 4.75 | 2.92 | 35.18a | 14.72 | 56.0 | 10.44 |
| 8.200 | 212.05 | 33.70a | 4.86 | 2.94 | 35.13a | 14.91 | 54.8 | 10.42 |
| 8.400 | 219.08 | 33.75a | 4.97 | 2.95 | 35.08a | 15.10 | 53.8 | 10.41 |
| 8.600 | 225.77 | 33.78a | 5.08 | 2.87 | 34.41a | 14.74 | 50.9 | 10.23 |
| 8.800 | 232.02 | 33.78a | 5.18 | 2.76 | 33.45a | 14.02 | 47.1 | 10.02 |
| 9.000 | 238.00 | 33.76a | 5.27 | 2.67 | 32.38a | 13.09 | 42.9 | 9.83 |

Distances in FEET.-----Specific Gravity = 1.025.-----Moment in Ft-LT.
 Trim is per 65.00Ft

Draft is from base plane.

HYDROSTATIC PROPERTIES
No Trim, No Heel, VCG = 0.00

| LCF | Displacement | Buoyancy-Ctr. | | Weight/ | Moment/ | | | |
|-------|--------------|---------------|------|---------|---------|---------|------|-------|
| Draft | Weight (LT) | LCB | VCB | Inch | LCF | IN trim | KML | KMT |
| 5.000 | 104.10 | 33.26a | 3.01 | 2.65 | 35.63a | 11.33 | 84.9 | 12.15 |
| 5.200 | 110.51 | 33.40a | 3.13 | 2.69 | 35.81a | 11.76 | 83.0 | 12.00 |
| 5.400 | 116.99 | 33.53a | 3.25 | 2.71 | 35.83a | 12.02 | 80.2 | 11.77 |
| 5.600 | 123.53 | 33.65a | 3.37 | 2.73 | 35.86a | 12.29 | 77.6 | 11.58 |
| 5.800 | 130.13 | 33.76a | 3.49 | 2.75 | 35.89a | 12.57 | 75.3 | 11.42 |
| 6.000 | 136.78 | 33.86a | 3.61 | 2.78 | 35.89a | 12.81 | 73.0 | 11.28 |
| 6.200 | 143.47 | 33.95a | 3.72 | 2.79 | 35.83a | 12.98 | 70.6 | 11.12 |
| 6.400 | 150.20 | 34.03a | 3.84 | 2.80 | 35.77a | 13.16 | 68.3 | 10.98 |
| 6.600 | 156.96 | 34.10a | 3.96 | 2.82 | 35.71a | 13.34 | 66.3 | 10.86 |
| 6.800 | 163.76 | 34.16a | 4.07 | 2.83 | 35.65a | 13.52 | 64.4 | 10.76 |
| 7.000 | 170.59 | 34.22a | 4.18 | 2.84 | 35.64a | 13.64 | 62.4 | 10.67 |
| 7.200 | 177.43 | 34.27a | 4.30 | 2.86 | 35.58a | 13.82 | 60.7 | 10.60 |
| 7.400 | 184.30 | 34.32a | 4.41 | 2.87 | 35.53a | 13.99 | 59.2 | 10.54 |
| 7.600 | 191.21 | 34.36a | 4.52 | 2.88 | 35.48a | 14.17 | 57.8 | 10.49 |
| 7.800 | 198.14 | 34.40a | 4.63 | 2.90 | 35.43a | 14.36 | 56.5 | 10.46 |
| 8.000 | 205.11 | 34.43a | 4.74 | 2.91 | 35.38a | 14.54 | 55.3 | 10.43 |
| 8.200 | 212.11 | 34.46a | 4.86 | 2.92 | 35.33a | 14.74 | 54.2 | 10.41 |
| 8.400 | 218.92 | 34.47a | 4.96 | 2.75 | 33.94a | 13.73 | 48.9 | 10.03 |
| 8.600 | 225.36 | 34.43a | 5.06 | 2.62 | 32.53a | 12.48 | 43.2 | 9.76 |
| 8.800 | 231.48 | 34.36a | 5.16 | 2.43 | 30.05a | 9.76 | 32.9 | 9.35 |
| 9.000 | 237.30 | 34.25a | 5.25 | 2.39 | 29.20a | 8.87 | 29.2 | 9.33 |

Distances in FEET.-----Specific Gravity = 1.025.-----Moment in Ft-LT.
Trim is per 65.00Ft

Draft is from base plane.

HYDROSTATIC PROPERTIES
Trim: Aft 1.00/65.00, No Heel, VCG = 0.00

| LCF | Displacement | Buoyancy-Ctr. | | Weight/ | Moment/ | | | |
|-------|--------------|---------------|------|---------|---------|---------|------|-------|
| Draft | Weight (LT) | LCB | VCB | Inch | LCF | IN trim | KML | KMT |
| 5.000 | 103.96 | 34.53a | 3.02 | 2.67 | 36.22a | 11.52 | 86.4 | 12.38 |
| 5.200 | 110.39 | 34.63a | 3.14 | 2.69 | 36.23a | 11.79 | 83.3 | 12.11 |
| 5.400 | 116.88 | 34.72a | 3.26 | 2.72 | 36.25a | 12.07 | 80.5 | 11.90 |
| 5.600 | 123.44 | 34.80a | 3.38 | 2.73 | 36.23a | 12.28 | 77.6 | 11.69 |
| 5.800 | 130.05 | 34.87a | 3.50 | 2.75 | 36.17a | 12.45 | 74.7 | 11.47 |
| 6.000 | 136.70 | 34.93a | 3.61 | 2.76 | 36.11a | 12.63 | 72.0 | 11.28 |
| 6.200 | 143.39 | 34.98a | 3.73 | 2.78 | 36.05a | 12.80 | 69.6 | 11.12 |
| 6.400 | 150.12 | 35.02a | 3.85 | 2.79 | 35.99a | 12.98 | 67.4 | 10.98 |
| 6.600 | 156.87 | 35.06a | 3.96 | 2.81 | 35.93a | 13.15 | 65.4 | 10.86 |
| 6.800 | 163.67 | 35.09a | 4.07 | 2.82 | 35.87a | 13.33 | 63.5 | 10.76 |
| 7.000 | 170.50 | 35.12a | 4.19 | 2.83 | 35.81a | 13.52 | 61.8 | 10.67 |
| 7.200 | 177.36 | 35.14a | 4.30 | 2.85 | 35.75a | 13.70 | 60.3 | 10.60 |
| 7.400 | 184.26 | 35.16a | 4.41 | 2.86 | 35.69a | 13.89 | 58.8 | 10.54 |
| 7.600 | 191.17 | 35.17a | 4.53 | 2.87 | 35.68a | 14.01 | 57.2 | 10.49 |
| 7.800 | 198.11 | 35.19a | 4.64 | 2.89 | 35.63a | 14.20 | 55.9 | 10.46 |
| 8.000 | 205.50 | 35.20a | 4.76 | 2.77 | 34.69a | 13.65 | 51.8 | 10.15 |
| 8.200 | 212.92 | 35.15a | 4.87 | 2.56 | 32.63a | 11.84 | 43.4 | 9.70 |
| 8.400 | 220.19 | 35.02a | 4.99 | 2.35 | 29.61a | 8.52 | 30.2 | 9.25 |
| 8.600 | 225.88 | 34.88a | 5.07 | 2.35 | 29.45a | 8.52 | 29.4 | 9.27 |
| 8.800 | 231.57 | 34.75a | 5.16 | 2.36 | 29.39a | 8.64 | 29.1 | 9.30 |
| 9.000 | 237.29 | 34.62a | 5.25 | 2.37 | 29.33a | 8.77 | 28.8 | 9.33 |

Distances in FEET.-----Specific Gravity = 1.025.-----Moment in Ft-LT.
Trim is per 65.00Ft

Draft is from base plane.

HYDROSTATIC PROPERTIES

Trim: Aft 4.00/65.00, No Heel, VCG = 0.00

| LCF Draft | Displacement Weight (LT) | Buoyancy-Ctr. | | Weight/ Inch | Moment/ | | | | |
|--------------|-----------------------------|---------------|------|-----------------|---------|---------|------|-------|--|
| | | LCB | VCB | | LCF | IN trim | KML | KMT | |
| 5.000 | 102.70 | 38.33a | 3.14 | 2.63 | 37.31a | 11.03 | 83.6 | 12.67 | |
| 5.200 | 109.29 | 38.27a | 3.25 | 2.65 | 37.19a | 11.26 | 80.2 | 12.34 | |
| 5.400 | 115.86 | 38.20a | 3.37 | 2.67 | 37.09a | 11.46 | 77.0 | 12.04 | |
| 5.600 | 122.47 | 38.14a | 3.49 | 2.69 | 36.99a | 11.67 | 74.2 | 11.79 | |
| 5.800 | 129.13 | 38.08a | 3.60 | 2.71 | 36.89a | 11.88 | 71.6 | 11.57 | |
| 6.000 | 135.81 | 38.02a | 3.71 | 2.72 | 36.80a | 12.09 | 69.3 | 11.38 | |
| 6.200 | 142.50 | 37.96a | 3.83 | 2.74 | 36.73a | 12.27 | 67.0 | 11.21 | |
| 6.400 | 149.22 | 37.90a | 3.94 | 2.75 | 36.66a | 12.46 | 65.0 | 11.07 | |
| 6.600 | 155.98 | 37.84a | 4.05 | 2.77 | 36.59a | 12.65 | 63.1 | 10.95 | |
| 6.800 | 162.77 | 37.79a | 4.16 | 2.78 | 36.53a | 12.84 | 61.4 | 10.85 | |
| 7.000 | 180.79 | 37.47a | 4.44 | 2.23 | 30.36a | 7.31 | 31.5 | 9.23 | |
| 7.200 | 186.29 | 37.26a | 4.52 | 2.25 | 30.29a | 7.42 | 31.0 | 9.22 | |
| 7.400 | 191.81 | 37.05a | 4.60 | 2.26 | 30.22a | 7.54 | 30.6 | 9.21 | |
| 7.600 | 197.36 | 36.86a | 4.68 | 2.27 | 30.15a | 7.66 | 30.2 | 9.21 | |
| 7.800 | 202.94 | 36.67a | 4.76 | 2.28 | 30.08a | 7.79 | 29.9 | 9.21 | |
| 8.000 | 208.54 | 36.49a | 4.85 | 2.29 | 30.01a | 7.91 | 29.5 | 9.22 | |
| 8.200 | 214.18 | 36.32a | 4.93 | 2.30 | 29.95a | 8.04 | 29.2 | 9.24 | |
| 8.400 | 219.84 | 36.15a | 5.02 | 2.32 | 29.88a | 8.17 | 28.9 | 9.25 | |
| 8.600 | 243.64 | 35.13a | 5.37 | 0.94 | 15.06a | 2.26 | 7.2 | 6.66 | |
| 8.800 | 245.93 | 34.94a | 5.40 | 0.94 | 15.01a | 2.29 | 7.3 | 6.69 | |
| 9.000 | 248.24 | 34.76a | 5.44 | 0.95 | 14.95a | 2.33 | 7.3 | 6.73 | |

Distances in FEET.-----Specific Gravity = 1.025.-----Moment in Ft-LT.
Trim is per 65.00Ft

Draft is from base plane.

TANK CHARACTERISTICS

No Trim, No Heel

Tank: FWD_HOLD.P, Contents: 1.025 Specific Gravity

| Ref Ht | Load | Weight | Center of Gravity | | | GML | GMT | FSM Ft-LT |
|--------|-------|-----------|-------------------|-------|------|------|------|--------------|
| | | LONG TONS | LCG | TCG | VCG | | | |
| -1.79 | .100 | 3.35 | 32.04a | 3.23p | 1.20 | 17.4 | 8.34 | 28.0 |
| -2.67 | .200 | 6.70 | 32.05a | 4.06p | 1.72 | 9.2 | 4.63 | 31.0 |
| -3.54 | .300 | 10.06 | 32.05a | 4.36p | 2.18 | 6.2 | 3.20 | 32.1 |
| -4.40 | .400 | 13.41 | 32.05a | 4.52p | 2.63 | 4.7 | 2.48 | 33.3 |
| -5.25 | .500 | 16.76 | 32.05a | 4.63p | 3.07 | 3.8 | 2.05 | 34.4 |
| -6.09 | .600 | 20.12 | 32.05a | 4.71p | 3.50 | 3.2 | 1.77 | 35.5 |
| -6.92 | .700 | 23.47 | 32.05a | 4.78p | 3.93 | 2.8 | 1.56 | 36.7 |
| -7.75 | .800 | 26.82 | 32.05a | 4.84p | 4.36 | 2.5 | 1.41 | 37.8 |
| -8.56 | .900 | 30.17 | 32.05a | 4.89p | 4.78 | 2.2 | 1.29 | 39.0 |
| -9.21 | .980 | 32.86 | 32.05a | 4.92p | 5.12 | 1.6 | 1.12 | 36.8 |
| | 1.000 | 33.53 | 32.10a | 4.93p | 5.20 | | | |

-----Distances in FEET.-----
FWD_HOLD.P Reference Point: Long.= 0.00 Trans.= 0.00 Vert.= 0.00

Tank: FWD_HOLD.S, Contents: 1.025 Specific Gravity

| Ref Ht | Load | Weight | | Center of Gravity | | | GML | GMT | FSM Ft-LT |
|--------|-------|--------|-------|-------------------|-------|------|------|------|--------------|
| | | LONG | TONS | LCG | TCG | VCG | | | |
| -1.79 | .100 | | 3.35 | 32.04a | 3.23s | 1.20 | 17.4 | 8.34 | 28.0 |
| -2.67 | .200 | | 6.70 | 32.05a | 4.06s | 1.72 | 9.2 | 4.63 | 31.0 |
| -3.54 | .300 | | 10.06 | 32.05a | 4.36s | 2.18 | 6.2 | 3.20 | 32.1 |
| -4.40 | .400 | | 13.41 | 32.05a | 4.52s | 2.63 | 4.7 | 2.48 | 33.3 |
| -5.25 | .500 | | 16.76 | 32.05a | 4.63s | 3.07 | 3.8 | 2.05 | 34.4 |
| -6.09 | .600 | | 20.12 | 32.05a | 4.71s | 3.50 | 3.2 | 1.77 | 35.5 |
| -6.92 | .700 | | 23.47 | 32.05a | 4.78s | 3.93 | 2.8 | 1.56 | 36.7 |
| -7.75 | .800 | | 26.82 | 32.05a | 4.84s | 4.36 | 2.5 | 1.41 | 37.8 |
| -8.56 | .900 | | 30.17 | 32.05a | 4.89s | 4.78 | 2.2 | 1.29 | 39.0 |
| -9.21 | .980 | | 32.86 | 32.05a | 4.92s | 5.12 | 1.6 | 1.12 | 36.8 |
| | 1.000 | | 33.53 | 32.10a | 4.93s | 5.20 | | | |

-----Distances in FEET.-----

FWD_HOLD.S Reference Point: Long.= 0.00 Trans.= 0.00 Vert.= 0.00

Tank: AFT_HOLD.P, Contents: 1.025 Specific Gravity

| Ref Ht | Load | Weight | | Center of Gravity | | | GML | GMT | FSM Ft-LT |
|--------|-------|--------|-------|-------------------|-------|------|------|------|--------------|
| | | LONG | TONS | LCG | TCG | VCG | | | |
| -2.44 | .100 | | 3.31 | 44.15a | 3.40p | 1.80 | 14.6 | 7.24 | 24.0 |
| -3.35 | .200 | | 6.63 | 44.93a | 4.08p | 2.35 | 9.4 | 4.68 | 31.0 |
| -4.20 | .300 | | 9.94 | 45.27a | 4.37p | 2.83 | 6.4 | 3.25 | 32.3 |
| -5.04 | .400 | | 13.25 | 45.45a | 4.54p | 3.28 | 4.9 | 2.52 | 33.5 |
| -5.88 | .500 | | 16.56 | 45.55a | 4.64p | 3.71 | 3.9 | 2.09 | 34.6 |
| -6.70 | .600 | | 19.88 | 45.62a | 4.72p | 4.14 | 3.3 | 1.80 | 35.8 |
| -7.52 | .700 | | 23.19 | 45.68a | 4.79p | 4.57 | 2.9 | 1.59 | 36.9 |
| -8.32 | .800 | | 26.50 | 45.71a | 4.84p | 4.99 | 2.5 | 1.44 | 38.1 |
| -9.12 | .900 | | 29.81 | 45.74a | 4.89p | 5.40 | 2.3 | 1.32 | 39.3 |
| -9.80 | .980 | | 32.46 | 45.79a | 4.93p | 5.73 | 0.5 | 0.79 | 25.6 |
| | 1.000 | | 33.13 | 45.88a | 4.94p | 5.82 | | | |

-----Distances in FEET.-----

AFT_HOLD.P Reference Point: Long.= 0.00 Trans.= 0.00 Vert.= 0.00

Tank: AFT_HOLD.S, Contents: 1.025 Specific Gravity

| Ref Ht | Load | Weight | | Center of Gravity | | | GML | GMT | FSM Ft-LT |
|--------|-------|--------|-------|-------------------|-------|------|------|------|--------------|
| | | LONG | TONS | LCG | TCG | VCG | | | |
| -2.44 | .100 | | 3.31 | 44.15a | 3.40s | 1.80 | 14.6 | 7.24 | 24.0 |
| -3.35 | .200 | | 6.63 | 44.93a | 4.08s | 2.35 | 9.4 | 4.68 | 31.0 |
| -4.20 | .300 | | 9.94 | 45.27a | 4.37s | 2.83 | 6.4 | 3.25 | 32.3 |
| -5.04 | .400 | | 13.25 | 45.45a | 4.54s | 3.28 | 4.9 | 2.52 | 33.5 |
| -5.88 | .500 | | 16.56 | 45.55a | 4.64s | 3.71 | 3.9 | 2.09 | 34.6 |
| -6.70 | .600 | | 19.88 | 45.62a | 4.72s | 4.14 | 3.3 | 1.80 | 35.8 |
| -7.52 | .700 | | 23.19 | 45.68a | 4.79s | 4.57 | 2.9 | 1.59 | 36.9 |
| -8.32 | .800 | | 26.50 | 45.71a | 4.84s | 4.99 | 2.5 | 1.44 | 38.1 |
| -9.12 | .900 | | 29.81 | 45.74a | 4.89s | 5.40 | 2.3 | 1.32 | 39.3 |
| -9.80 | .980 | | 32.46 | 45.79a | 4.93s | 5.73 | 0.5 | 0.79 | 25.6 |
| | 1.000 | | 33.13 | 45.88a | 4.94s | 5.82 | | | |

-----Distances in FEET.-----

AFT_HOLD.S Reference Point: Long.= 0.00 Trans.= 0.00 Vert.= 0.00

APPENDIX B

STABILITY RESULTS FOR SELECTED CRITERIA – SHIP SCALE

- 1. Intact Righting Energy – 46 CFR 28.570**
- 2. Severe Wind and Roll – 46 CFR 28.575**
- 3. Water on Deck – 46 CFR 28.565**
- 4. Lifting of Heavy Weights over the Side - 46 CFR 28.545**
- 5. Unintentional Flooding (Damage to ER) - 46 CFR 28.580**
- 6. Unintentional Flooding (Damage to Lazerette) - 46 CFR 28.580**

Notes on Stability Criteria

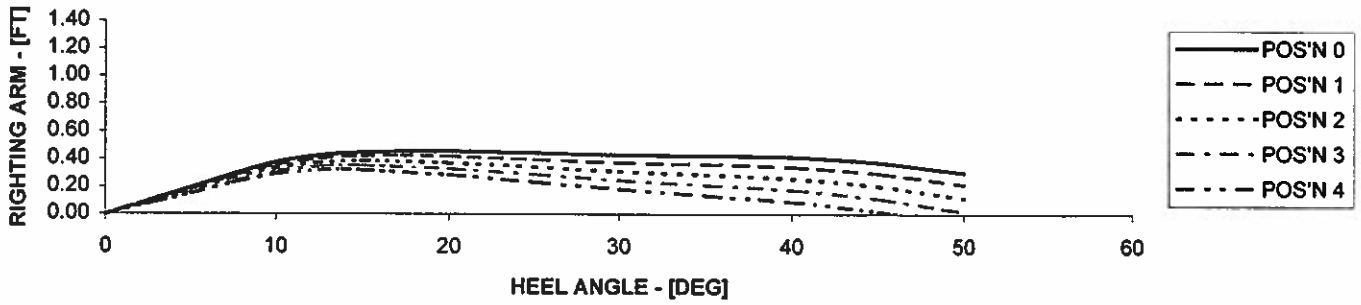
1. For each U.S. Coast Guard regulation cited, the vessel has been assessed using 4 different loading conditions. Each loading condition has been assessed with the VCG weight at 5 different positions.
2. All combinations of cargo loading and position of VCG weight have been analyzed, while keeping the removable bulkhead (located on the longitudinal centerline) in place. Thus, 20 cases, labeled "P&S", have been analyzed for each regulation.
3. For the cases where the removable bulkhead has been removed, each loading condition has been analyzed at Position 0 only. Thus, only 4 cases, labeled "CL", are presented for each stability regulation.
4. Loading Condition 2 features a 50% loading achieved by loading the forward compartments completely full and then partially loading the aft compartments. By loading in this manner, the magnitude of the free surface is kept to a minimum. By comparison, Loading Condition 3 features all compartments loaded at a 50% level, thereby creating a large free surface effect. This has been included for illustration purposes only. The vessel would not be realistically loaded in this manner.

Summary of Stability Conditions - S.S. Spade

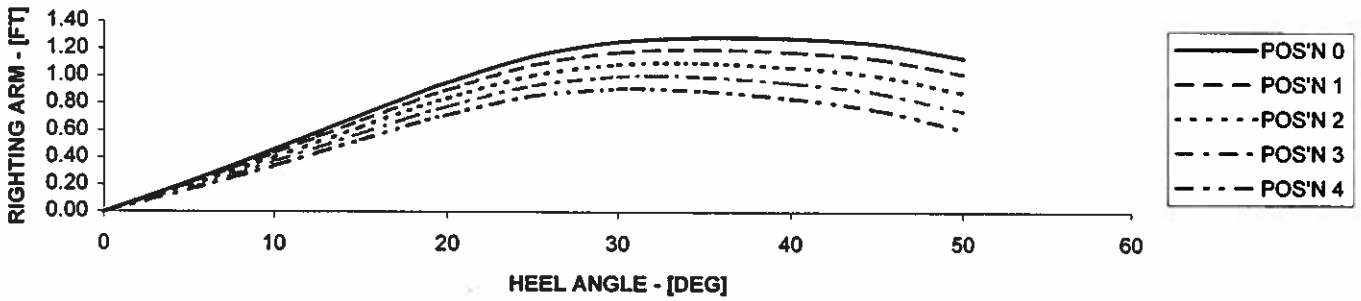
INTACT RIGHTING ENERGY - 46 CFR 28.570
 [Items in BOLD are not compliant.]

| Condition | Location of VCG Wt. | Δ [L-T] | Mean Draft [Ft] | Trim [Ft] | GM [Ft] | Area | | Area (30-40°) [Ft-Deg] | GZ-Max | | GZ @30° [Ft] | Status |
|------------------------------|---------------------|---------|-----------------|-----------|-------------|------------------|------------------|------------------------|---|-------------|--------------|---------------|
| | | | | | | (0-40°) [Ft-Deg] | (0-30°) [Ft-Deg] | | Value [Ft] | Angle [Deg] | | |
| | | | | | 1.15 | 16.9 | 10.3 | 5.64 | To Occur at Angle Greater than 25° | | 0.66 | |
| | | | | | | | | | | | | |
| Full Load w/ P&S Holds | Pos'n 0 | 202 | 7.91 | 1.01A | 2.39 | 14.99 | 10.74 | 4.25 | 0.46 | 20.0 | 0.43 | Non-Compliant |
| | Pos'n 1 | 202 | 7.91 | 1.01A | 2.28 | 13.48 | 9.88 | 3.60 | 0.42 | 17.3 | 0.38 | Non-Compliant |
| | Pos'n 2 | 202 | 7.91 | 1.01A | 2.16 | 11.75 | 8.89 | 2.86 | 0.39 | 15.2 | 0.31 | Non-Compliant |
| | Pos'n 3 | 202 | 7.91 | 1.01A | 2.03 | 10.01 | 7.90 | 2.11 | 0.35 | 14.4 | 0.25 | Non-Compliant |
| | Pos'n 4 | 202 | 7.91 | 1.01A | 1.90 | 8.28 | 6.91 | 1.37 | 0.32 | 13.8 | 0.18 | Non-Compliant |
| | | | | | | | | | | | | |
| Full Load w/ CL Holds | Pos'n 0 | 202 | 7.91 | 1.01A | 0.30 | 12.72 | 9.00 | 3.72 | 0.40 | 19.0 | 0.38 | Non-Compliant |
| | | | | | | | | | | | | |
| 50% w/ P&S Holds - Small FSM | Pos'n 0 | 144 | 6.25 | 3.38F | 2.40 | 33.45 | 20.64 | 12.81 | 1.28 | 40.0 | 1.25 | Compliant |
| | Pos'n 1 | 144 | 6.25 | 3.38F | 2.24 | 31.37 | 19.44 | 11.93 | 1.20 | 35.0 | 1.18 | Compliant |
| | Pos'n 2 | 144 | 6.25 | 3.38F | 2.06 | 28.98 | 18.07 | 10.91 | 1.10 | 33.3 | 1.09 | Compliant |
| | Pos'n 3 | 144 | 6.25 | 3.38F | 1.88 | 26.60 | 16.70 | 9.90 | 1.00 | 32.1 | 1.00 | Compliant |
| | Pos'n 4 | 144 | 6.25 | 3.38F | 1.70 | 24.22 | 15.34 | 8.88 | 0.91 | 30.9 | 0.91 | Compliant |
| | | | | | | | | | | | | |
| 50% w/ CL Holds - Small FSM | Pos'n 0 | 144 | 6.25 | 3.38F | 0.66 | 26.50 | 15.82 | 10.68 | 1.07 | 35.7 | 1.04 | Compliant |
| | | | | | | | | | | | | |
| 50% w/ P&S Holds - Large FSM | Pos'n 0 | 138 | 6.04 | 0.52F | 2.96 | 31.37 | 21.51 | 9.86 | 1.15 | 26.5 | 1.12 | Compliant |
| | Pos'n 1 | 138 | 6.04 | 0.52F | 2.79 | 29.20 | 20.27 | 8.93 | 1.08 | 26.0 | 1.04 | Compliant |
| | Pos'n 2 | 138 | 6.04 | 0.52F | 2.61 | 26.71 | 18.85 | 7.86 | 1.00 | 25.3 | 0.94 | Compliant |
| | Pos'n 3 | 138 | 6.04 | 0.52F | 2.42 | 24.23 | 17.42 | 6.81 | 0.92 | 25.0 | 0.85 | Compliant |
| | Pos'n 4 | 138 | 6.04 | 0.52F | 2.24 | 21.74 | 16.00 | 5.74 | 0.84 | 25.0 | 0.76 | Compliant |
| | | | | | | | | | | | | |
| 50% w/ CL Holds - Large FSM | | | | | | CAPSIZE | | | | | | Non-Compliant |
| | | | | | | | | | | | | |
| 5% Load w/ P&S Holds | Pos'n 0 | 78 | 4.26 | 3.72F | 1.58 | 9.92 | 8.88 | 1.04 | 0.43 | 17.8 | 0.24 | Non-Compliant |
| | Pos'n 1 | 78 | 4.26 | 3.72F | 1.29 | 6.81 | 6.66 | 0.15 | 0.34 | 16.0 | 0.10 | Non-Compliant |
| | Pos'n 2 | 78 | 4.26 | 3.72F | 0.96 | 4.19 | 4.10 | 0.00 | 0.24 | 12.5 | 0.00 | Non-Compliant |
| | Pos'n 3 | 78 | 4.26 | 3.72F | 0.62 | 2.32 | 2.32 | 0.00 | 0.17 | 14.3 | 0.00 | Non-Compliant |
| | Pos'n 4 | 78 | 4.26 | 3.72F | 0.29 | 1.01 | 1.01 | 0.00 | 0.09 | 12.5 | 0.00 | Non-Compliant |
| | | | | | | | | | | | | |
| 5% Load w/ CL Holds | Pos'n 0 | 78 | 4.26 | 3.72F | -0.39 | 2.28 | 2.28 | 0.00 | 0.17 | 16.5 | 0.00 | Non-Compliant |
| | | | | | | | | | | | | |

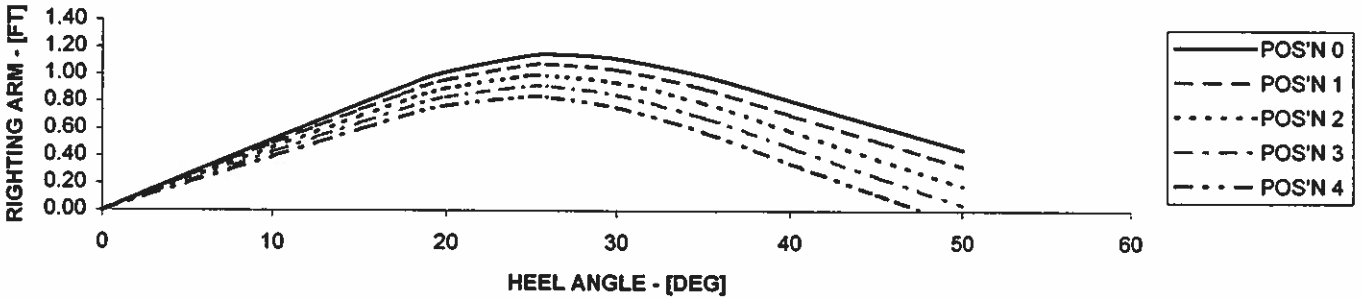
**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - FULL LOAD**



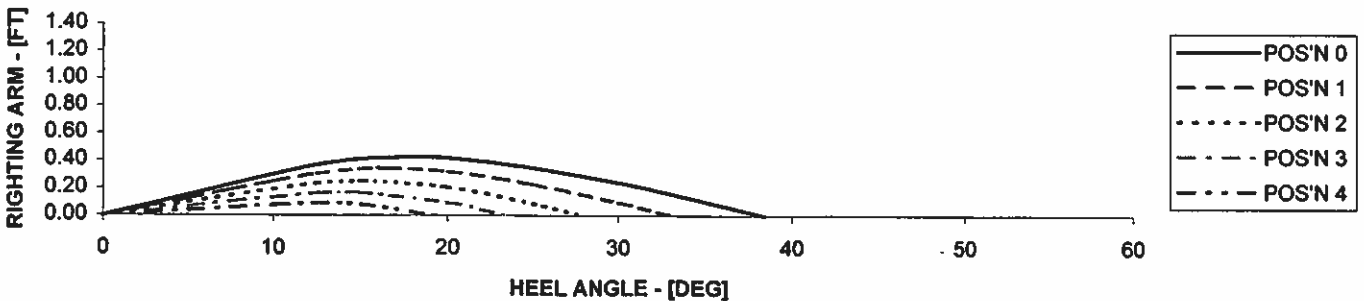
**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - 50% LOAD (SMALL FSM)**



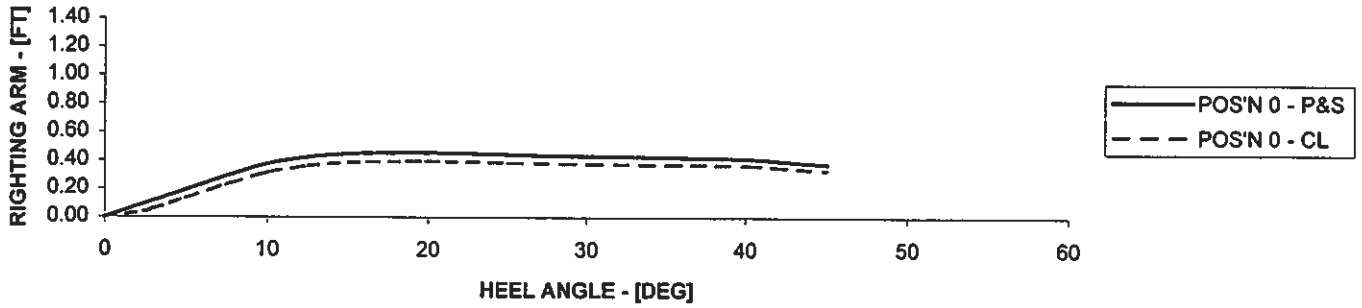
**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - 50% LOAD (LARGE FSM)**



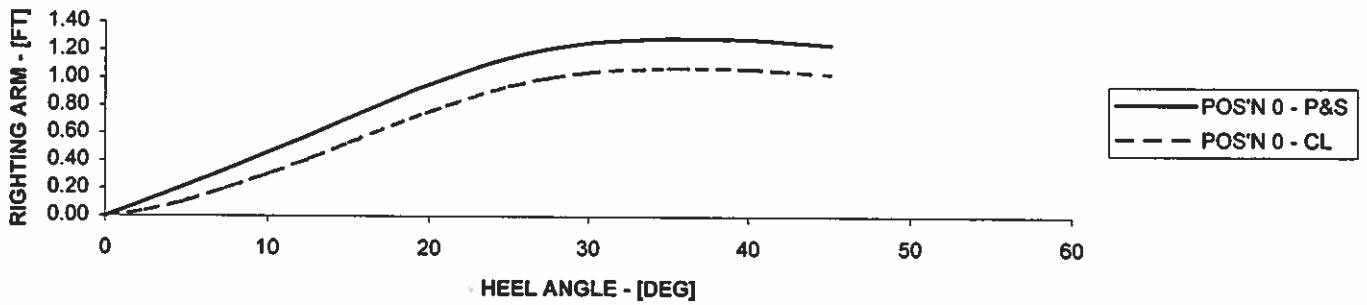
**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - 5% LOAD**



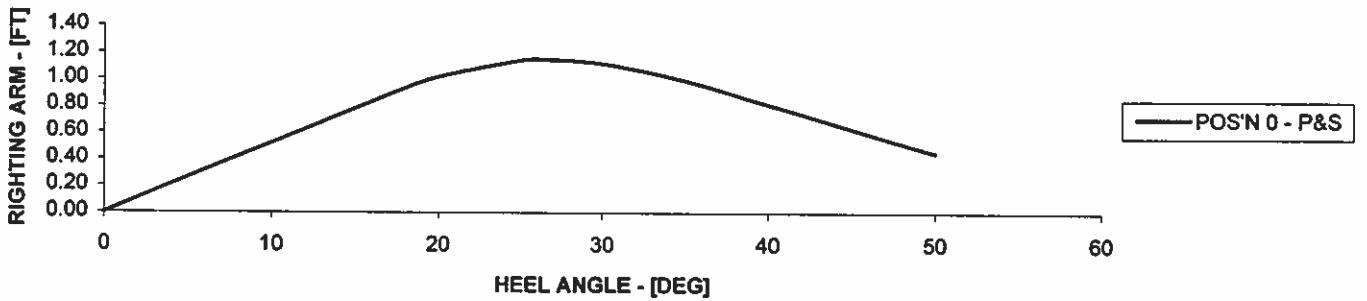
**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - FULL LOAD**



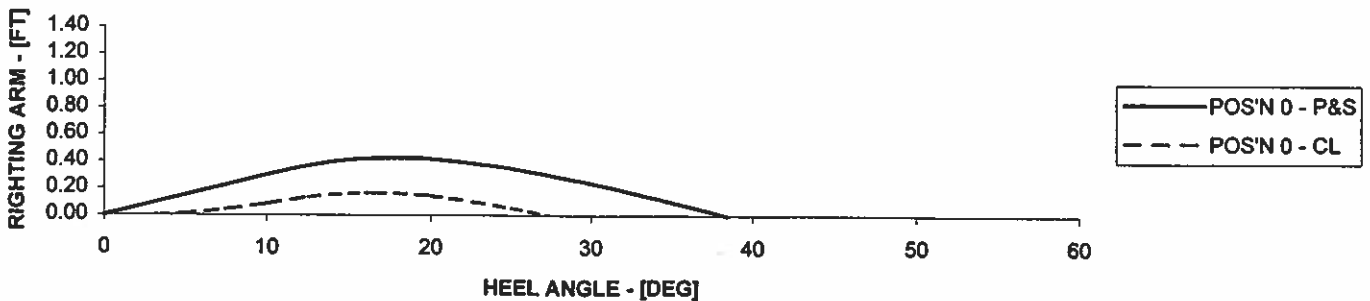
**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - 50% LOAD (SMALL FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - 50% LOAD (LARGE FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
INTACT RIGHTING ENERGY - 46 CFR 28.570 - 5% LOAD**



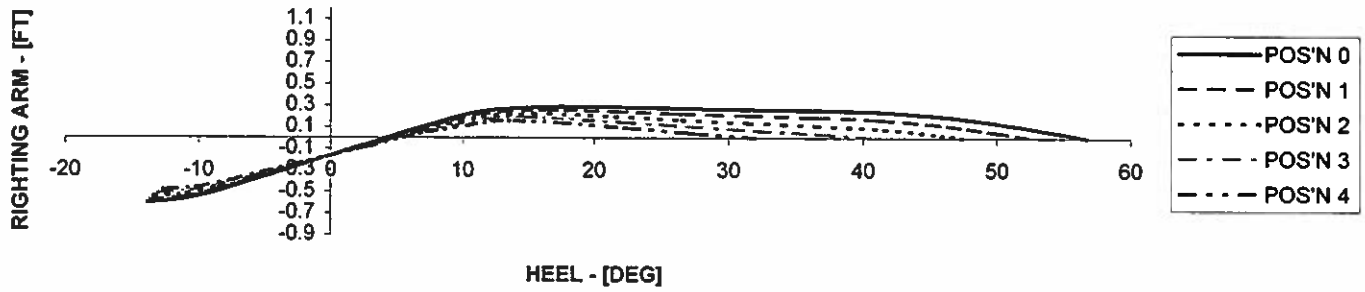
Summary of Stability Conditions - S.S. Spade

SEVERE WIND AND ROLL CRITERION - 46 CFR 28.575

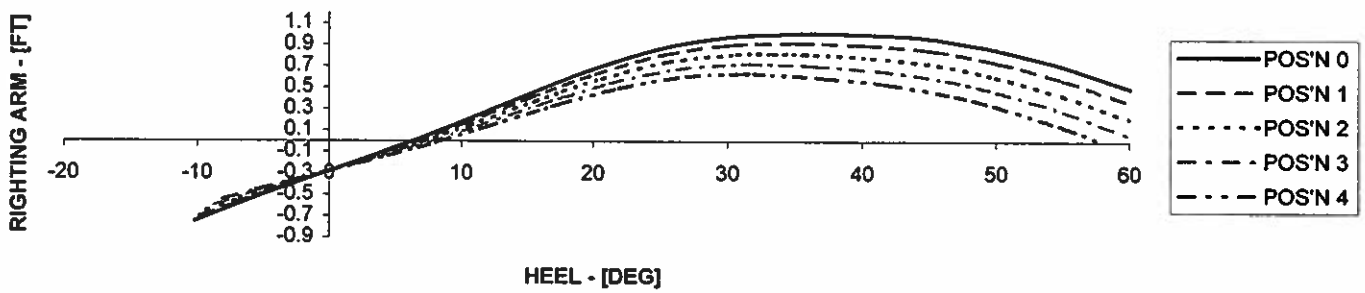
[Items in BOLD are not compliant.]

| Condition | Location of VCG Wt. | Δ [L/T] | Mean Draft [Ft] | Trim [Ft] | Absolute Angle of Equilibrium - [Deg] | | Residual Ratio From Roll to Abs. 50 or RA-zero | Status |
|------------------------------|---------------------|---------|-----------------|-----------|---------------------------------------|-------------------|--|--------|
| | | | | | Less than 1.0° | Greater than 1.0° | | |
| Full Load w/ P&S Holds | Pos'n 0 | 202 | 7.91 | 1.01A | 4.3 | 1.757 | Compliant | |
| | Pos'n 1 | 202 | 7.91 | 1.01A | 4.5 | 1.450 | Compliant | |
| | Pos'n 2 | 202 | 7.91 | 1.01A | 4.8 | 1.071 | Compliant | |
| | Pos'n 3 | 202 | 7.91 | 1.01A | 5.2 | 0.738 | Non-Compliant | |
| | Pos'n 4 | 202 | 7.91 | 1.01A | 5.5 | 0.499 | Non-Compliant | |
| Full Load w/ CL Holds | Pos'n 0 | 202 | 7.91 | 1.01A | 5.8 | 5.018 | Compliant | |
| 50% w/ P&S Holds - Small FSM | Pos'n 0 | 144 | 6.25 | 3.38F | 6.3 | 5.394 | Compliant | |
| | Pos'n 1 | 144 | 6.25 | 3.38F | 6.7 | 5.150 | Compliant | |
| | Pos'n 2 | 144 | 6.25 | 3.38F | 7.2 | 4.890 | Compliant | |
| | Pos'n 3 | 144 | 6.25 | 3.38F | 7.8 | 4.563 | Compliant | |
| | Pos'n 4 | 144 | 6.25 | 3.38F | 8.4 | 4.178 | Compliant | |
| 50% w/ CL Holds - Small FSM | Pos'n 0 | 144 | 6.25 | 3.38F | 9.4 | 9.274 | Compliant | |
| 50% w/ P&S Holds - Large FSM | Pos'n 0 | 138 | 6.04 | 0.52F | 5.7 | 3.434 | Compliant | |
| | Pos'n 1 | 138 | 6.04 | 0.52F | 6.0 | 3.072 | Compliant | |
| | Pos'n 2 | 138 | 6.04 | 0.52F | 6.4 | 2.695 | Compliant | |
| | Pos'n 3 | 138 | 6.04 | 0.52F | 6.9 | 2.328 | Compliant | |
| | Pos'n 4 | 138 | 6.04 | 0.52F | 7.5 | 2.006 | Compliant | |
| 50% w/ CL Holds - Large FSM | Pos'n 0 | | | | CAPSIZE | | Non-Compliant | |
| 5% Load w/ P&S Holds | Pos'n 0 | | | | CAPSIZE | | Non-Compliant | |
| | Pos'n 1 | | | | CAPSIZE | | Non-Compliant | |
| | Pos'n 2 | | | | CAPSIZE | | Non-Compliant | |
| | Pos'n 3 | | | | CAPSIZE | | Non-Compliant | |
| | Pos'n 4 | | | | CAPSIZE | | Non-Compliant | |
| 5% Load w/ CL Holds | Pos'n 0 | | | | CAPSIZE | | Non-Compliant | |

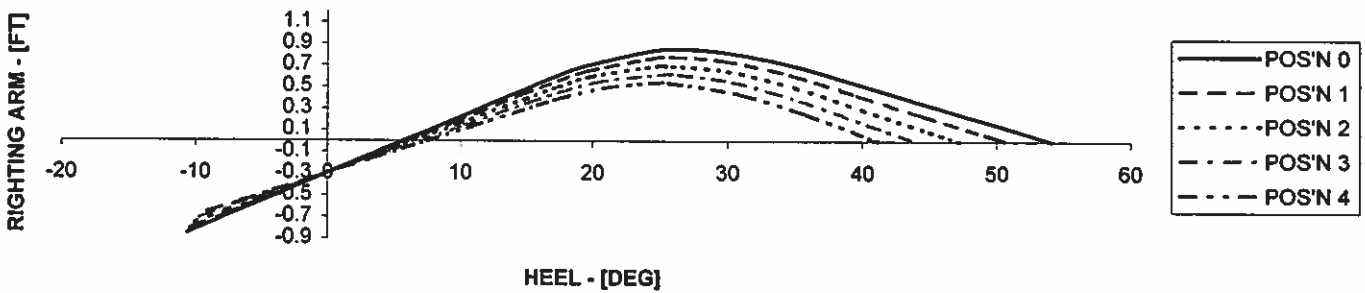
**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - FULL LOAD**



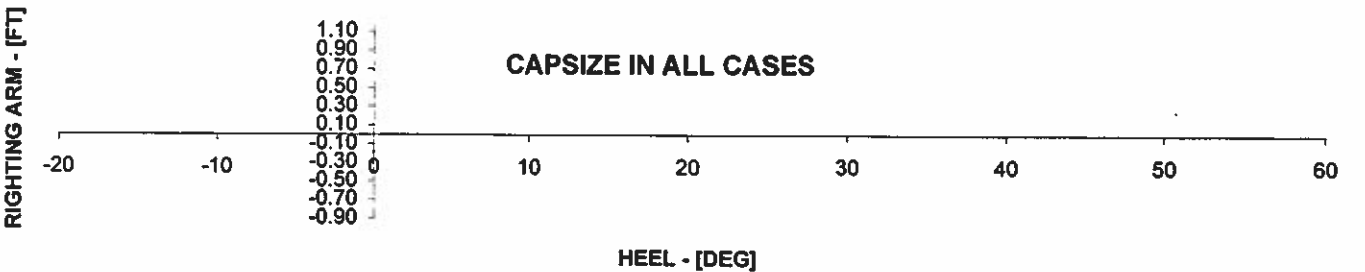
**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - 50% LOAD (SMALL FSM)**



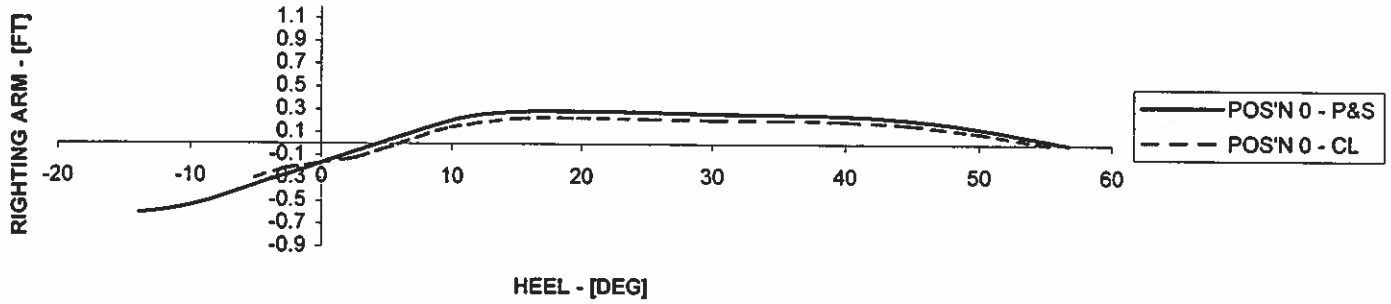
**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - 50% LOAD (LARGE FSM)**



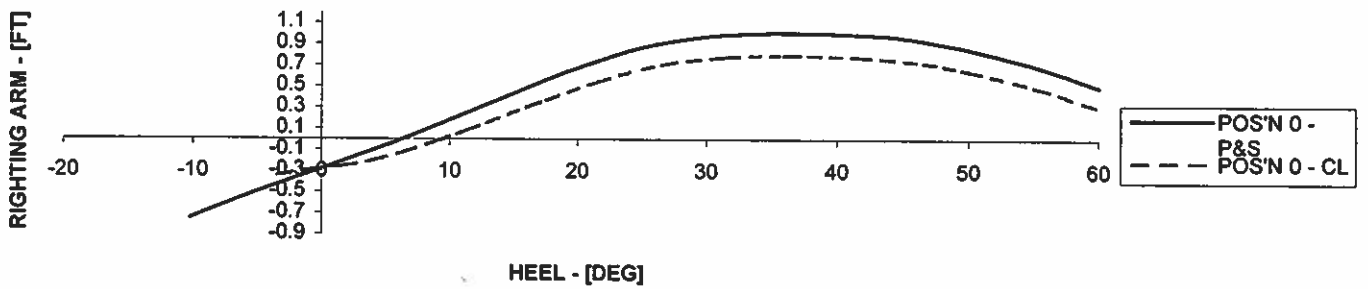
**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - 5% LOAD**



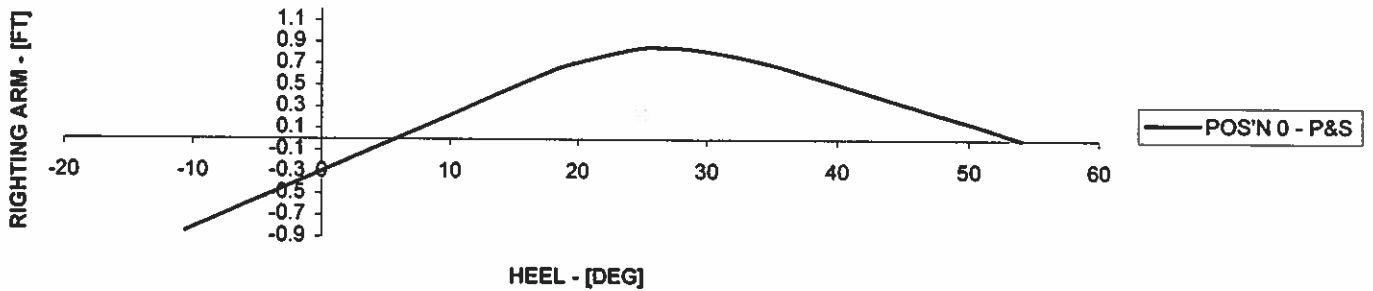
**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - FULL LOAD**



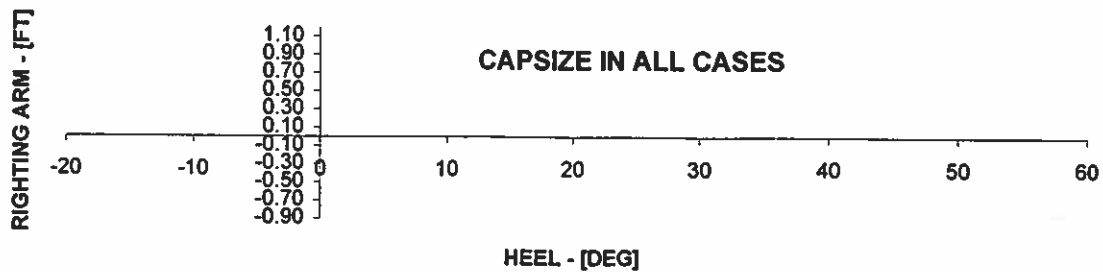
**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - 50% LOAD (SMALL FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - 50% LOAD (LARGE FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
SEVERE WIND AND ROLL - 46 CFR 28.575 - 5% LOAD**

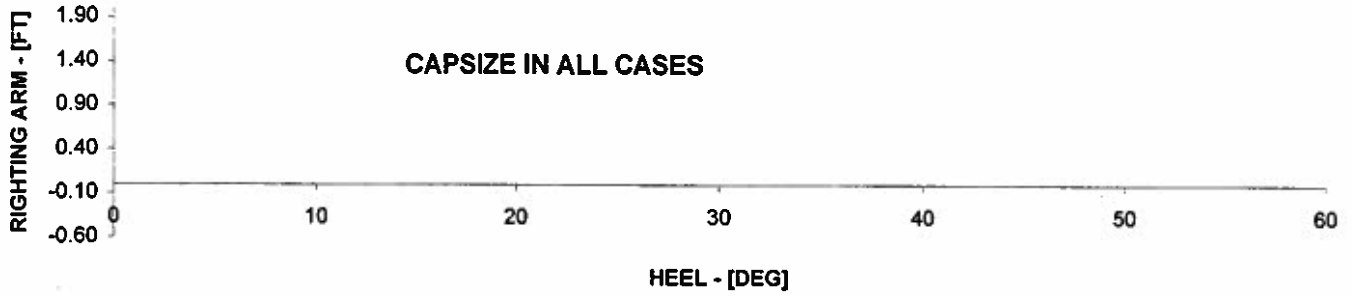


Summary of Stability Conditions - S.S. Spade

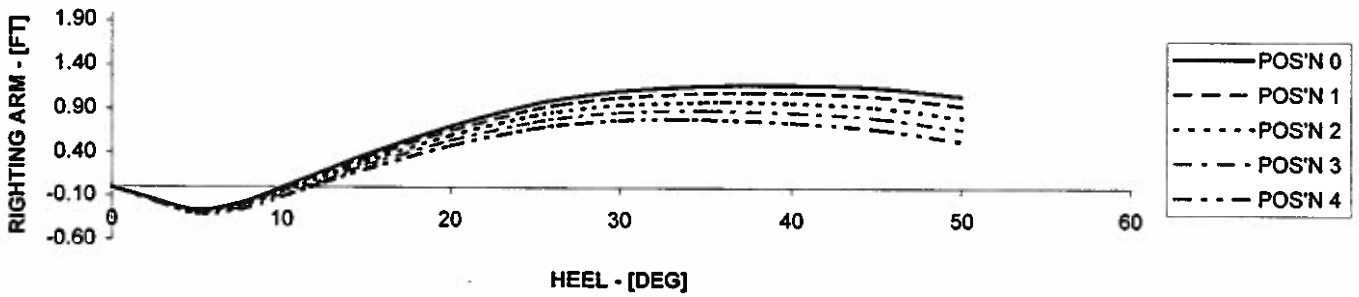
WATER ON DECK - 46 CFR 28.565
[Items in BOLD are not compliant.]

| Condition | Location of VCG Wt. | Δ [LT] | Mean Draft [Ft] | Trim [Ft] | Residual Area Ratio From Abs.0 to 40° | Status |
|------------------------------|---------------------|--------|-----------------|-----------|---------------------------------------|---------------|
| | | | | | | |
| Full Load w/ P&S Holds | Pos'n 0 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 1 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 2 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 3 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 4 | | | CAPSIZ | | Non-Compliant |
| Full Load w/ CL Holds | Pos'n 0 | | | CAPSIZ | | Non-Compliant |
| 50% w/ P&S Holds - Small FSM | Pos'n 0 | 180 | 7.32 | 0.62F | 16.411 | Compliant |
| | Pos'n 1 | 180 | 7.32 | 0.62F | 14.049 | Compliant |
| | Pos'n 2 | 180 | 7.32 | 0.62F | 11.683 | Compliant |
| | Pos'n 3 | 180 | 7.32 | 0.62F | 9.622 | Compliant |
| | Pos'n 4 | 180 | 7.32 | 0.62F | 7.807 | Compliant |
| 50% w/ CL Holds - Small FSM | Pos'n 0 | 180 | 7.32 | 0.62F | 7.395 | Compliant |
| 50% w/ P&S Holds - Large FSM | Pos'n 0 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 1 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 2 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 3 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 4 | | | CAPSIZ | | Non-Compliant |
| 50% w/ CL Holds - Large FSM | Pos'n 0 | | | CAPSIZ | | Non-Compliant |
| 5% Load w/ P&S Holds | Pos'n 0 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 1 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 2 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 3 | | | CAPSIZ | | Non-Compliant |
| | Pos'n 4 | | | CAPSIZ | | Non-Compliant |
| 5% Load w/ CL Holds | Pos'n 0 | | | CAPSIZ | | Compliant |

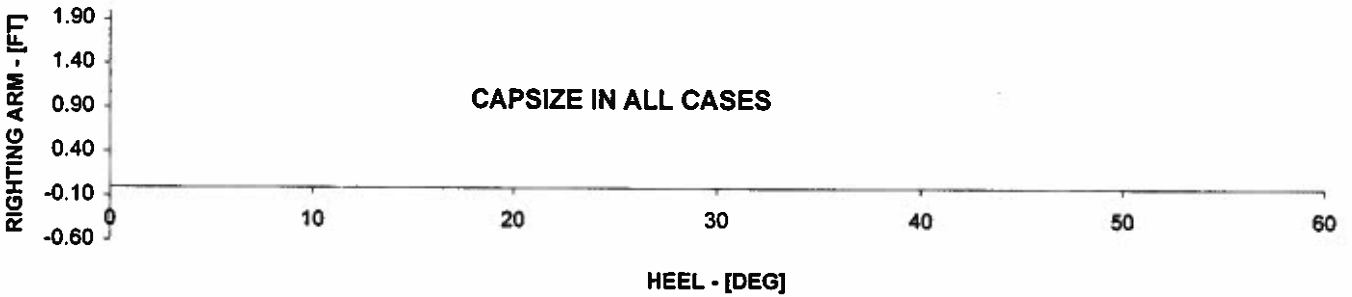
RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - FULL LOAD



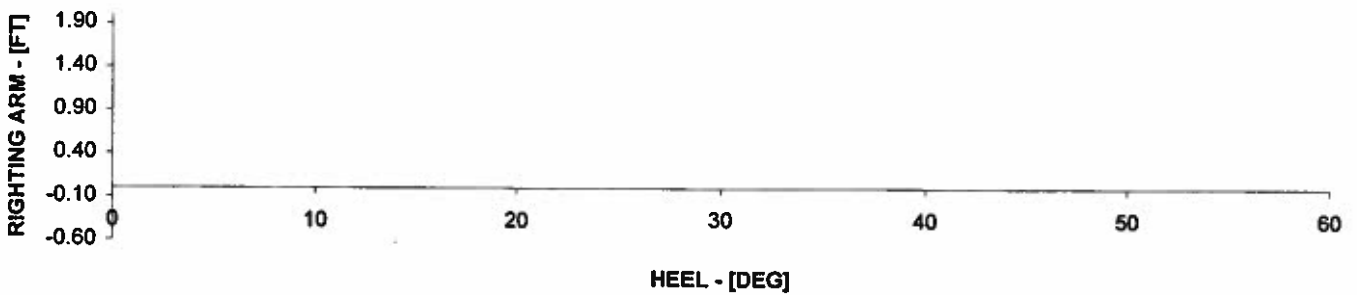
RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - 50% LOAD (SMALL FSM)



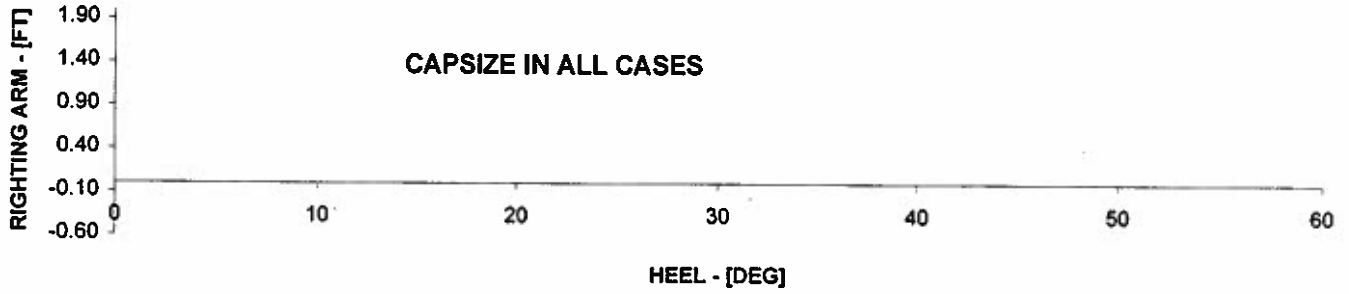
RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - 50% LOAD (LARGE FSM)



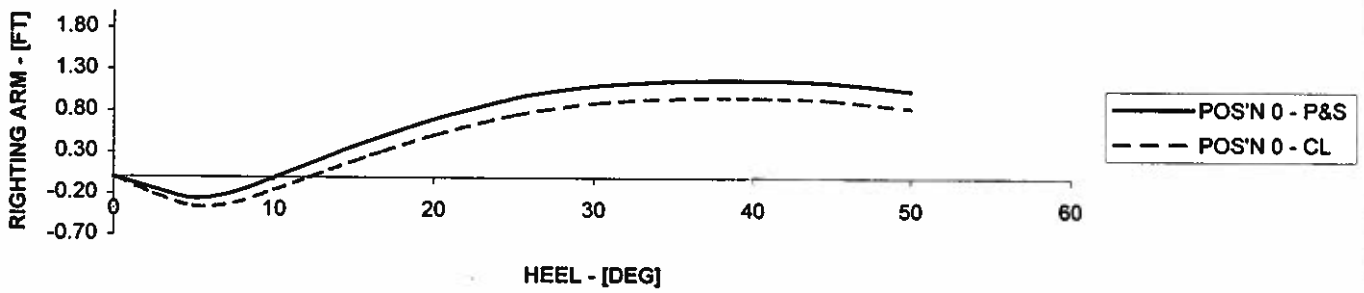
RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - 5% LOAD



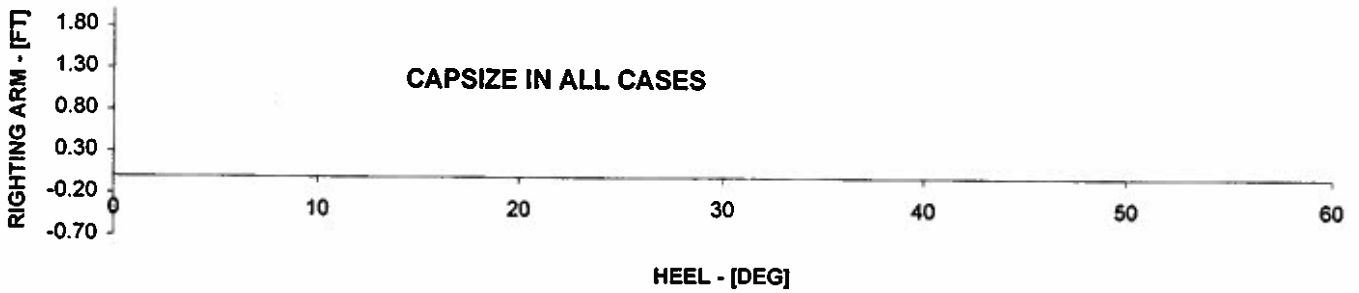
RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - FULL LOAD



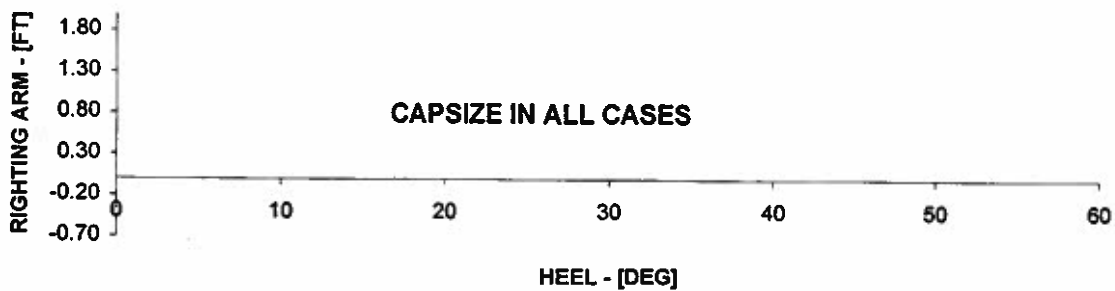
RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - 50% LOAD (SMALL FSM)



RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - 50% LOAD (LARGE FSM)



RIGHTING ARM CURVE - S.S. SPADE
WATER ON DECK - 46 CFR 28.565 - 5% LOAD

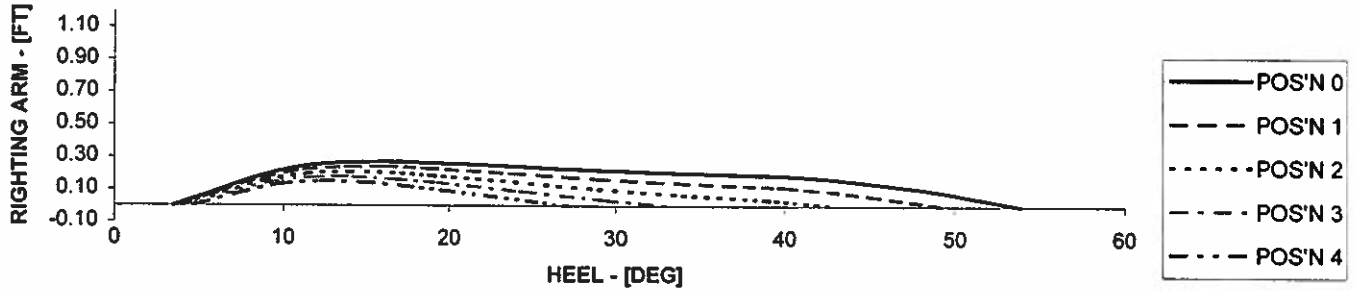


Summary of Stability Conditions - S.S. Spade

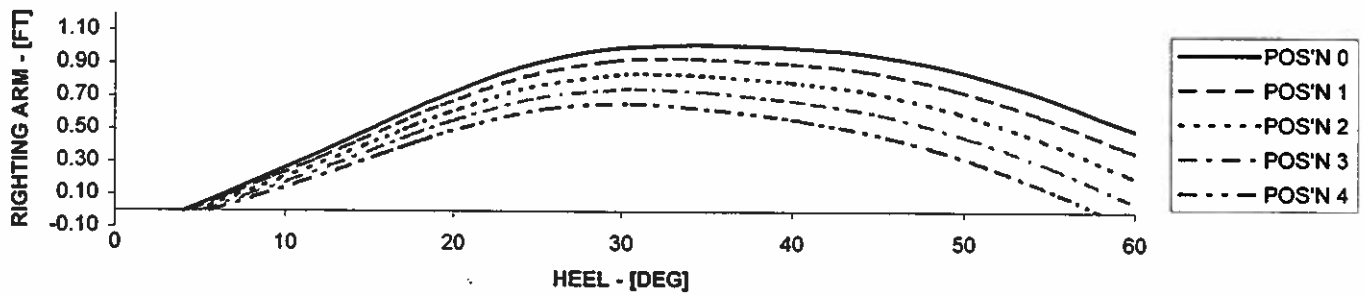
LIFTING OVER THE SIDE - 46 CFR 28.545 (Heeling Moment = 24 [LT-Ft])
 [Items in BOLD are not compliant.]

| Condition | Location of VCG Wt. | Δ [LT] | Mean Draft [Ft] | Trim [Ft] | Absolute Angle of Equilibrium - [Deg] | Area From Angle of Equilibrium to 40° or RA-zero | Status |
|------------------------------|---------------------|--------|-----------------|-----------|---------------------------------------|--|---------------|
| Requirements | | | | | | | |
| | | | | | Less Than 10° | Greater Than 15.0 Ft-Deg | |
| Full Load w/ P&S Holds | Pos'n 0 | 203 | 7.92 | 1.31A | 3.5 | 7.73 | Non-Compliant |
| | Pos'n 1 | 203 | 7.92 | 1.31A | 3.7 | 6.23 | Non-Compliant |
| | Pos'n 2 | 203 | 7.92 | 1.31A | 4.0 | 4.52 | Non-Compliant |
| | Pos'n 3 | 203 | 7.92 | 1.31A | 4.3 | 2.98 | Non-Compliant |
| | Pos'n 4 | 203 | 7.92 | 1.31A | 4.7 | 2.02 | Non-Compliant |
| Full Load w/ CL Holds | Pos'n 0 | 203 | 7.92 | 1.31A | 5.2 | 5.60 | Non-Compliant |
| 50% w/ P&S Holds - Small FSM | Pos'n 0 | 145 | 6.27 | 3.21F | 4.0 | 24.83 | Compliant |
| | Pos'n 1 | 145 | 6.27 | 3.21F | 4.3 | 22.78 | Compliant |
| | Pos'n 2 | 145 | 6.27 | 3.21F | 4.7 | 20.44 | Compliant |
| | Pos'n 3 | 145 | 6.27 | 3.21F | 5.1 | 18.11 | Compliant |
| | Pos'n 4 | 145 | 6.27 | 3.21F | 5.6 | 15.79 | Compliant |
| 50% w/ CL Holds - Small FSM | Pos'n 0 | 145 | 6.27 | 3.21F | 7.1 | 18.28 | Compliant |
| 50% w/ P&S Holds - Large FSM | Pos'n 0 | 139 | 6.06 | 0.35F | 3.5 | 22.15 | Compliant |
| | Pos'n 1 | 139 | 6.06 | 0.35F | 3.7 | 20.02 | Compliant |
| | Pos'n 2 | 139 | 6.06 | 0.35F | 4.0 | 17.57 | Compliant |
| | Pos'n 3 | 139 | 6.06 | 0.35F | 4.3 | 15.12 | Compliant |
| | Pos'n 4 | 139 | 6.06 | 0.35F | 4.7 | 12.69 | Non-Compliant |
| 50% w/ CL Holds - Large FSM | Pos'n 0 | | | | CAPSIZE | | Non-Compliant |
| 5% Load w/ P&S Holds | Pos'n 0 | 79 | 4.20 | 3.70F | 12.0 | 0.37 | Non-Compliant |
| | Pos'n 1 | | | | CAPSIZE | | Non-Compliant |
| | Pos'n 2 | | | | CAPSIZE | | Non-Compliant |
| | Pos'n 3 | | | | CAPSIZE | | Non-Compliant |
| | Pos'n 4 | | | | CAPSIZE | | Non-Compliant |
| 5% Load w/ CL Holds | Pos'n 0 | | | | CAPSIZE | | Non-Compliant |

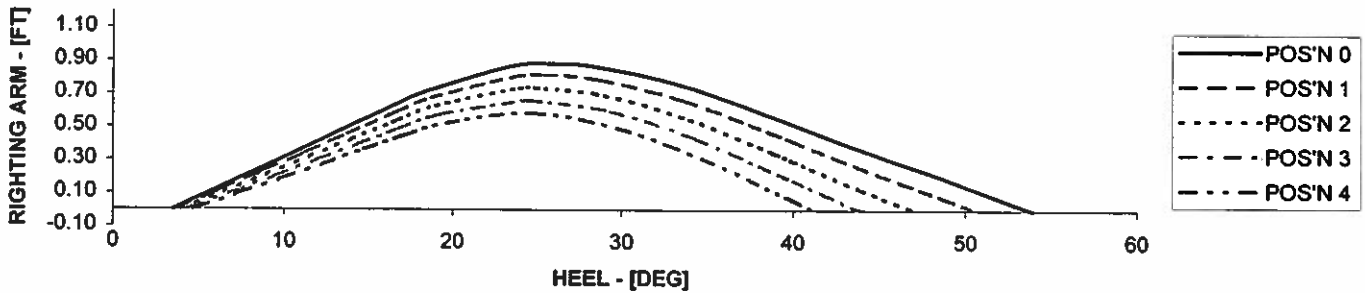
RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - FULL LOAD



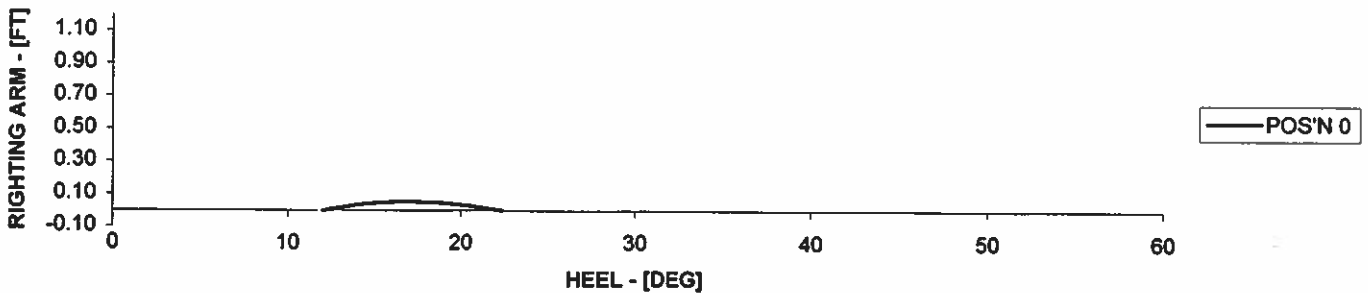
RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - 50% LOAD (SMALL FSM)



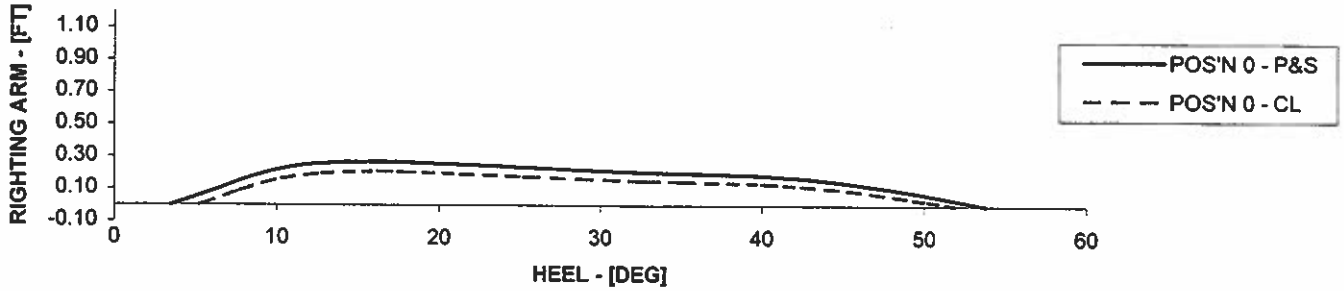
RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - 50% LOAD (LARGE FSM)



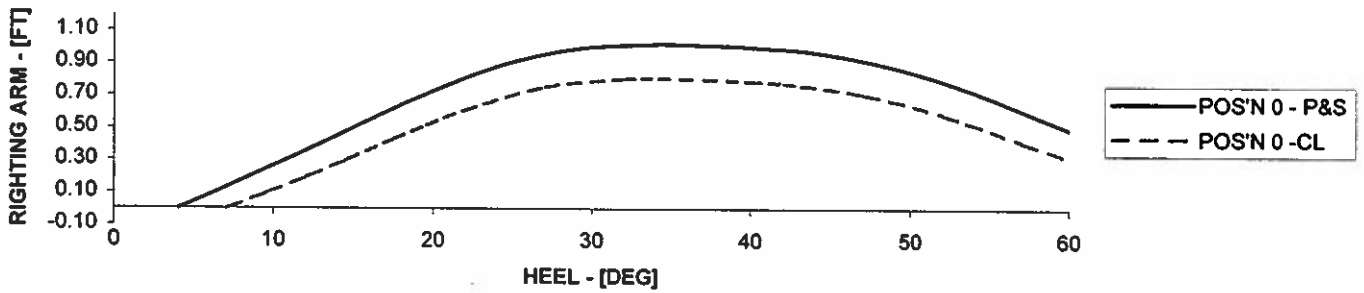
RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - 5% LOAD



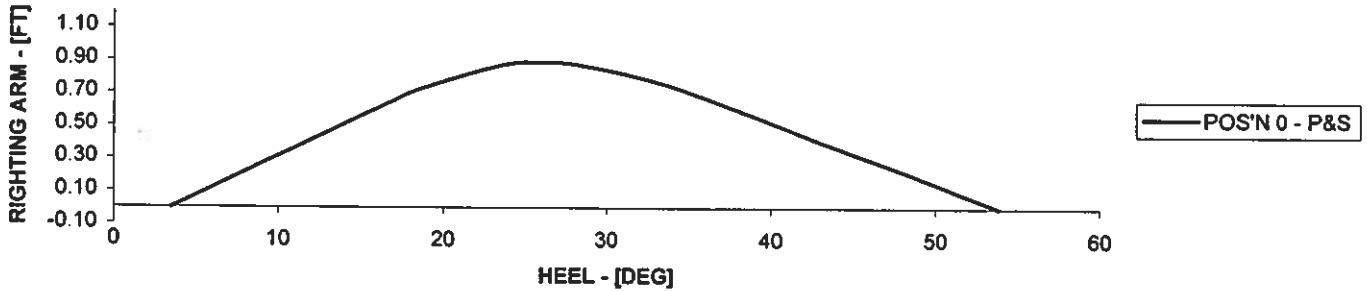
**RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - FULL LOAD**



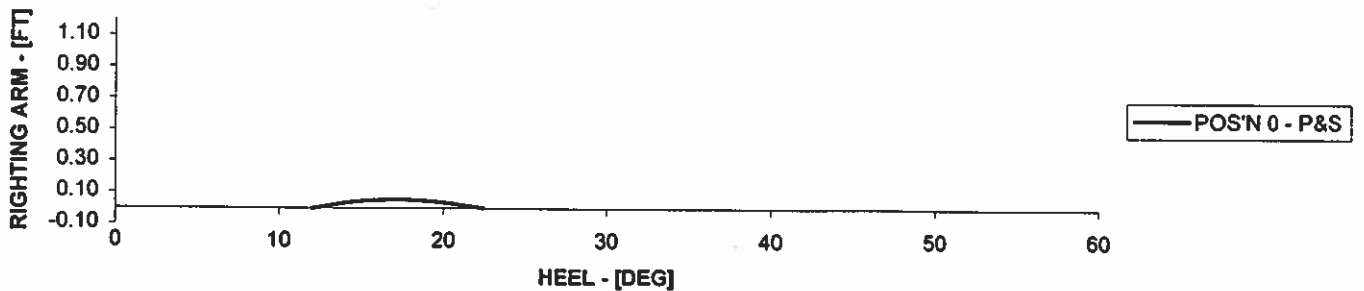
**RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - 50% LOAD (SMALL FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - 50% LOAD (LARGE FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
LIFTING OVER THE SIDE - 46 CFR 28.545 - 5% LOAD**



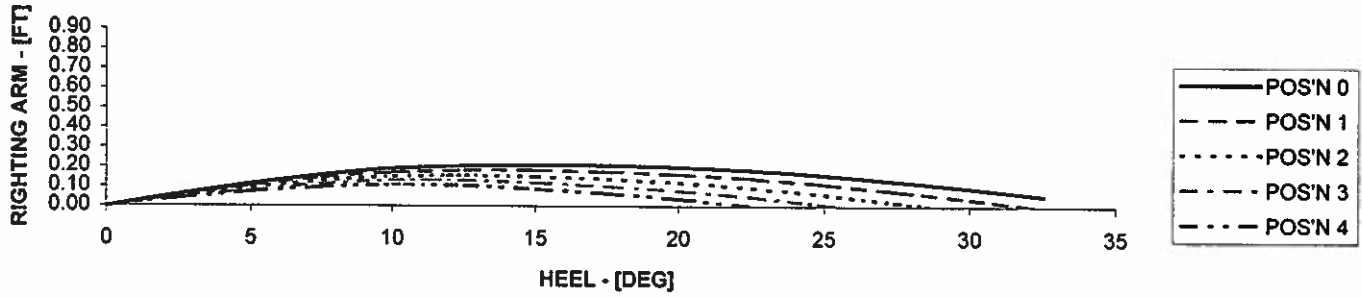
Summary of Stability Conditions - S.S. Spade

DAMAGE TO ENGINE ROOM - 46 CFR 28.580

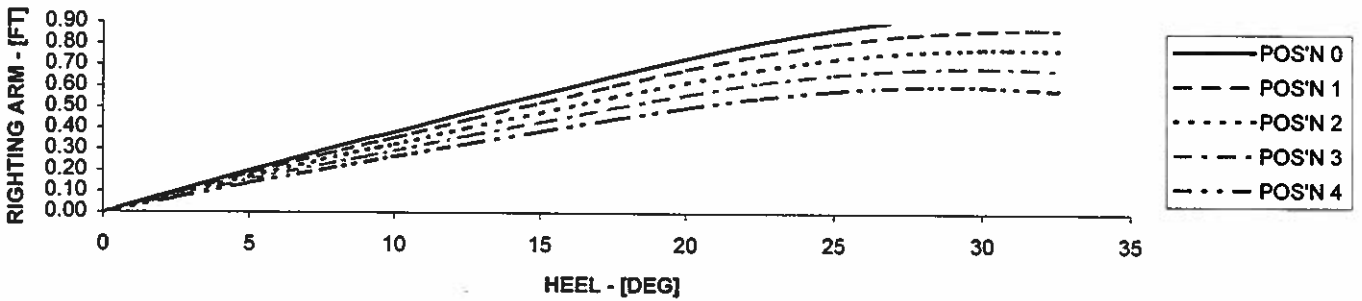
[Items in BOLD are not compliant.]

| Condition | Location of VCG Wt. | Δ | Mean Draft [Ft] | Trim [Ft] | Absolute Angle of Equilibrium - [Deg] | Positive Range of Stability [Deg] | RA-Max [Ft] | Status |
|------------------------------|---------------------|-----|-----------------|-----------|---------------------------------------|-----------------------------------|---------------------|---------------|
| | | | | | Less Than 25° | Greater Than 20.0° | Greater Than 0.333F | |
| | | | | | Requirements | | | |
| Full Load w/ P&S Holds | Pos'n 0 | 202 | 9.66 | 6.46F | 0.0 | >30 | 0.21 | Non-Compliant |
| | Pos'n 1 | 202 | 9.66 | 6.46F | 0.0 | >30 | 0.18 | Non-Compliant |
| | Pos'n 2 | 202 | 9.66 | 6.46F | 0.0 | 28.6 | 0.15 | Non-Compliant |
| | Pos'n 3 | 202 | 9.66 | 6.46F | 0.0 | 25.4 | 0.13 | Non-Compliant |
| | Pos'n 4 | 202 | 9.66 | 6.46F | 0.0 | 22.5 | 0.11 | Non-Compliant |
| Full Load w/ CL Holds | Pos'n 0 | 202 | 9.66 | 6.46F | 0.0 | >30 | 0.14 | Non-Compliant |
| 50% w/ P&S Holds - Small FSM | Pos'n 0 | 144 | 7.82 | 10.22F | 0.0 | >30 | 0.95 | Compliant |
| | Pos'n 1 | 144 | 7.82 | 10.22F | 0.0 | >30 | 0.87 | Compliant |
| | Pos'n 2 | 144 | 7.82 | 10.22F | 0.0 | >30 | 0.78 | Compliant |
| | Pos'n 3 | 144 | 7.82 | 10.22F | 0.0 | >30 | 0.69 | Compliant |
| | Pos'n 4 | 144 | 7.82 | 10.22F | 0.0 | >30 | 0.60 | Compliant |
| 50% w/ CL Holds - Small FSM | Pos'n 0 | 144 | 7.82 | 10.22F | 0.0 | >30 | 0.74 | Compliant |
| 50% w/ P&S Holds - Large FSM | Pos'n 0 | 138 | 7.35 | 6.84F | 0.0 | >30 | 0.78 | Compliant |
| | Pos'n 1 | 138 | 7.35 | 6.84F | 0.0 | >30 | 0.71 | Compliant |
| | Pos'n 2 | 138 | 7.35 | 6.84F | 0.0 | >30 | 0.63 | Compliant |
| | Pos'n 3 | 138 | 7.35 | 6.84F | 0.0 | >30 | 0.55 | Compliant |
| | Pos'n 4 | 138 | 7.35 | 6.84F | 0.0 | >30 | 0.47 | Compliant |
| 50% w/ CL Holds - Large FSM | Pos'n 0 | | | | CAPSIZING | | | Non-Compliant |
| 5% Load w/ P&S Holds | Pos'n 0 | 78 | 5.56 | 10.48F | 0.0 | >30 | 0.20 | Non-Compliant |
| | Pos'n 1 | 78 | 5.56 | 10.48F | 0.0 | 28.9 | 0.10 | Non-Compliant |
| | Pos'n 2 | | | | CAPSIZING | | | Non-Compliant |
| | Pos'n 3 | | | | CAPSIZING | | | Non-Compliant |
| | Pos'n 4 | | | | CAPSIZING | | | Non-Compliant |
| 5% Load w/ CL Holds | Pos'n 0 | | | | CAPSIZING | | | Non-Compliant |

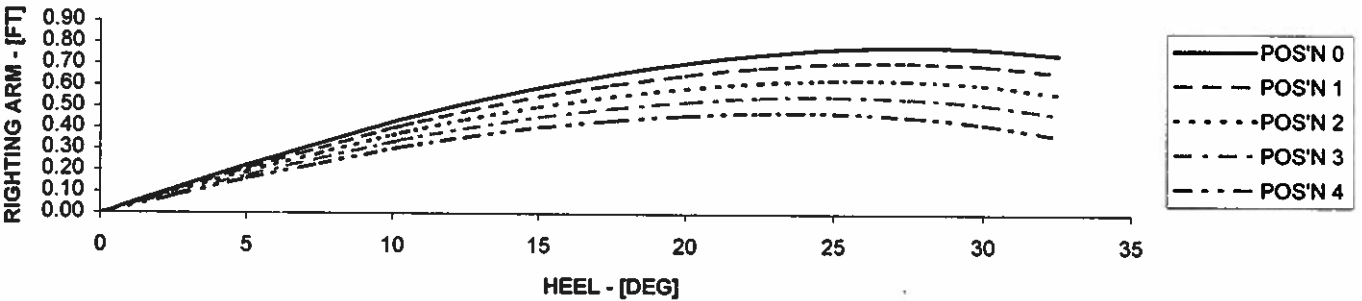
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO ENGINE ROOM - 46 CFR 28.580 - FULL LOAD**



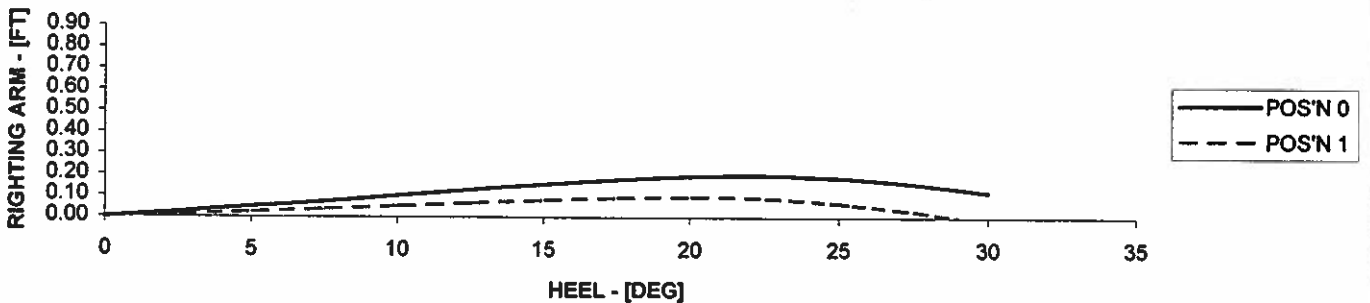
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO ENGINE ROOM - 46 CFR 28.580 - 50% LOAD (SMALL FSM)**

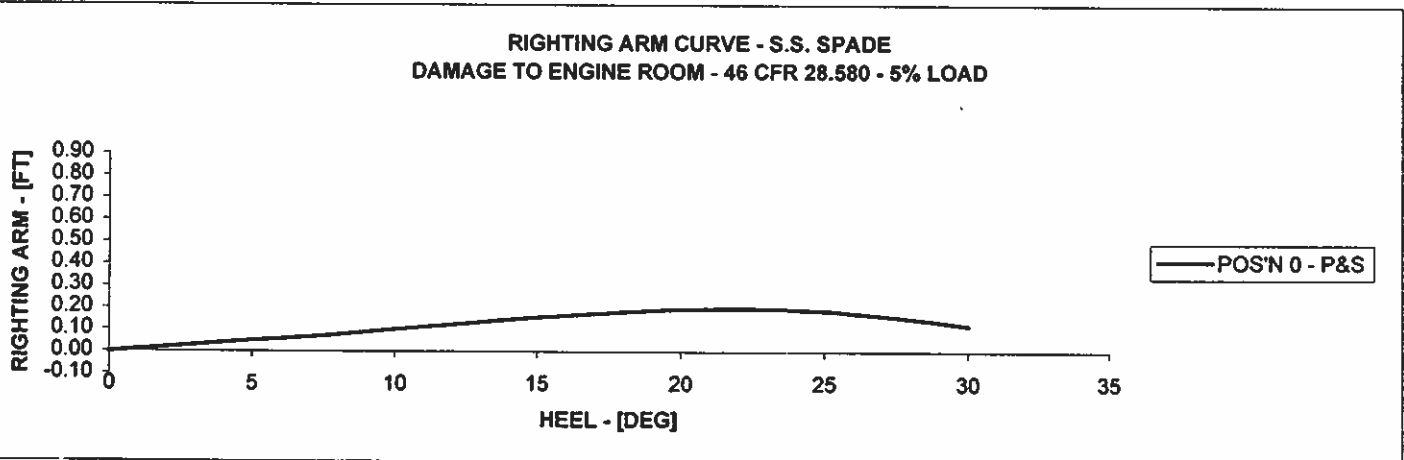
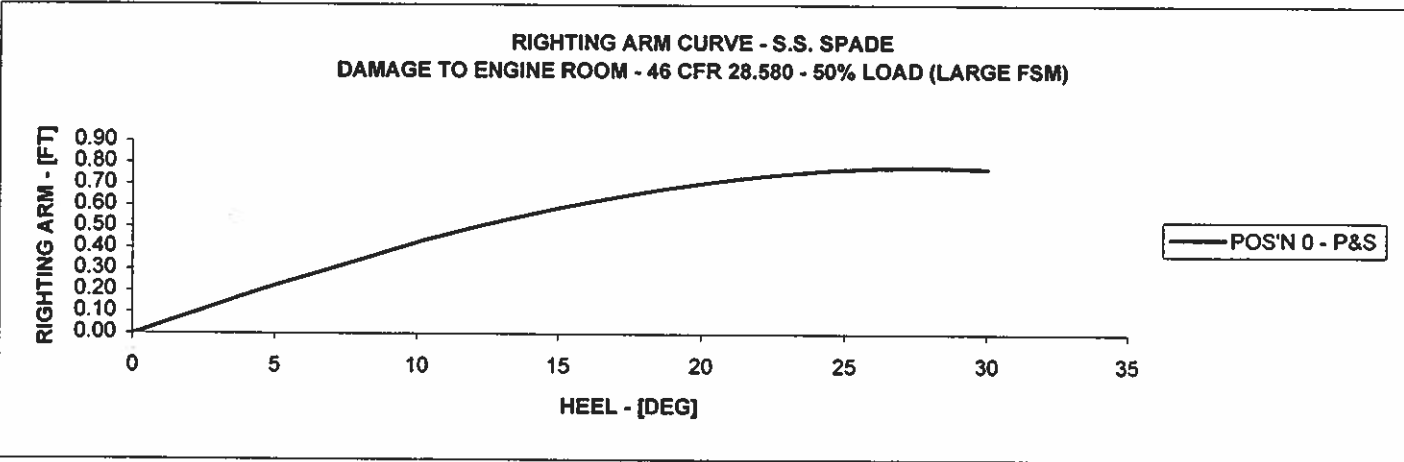
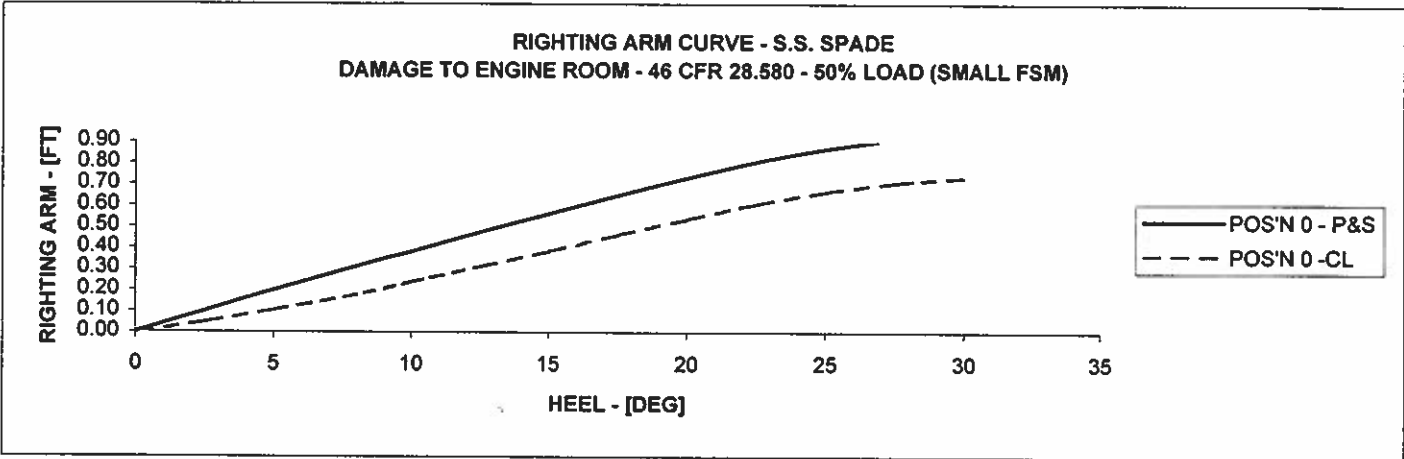
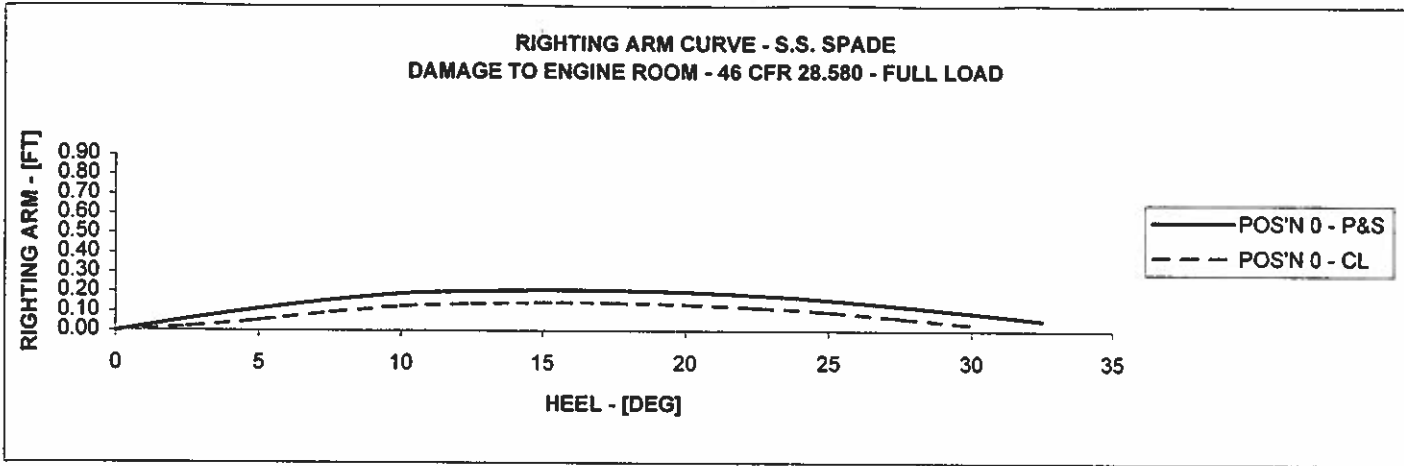


**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO ENGINE ROOM - 46 CFR 28.580 - 50% LOAD (LARGE FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO ENGINE ROOM - 46 CFR 28.580 - 5% LOAD**



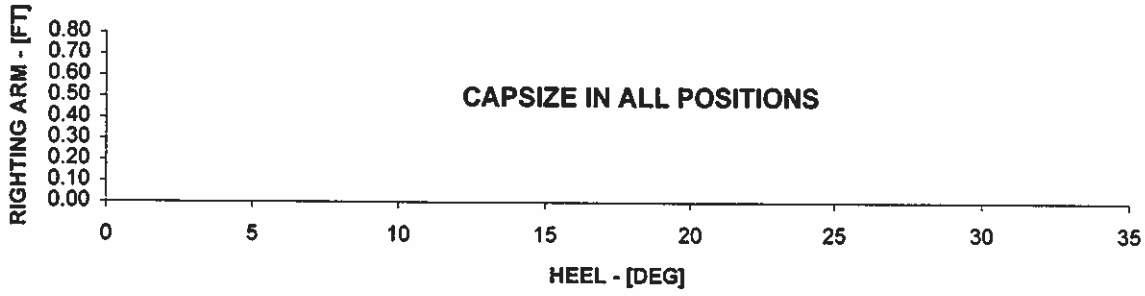


Summary of Stability Conditions - S.S. Spade

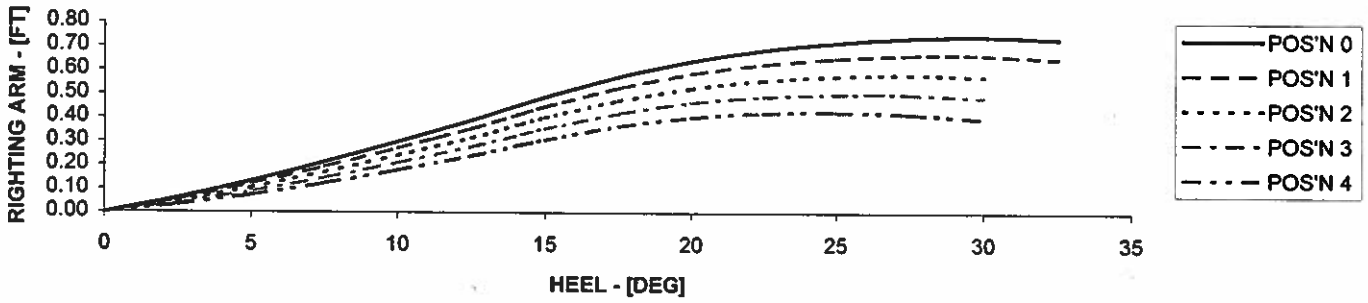
DAMAGE TO LAZERETTES (AFTPEAK.C) - 46 CFR 28.580
 [Items in **BOLD** are not compliant.]

| Condition | Location of VCG Wt. | Δ [LT] | Mean Draft [Ft] | Trim [Ft] | Absolute Angle of Equilibrium - [Deg] | Positive Range of Stability [Deg] | RA-Max [Ft] | Status |
|------------------------------|---------------------|--------|-----------------|-----------|---------------------------------------|-----------------------------------|-------------|---------------|
| | | | | | | | | |
| Full Load w/ P&S Holds | Pos'n 0 | | | | CAPSIZ | | | Non-Compliant |
| | Pos'n 1 | | | | CAPSIZ | | | Non-Compliant |
| | Pos'n 2 | | | | CAPSIZ | | | Non-Compliant |
| | Pos'n 3 | | | | CAPSIZ | | | Non-Compliant |
| | Pos'n 4 | | | | CAPSIZ | | | Non-Compliant |
| Full Load w/ CL Holds | Pos'n 0 | | | | CAPSIZ | | | Non-Compliant |
| 50% w/ P&S Holds - Small FSM | Pos'n 0 | 144 | 6.79 | 0.23F | 0.0 | >30 | 0.74 | Compliant |
| | Pos'n 1 | 144 | 6.79 | 0.23F | 0.0 | >30 | 0.67 | Compliant |
| | Pos'n 2 | 144 | 6.79 | 0.23F | 0.0 | >30 | 0.58 | Compliant |
| | Pos'n 3 | 144 | 6.79 | 0.23F | 0.0 | >30 | 0.50 | Compliant |
| | Pos'n 4 | 144 | 6.79 | 0.23F | 0.0 | >30 | 0.42 | Compliant |
| 50% w/ CL Holds - Small FSM | Pos'n 0 | 144 | 6.79 | 0.23F | 0.0 | >30 | 0.53 | Compliant |
| 50% w/ P&S Holds - Large FSM | Pos'n 0 | 138 | 6.60 | 5.13A | 0.0 | >30 | 0.49 | Compliant |
| | Pos'n 1 | 138 | 6.60 | 5.13A | 0.0 | >30 | 0.44 | Compliant |
| | Pos'n 2 | 138 | 6.60 | 5.13A | 0.0 | >30 | 0.38 | Compliant |
| | Pos'n 3 | 138 | 6.60 | 5.13A | 0.0 | >30 | 0.33 | Non-Compliant |
| | Pos'n 4 | 138 | 6.60 | 5.13A | 0.0 | 27.8 | 0.28 | Non-Compliant |
| 50% w/ CL Holds - Large FSM | Pos'n 0 | | | | CAPSIZ | | | Non-Compliant |
| 5% Load w/ P&S Holds | Pos'n 0 | 78 | 4.33 | 3.53F | 0.0 | >30 | 0.38 | Compliant |
| | Pos'n 1 | 78 | 4.33 | 3.53F | 0.0 | >30 | 0.30 | Non-Compliant |
| | Pos'n 2 | 78 | 4.33 | 3.53F | 0.0 | 25.9 | 0.21 | Non-Compliant |
| | Pos'n 3 | 78 | 4.33 | 3.53F | 0.0 | 21.5 | 0.12 | Non-Compliant |
| | Pos'n 4 | 78 | 4.33 | 3.53F | 0.0 | 17.1 | 0.05 | Non-Compliant |
| 5% Load w/ CL Holds | Pos'n 0 | 78 | 4.33 | 3.53F | 4.5 | 20.2 | 0.12 | Non-Compliant |

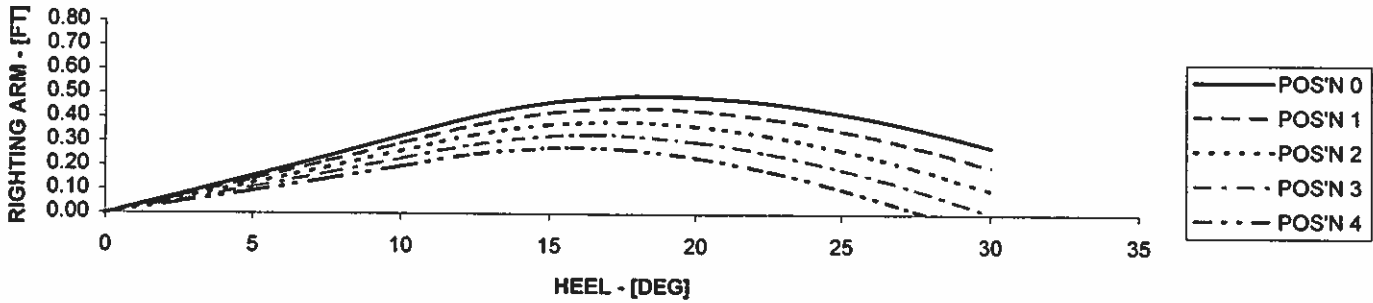
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - FULL LOAD**



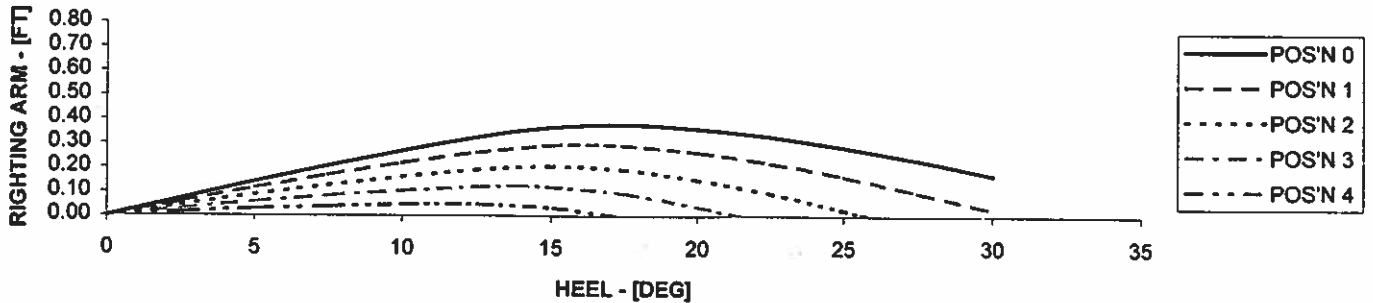
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - 50% LOAD (SMALL FSM)**



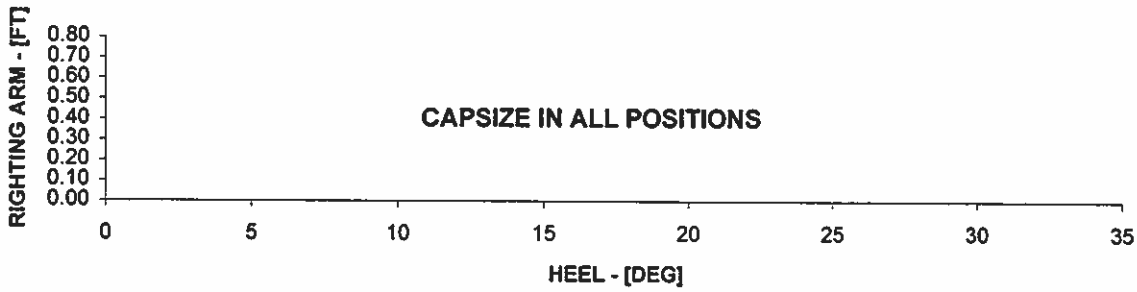
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - 50% LOAD (LARGE FSM)**



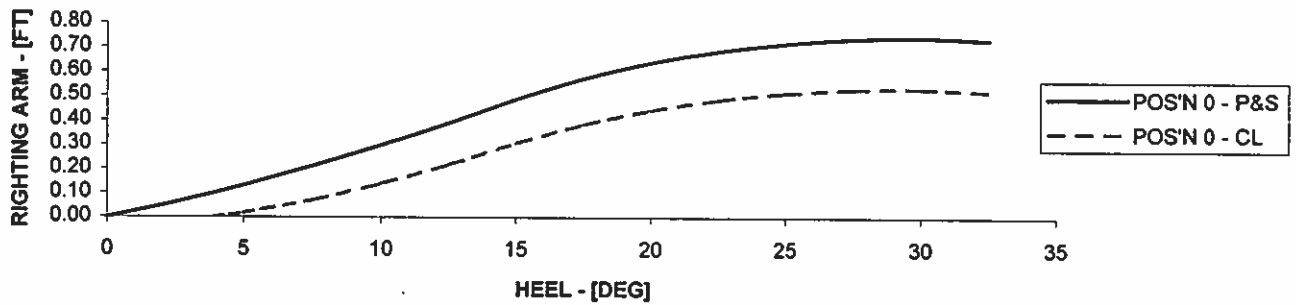
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - 5% LOAD**



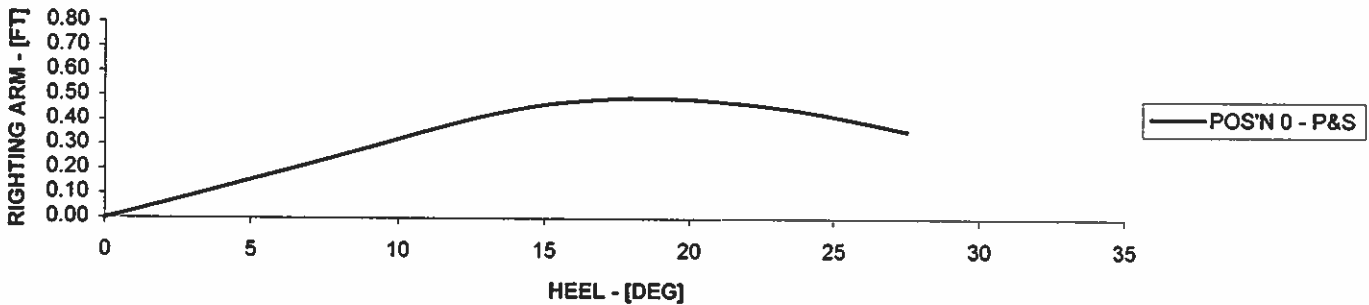
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - FULL LOAD**



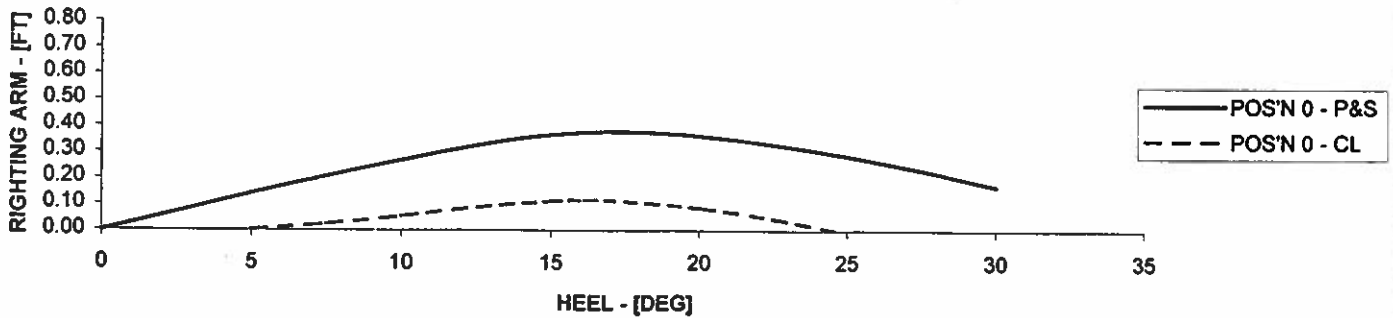
**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - 50% LOAD (SMALL FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - 50% LOAD (LARGE FSM)**



**RIGHTING ARM CURVE - S.S. SPADE
DAMAGE TO LAZERETTE - 46 CFR 28.580 - 5% LOAD**



APPENDIX C
INCLINING DATA FOR "S.S. SPADE"

Inclining Instructions - S.S. Spade

In order to incline the “Spade”, the following equipment items are needed:

- Inclining weights, included with this model;
- Pendulum (string with attached weight), attached to the top of the mast;
- A measuring scale taped to the wheelhouse deck, used to measure the deflections;
- A bathroom scale, or equivalent, used to weigh the “Spade”.

An anecdotal description of the inclining procedure is presented below:

1. Float the model in its water tank and position the 2 inclining weights on the longitudinal centerline, per the configuration of Figure 1. Ensure that the VCG weights are in their lowest positions;
2. Attach the pendulum to the top of the mast, leaving enough string so that the end of the pendulum is suspended less than an inch above the wheelhouse deck. Measure and record the length of the pendulum in inches;
3. Secure a measuring scale, such as a flat ruler, by taping it to the wheelhouse deck, immediately forward of the mast. In this way, as the pendulum shifts from side to side, its deflections can be measured using the ruler;
4. At right angles to the longitudinal centerline, i.e., athwartships, shift Weight No.1 to the extreme port side of the vessel. Measure the weight shift distance “d” and the pendulum deflection “y”. Using the Sample Calculation Table on the next page, record these values in the appropriate columns of the row labeled “1st Trial”. Also, use the recorded data and the given data to calculate the moment ($w d$), the cumulative moment ($\Sigma w d$) and the heel angle ($\tan\phi$);
5. While keeping Weight No.1 at its new position, move Weight No.2 athwartships to the extreme port side of the vessel. Measure the weight shift distance “d” and the pendulum deflection “y”. Using the Sample Calculation Table on the next page, record these values in the appropriate columns of the row labeled “2nd Trial”. Also, use the recorded data and the given data to calculate the moment ($w d$), the cumulative moment ($\Sigma w d$) and the heel angle ($\tan\phi$);
6. Move both weights back to the neutral position and insert “0” in the appropriate columns of the Sample Calculation Table row labeled “3rd Trial”.
7. Repeat steps 4 and 5, only this time make the 2 weight shifts to starboard instead of port. Record the data and perform the necessary calculations in the rows labeled “4th Trial” and “5th Trial”.
8. Plot a graph of “ $\tan\phi$ ” vs. “ $\Sigma w d$ ” and determine the slope of this graph.
9. Weigh the model using a bathroom scale or shipper’s scale, and multiply the weight by the slope of the graph in 8 above. The reciprocal of this value equals the GM in inches.

U.S.C.G. Interactive Stability Trainer - Inclining Experiment Results

Project No: 343
 Vessel: S.S. Spade
 Date: 20-Aug-98

$$GM = \frac{1}{\Delta (\tan\phi / w d)}$$

Where:
 Δ = Weight of model;
 w = Weight of inclining weights [lbs];
 d = Distance that inclining weight is shifted [in];
 $\tan\phi$ = Heel angle due to shift of inclining weight(s) = y / l ,
 where: y = pendulum deflection [in]; and l = length of pendulum [in].

| | | |
|--|----------------|---|
| Weight of Model, Including VCG Weights: | 39.0000 | |
| Weight of Pendulum and Ruler: | 0.1375 | Pendulum Length l = 15.96 |
| Weight of Inclining Wts. 1 and 2 (2x8.5oz) | 1.0625 | |
| Total = As-Inclined Weight of Model | 40.2000 | |

| | Weight | | Weight Shift d Stbd/Port (+/-) in | Moment - $w d$ Stbd/Port (+/-) in-lbs | Cumulative Moment - $\Sigma w d$ Stbd/Port (+/-) in-lbs | Pendulum Deflections - y Stbd/Port (+/-) in | $\tan\phi - y / l$ |
|---|--|---------|--|---|--|--|--------------------|
| | No. | lbs | | | | | |
| Weights on longitudinal centerline | | | | | | | |
| 1st Trial | 1 | 0.53125 | 7.5 | 3.9844 | 3.9844 | 1.339 | 0.0839 |
| 2nd Trial | 2 | 0.53125 | 7.5 | 3.9844 | 7.9688 | 2.677 | 0.1677 |
| 3rd Trial | Move both weights back to longitudinal centerline | | | | 0.0000 | 0 | 0.0000 |
| 4th Trial | 1 | 0.53125 | -7.5 | -3.9844 | -3.9844 | -1.378 | -0.0863 |
| 5th Trial | 2 | 0.53125 | -7.5 | -3.9844 | -7.9688 | -2.756 | -0.1727 |

The above data is used to plot a graph of $\tan\phi$ vs. $\Sigma w d$ (Cumulative Moment). See following page.

From graph, slope of line ($\tan\phi / \Sigma w d$) = 0.02136

| Draft Readings [in] | |
|---------------------|------|
| Fwd | Aft |
| 4.44 | 1.68 |

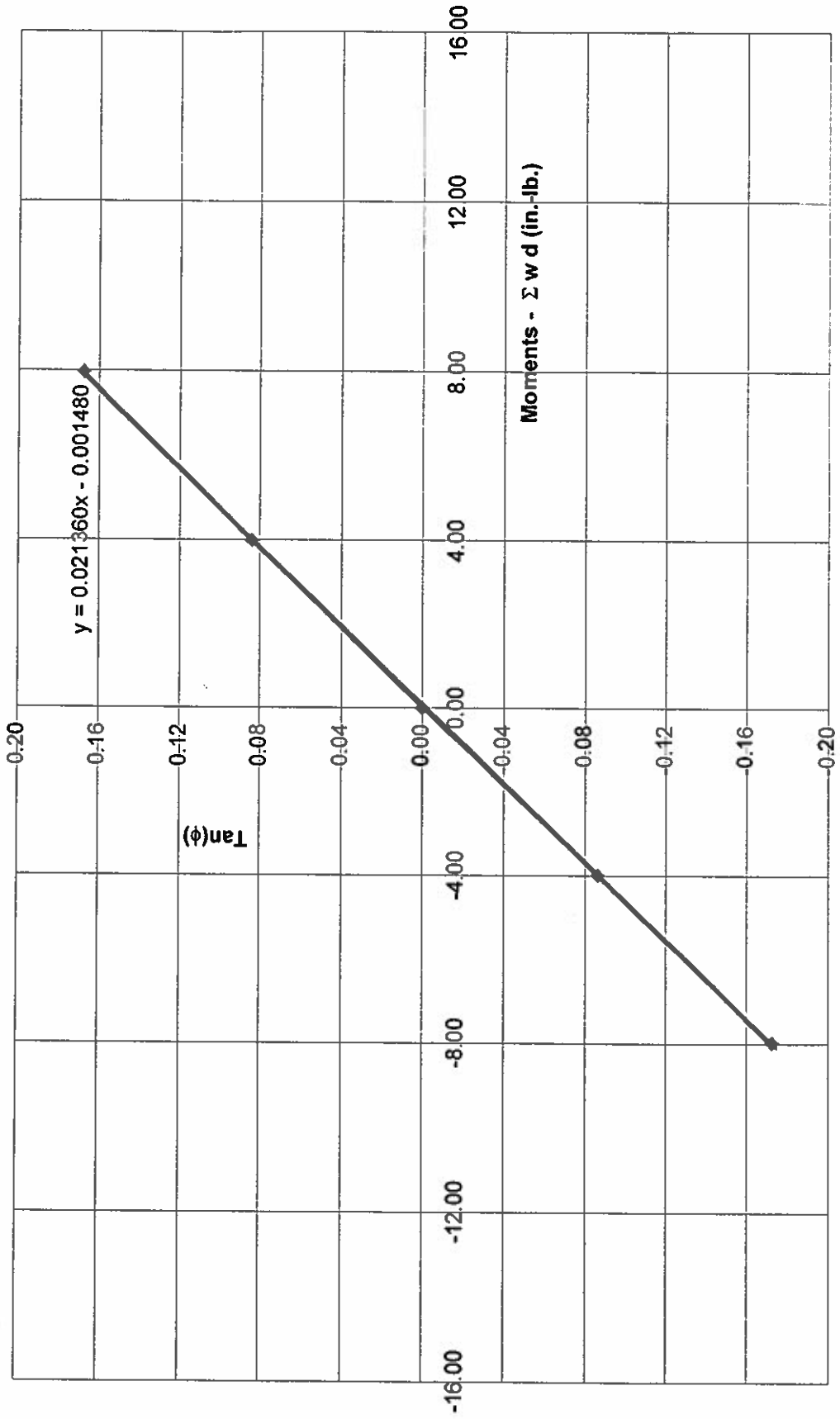
GM_t = 1.16 in. - Model
1.55 ft. - Full Scale

Weights on /Off Correction
 Pendulum and inclining weights removed

Based on above corrections:

GM (corrected) = 1.20 in.

Stability Test of S.S. Spade



U.S.C.G. Interactive Stability Trainer - Inclining Experiment Results

Project No:

Vessel:

Date:

| | |
|--|--|
| $GM = \frac{1}{\Delta (\tan\phi / w d)}$ | <p>Where:</p> <p>Δ = Weight of model;</p> <p>w = Weight of inclining weights [lbs];</p> <p>d = Distance that inclining weight is shifted [in];</p> <p>$\tan\phi$ = Heel angle due to shift of inclining weight(s) = y / l,</p> <p>where: y = pendulum deflection [in]; and l = length of pendulum [in].</p> |
|--|--|

| | |
|---|--|
| Weight of Model, Including VCG Weights: | |
| Weight of Pendulum and Ruler: | |
| Weight of Inclining Wts. 1 and 2 | |
| Total = As-Inclined Weight of Model | |

Pendulum Length l =

| | Weight | | Weight Shift d Stbd/Port (+/-) in | Moment - w d Stbd/Port (+/-) in-lbs | Cumulative Moment - $\Sigma w d$ Stbd/Port (+/-) in-lbs | Pendulum Deflections - y Stbd/Port (+/-) in | $\tan\phi - y / l$ |
|-----------|--|-----|--|---|--|--|--------------------|
| | No. | lbs | | | | | |
| | Weights on longitudinal centerline | | | | | | |
| 1st Trial | 1 | | -7.5 | | | | |
| 2nd Trial | 2 | | -7.5 | | | | |
| 3rd Trial | Move both weights back to longitudinal centerline | | | | | | |
| 4th Trial | 1 | | 7.5 | | | | |
| 5th Trial | 2 | | 7.5 | | | | |

The above data is used to plot a graph of $\tan\phi$ vs. $\Sigma w d$ (Cumulative Moment). See following page.

From graph, slope of line ($\tan\phi / \Sigma w d$) =

$GM_t =$ in. - Model
 ft. - Full Scale

| Draft Readings [in] | |
|---|---|
| Fwd | Aft |
| <input style="width: 50px;" type="text"/> | <input style="width: 50px;" type="text"/> |