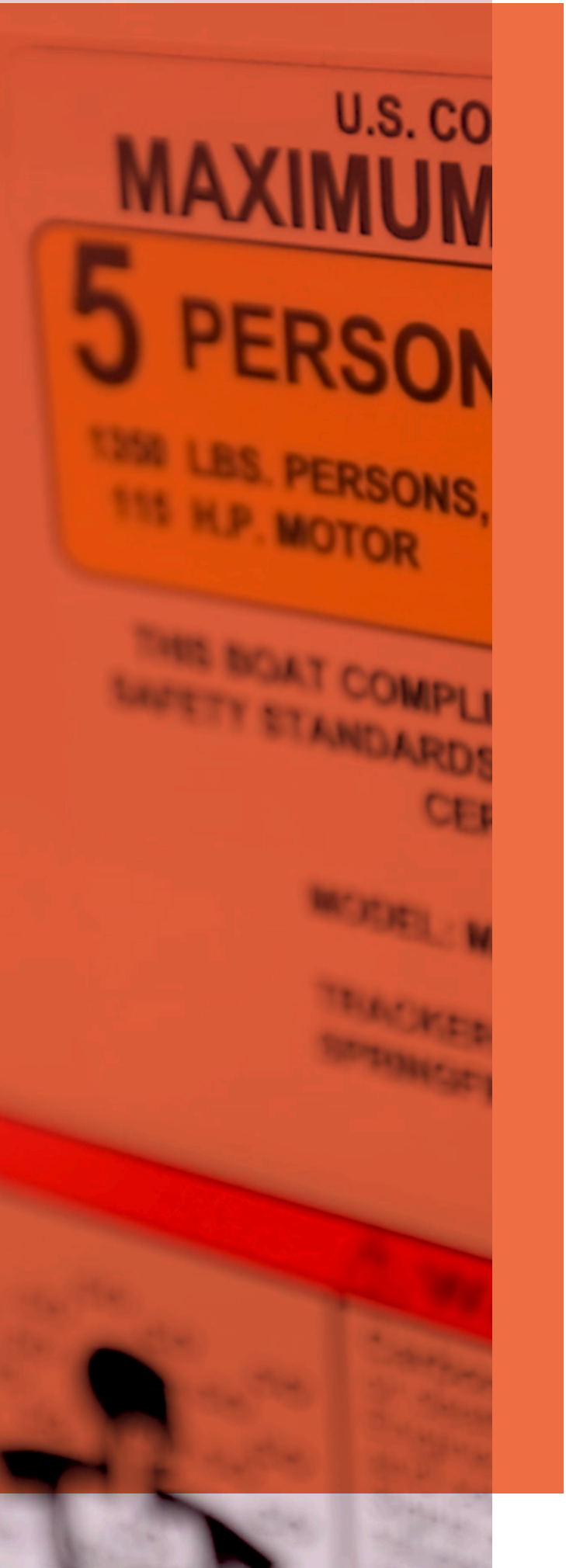


BOAT BUILDER'S HANDBOOK

2021 Edition

FLOTATION REQUIREMENTS FOR INBOARD BOATS, INBOARD/OUTDRIVE BOATS, AND AIRBOATS

33 CFR 183 SUBPART F

FLOTATON REQUIREMENTS FOR OUTBOARD BOATS RATED FOR ENGINES OF MORE THAN 2 HORSEPOWER

33 CFR 183 SUBPART G

FLOTATION REQUIREMENTS FOR OUTBOARD BOATS RATED FOR ENGINES OF 2 HORSEPOWER OR LESS

33 CFR 183 SUBPART H

Produced under a grant from the Sport Fish Restoration and Boating Trust Fund Administered by the U.S. Coast Guard

CONTENTS

INTRODUCTION . . . 3

1.0 APPLICABILITY . . . 5

2.0 DEFINITIONS . . . 6

3.0 FLOTATION & STABILITY TESTS . . . 13

3.1 Persons and Gear Weight . . . 13

3.2 Preconditioning . . . 14

3.3 Passing Criteria . . . 14

4.0 ESTIMATING THE REQUIRED QUANTITY OF FLOTATION . . . 19

4.1 Basic Flotation . . . 19

4.1.1Example Calculation for Basic Flotation . . . 23

4.2 Level Flotation . . . 25

4.2.1 Example Calculation for Level Flotation . . . 33

4.3 Modified Level Flotation . . . 36

4.3.1 Example Calculations for Modified Level Flotation . . . 38

5.0 FLOTATION MATERIALS . . . 40

5.1 FLOTATION MATERIAL TESTS . . . 40

5.2 FLOTATION MATERIAL INSTALLATION REQUIREMENTS . . . 42

Appendix 1. Flotation References & Resources . . . 44

Appendix 2. 33 CFR Subpart F – Flotation Requirements for Inboard Boats, Inboard/Outdrive Boats, and Airboats . . . 45

Appendix 3. 33 CFR Subpart G – Flotation Requirements for Outboard Boats Rated for Engines of More than 2 Horsepower . . . 48

Appendix 4. 33 CFR Subpart H – Flotation Requirements for Outboard Boats Rated for Engines of 2 Horsepower of Less . . . 52

INTRODUCTION

This guide is intended to help a boat manufacturer comply with the flotation requirements for certain boats. The CFR has separate subparts applicable to the three basic types of boats covered (Subpart F for inboards & Sterndrives / Subpart G for Outboards over 2 HP / Subpart H for Manual propulsion and outboards over 2 HP). The three subparts repeat many regulations; this guideline will cover the three boat types together section by section without repeating common regulations.

Compliance with these requirements IS THE RESPONSIBILITY of the boat manufacturer. This guide shows the calculations necessary for design and production considerations, and describes the test methods necessary to achieve and confirm compliance.

The regulations only refer to 'flotation'. There are commonly used terms to differentiate among the flotation requirements for the three boat types. This guideline will routinely use the following terms:

BASIC FLOTATION: the flotation requirements for inboards and sterndrives where in a swamped boat must have some part of the hull above water.

LEVEL FLOTATION: the flotation requirements for outboard powered boats over 2 HP to meet specific flotation and stability criteria with respect to a swamped boat's orientation with both the swamped persons weights centered and a portion of the swamped persons weights off to the side.

MODIFIED LEVEL FLOTATION: the flotation requirements for manual propulsion boats and outboard powered boats of 2 HP or less – wherein the flotation and stability guidelines are the same as for an outboard over 2HP but the persons load is 'modified' to a lower load.

The flotation & stability test criteria will be discussed in detail in this guideline. Each one has its own requirements and specific tests. This Guideline is organized in an easy-to-follow format. Each subpart describes the boats included, explains the general requirements for these boats, and lists the type of flotation necessary in each.

See the Boat Tests for Flotation & Stability' (and displacement/weight capacity) training video on safeafloat.com.

As demonstrated in the video, the flotation and stability tests for rowboats and all outboards is a series of four tests:

Level flotation with swamped persons weight – with the designated quantity of swamped persons weight within the designated area in the center of the boat (swamped boat should provide secure platform for people to remain with the boat)

Starboard stability – with half the swamped persons weight moved to starboard and the other half removed) – (swamped boat should allow for some movement without turning over)

Port stability – half swamped persons weight to port.

Level flotation without persons weight (swamped boat should provide a secure platform for people to remain with the swamped boat). The purpose of this test is to check that the boat, without weights for passengers, will not capsize. The persons weights may actually help the boat stay level because of a lower center of gravity while, if removed, the boat could overturn if the flotation material buoys up the center of the boat.

A key point to meeting the flotation and stability criteria is that both quantity of flotation material and the location of the flotation material are critical.

The CFR only covers the method to determine if a boat passes the applicable flotation and stability tests. This guideline will provide training both in estimating the quantity and specifying the placement of the flotation material as needed to pass the tests. In one instance the guideline provides a method to estimate the quantity of flotation material with an added safety factor. That is, for both Basic Flotation and Modified Level Flotation, the CFR requirement is for flotation to support 2/15 (or 13%) of the maximum persons capacity (MPC) and 25% of the gear weight. The guideline suggests flotation material to support 25% of the maximum weight capacity (MWC) – which is the combination of the MPC and gear weight. Thus, the estimated quantity of flotation material is larger – and the math is easier.

Engine weight Table 183.75 is used in this process of establishing engine and battery test weights for the flotation and stability tests. Table183.75 is covered in this Boatbuilder's Handbook in the guideline for engine weights per 33 CFR 183 Subpart.

TAKE HEED: Boat builder compliance means fully meeting all applicable regulations. The Boatbuilder's Handbook provides a basic introduction and summary of the regulations. Builders need to refer to the actual regulations for the complete text of the regulation to ensure full compliance. It is the boat manufacturer's responsibility to review, understand, and comply with all applicable regulations.

1.0 APPLICABILITY

The flotation regulations apply to monohull boats less than 20 feet in length, except sailboats, canoes, kayaks, inflatable boats, submersibles, surface effect vessels, amphibious vessels, and race boats.

The word "regulations" (plural) is used as there are three flotation subparts applicable to three classifications of boats.

Following is a summary of the applicability by boat type and subpart.

Subpart	Boat Type	Flotation Required
F	Inboards, sterndrives, and Air Boats	*BASIC FLOTATION*
G	Outboard Boats Rated for More Than 2 Horsepower	*LEVEL FLOTATION*
H	Outboard Boats Rated for 2 Horsepower or Less and Manually Propelled Boats	*MODIFIED LEVEL FLOTATION*

Monohull inboard, sterndrives and airboats less than 20 feet in length must comply with a flotation system called Basic Flotation. Basic flotation is the simplest type of flotation mode. It simply requires that the boat be manufactured with sufficient flotation material to keep it afloat in the event of a swamping. It does not require that the boat remain in an upright or in any specific position. It may float, and usually does, in a "spar" position, the bow sticking up and the stern sunk. Many sterndrive boat builders opt to provide flotation material to meet a higher standard.

Monohull boats under 20 feet in length and rated for more than two horsepower must comply with the more demanding flotation system called Level Flotation. The Level Flotation system requires that the swamped boat, loaded with certain weights representing persons capacity, the swamped engine, gear weight, and a permanent fuel tank (if installed), must float in an approximately level position and not heel past a certain angle, even when part of the passengers' weight is to the side of the passenger carrying area – or when the passengers are outside the boat.

Manually propelled boats and boats rated for outboard engines of 2 HP or less must comply with the Modified Level Flotation requirements. As the name suggests, Modified Level Flotation is similar to Level Flotation, but with a lesser amount of persons weight. One additional difference is that air chambers are allowed to provide flotation for these type boats. The potential use of air chambers for flotation for inboards/sterndrives and outboards over 2 HP is so restrictive that they are not used.

2.0 DEFINITIONS

Several of the definitions are then demonstrated in Figures 1 through 10.

Basic Flotation: A flotation system which will keep a swamped boat from sinking when its passengers are in the water clinging to it, provided that the aggregate weight of the motor, passengers and equipment carried in or attached to the boat does not exceed the boat's maximum weight capacity. With Basic Flotation, the swamped boat may float at any attitude.

Bilge: The area in the boat, below a height of 4 inches measured from the lowest point in the boat, where liquid can collect when the boat is in its static floating position, except engine rooms.

Boat Length: Means the straight line horizontal measurement of the overall length from the foremost part of the boat to the aftermost part of the boat, measured from end to end over the deck excluding sheer, and measured parallel to the centerline. Bowsprits, bumpkins, rudders, outboard motor brackets, handles, and other similar fittings, attachments, and extensions are not included in the measurement. Molded in / welded on components are considered to be a part of boat length.

Connected: Allowing a flow of water in excess of one-quarter ounce per hour from the engine room bilge into any other compartment with a 12-inch head of water on the engine room side of the bulkhead.

Engine room: The compartment where a permanently installed gasoline engine, diesel engine, or electric motor is installed, including connected compartments.

Engine room bilge: The area in the engine room or a connected compartment below a height of 12 inches measured from the lowest point where liquid can collect in these compartments when the boat is in its static floating position.

Gear Weight: The allowance for additional material to be loaded into the boat (ground tackle / anchoring gear / fishing gear / hunting gear / picnicking gear / water sports gear). Gear weight is calculated by taking the maximum weight capacity (MWC) marked on the boat minus the maximum persons capacity (MPC) marked on the boat minus the Table 183.75 column 9 figure for combined engine, controls, battery, permanent fuel tank. For inboard & sterndrives (with no Table 183.75 factor) gear weight is simply the quantity (MWC – MPC). The CFR refers to this quantity for inboards/sterndrives as "dead weight". The better and much more descriptive term "gear weight" is used in this guideline for all three basic boat types.

Horsepower Capacity: The maximum recommended horsepower capacity of a boat as stated on the boat's capacity plate.

Level Flotation: A flotation system that will keep a swamped boat and a specified quantity of the weights of its motor, equipment, passengers and gear floating in an approximately level attitude. Sufficient stability is provided to prevent the swamped craft from capsizing in calm water when one-half of the passengers are evenly distributed at one side of the passenger carrying area. Level Flotation does not provide a self-righting capability.

Modified Level Flotation: A flotation system that provides level flotation, as defined above - but - with a reduction in the quantity of flotation required for passengers. Plus, air chambers are allowed to provide flotation.

Mono-hull: any vessel on which, when it is at rest and carries its maximum rated horsepower capacity and maximum weight capacity, the line of intersection of the water surface and the hull forms a single closed curve. For example: a catamaran, trimaran or pontoon boat is not a mono-hull boat. However, it is important to observe that some small catamarans, when loaded, do form a single water line and must be considered mono-hulls.

Open to atmosphere: A compartment that has at least 15 square inches of open area directly exposed to the atmosphere for each cubic foot of net compartment volume.

Passenger Carrying Area: When swamped the passenger carrying area is the area within the recess of a boat in which persons can reasonable occupy in a seated position or stand while the boat is swamped and underway. A boat is underway when it is not at anchor or moored. The passenger carrying area may include areas other than recommended on plane or designated occupant positions. Figures 1 to 5 explain the passenger carrying area for different boat configurations.

Race boat: Any vessel that is manufactured solely for use in sanctioned racing events, and is not intended for use as a recreational boat. By USCG policy, a race boat is not subject to any recreational boat regulations. Boats not in full compliance with all applicable USCG regulations for the appropriate boat type must not have a hull identification number (HIN) affixed.

Reference area: The forward most and after most two feet of the top surface of the boat hull or deck.

Reference depth: The vertical distance from the uppermost surface of the swamped boat's reference area to the surface of the water measured on the centerline of the boat.

Sailboat: A boat designed or intended to use sails as the primary means of propulsion.

Sealed compartment: An enclosure that can resist an exterior water level of 12 inches without seepage of more than one-quarter fluid ounce per hour.

Static Floating Position: The attitude in which a boat floats in calm, fresh water with fuel tanks filled to rated capacity, but with no person or items of portable equipment aboard. The boat should include all permanently installed factory supplied equipment and options such as, but not limited to the engine or engines, batteries, seats, engine oil, railings, fishing towers, etc. It should not include portable gear such as, but not limited to flags, searchlights, movable cushions, mattresses, portable fire extinguishers, lines, fenders, chairs, tables, anchors or live bait wells.

Swamped Waterline: A theoretical waterline above that dry weights will be used and below that submerged weights will be used, when calculating for the required flotation.

FIGURE 1 Length of Passenger Carrying Area — Location of Center of Gravity of Weights

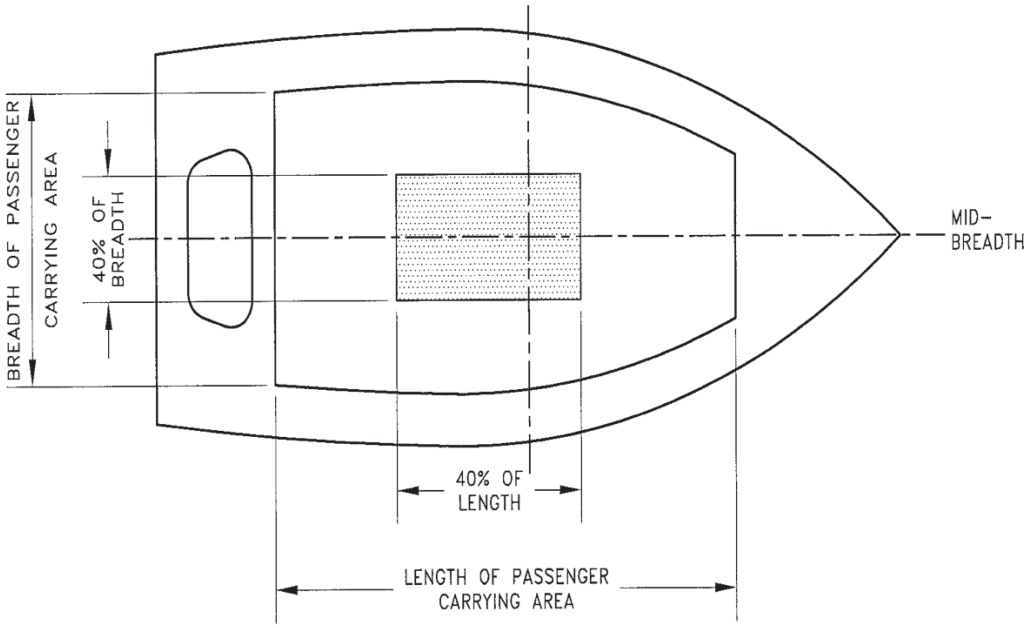


FIGURE 2 Length of Passenger Carrying Area — Boat with Deck

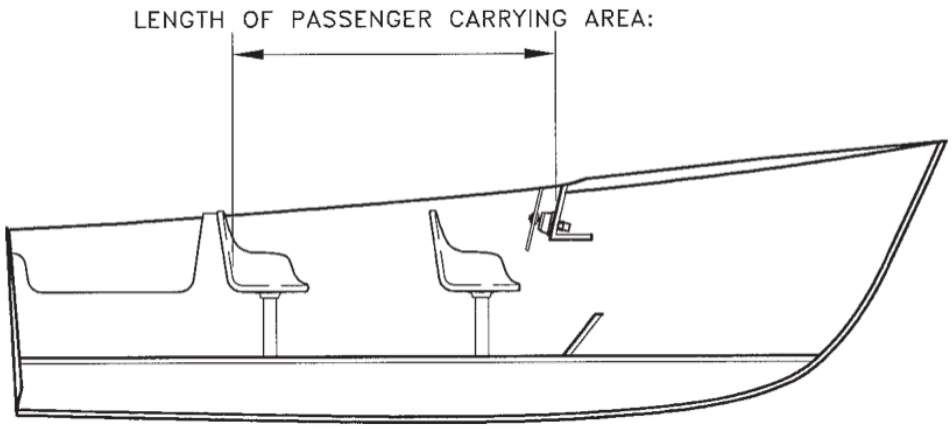


FIGURE 3 Length of Passenger Carrying Area – Boat with Center Console

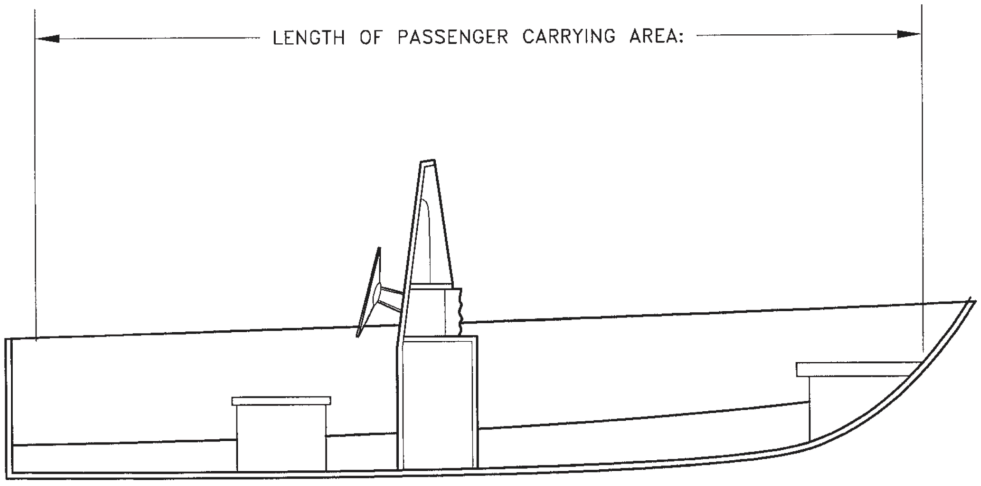


FIGURE 4 Length of Passenger Carrying Area – Open Boat with Curved Stem

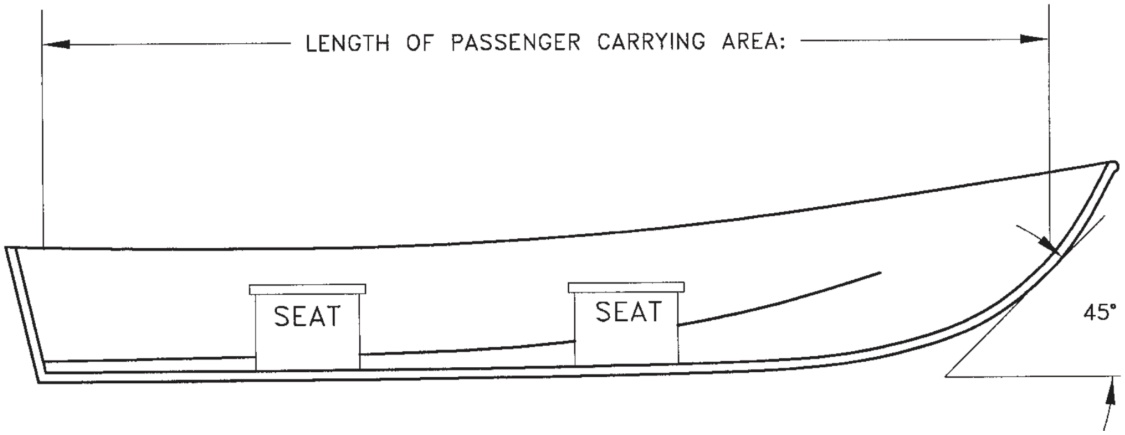


FIGURE 5 Length of Passenger Carrying Area – Boat with Cabin

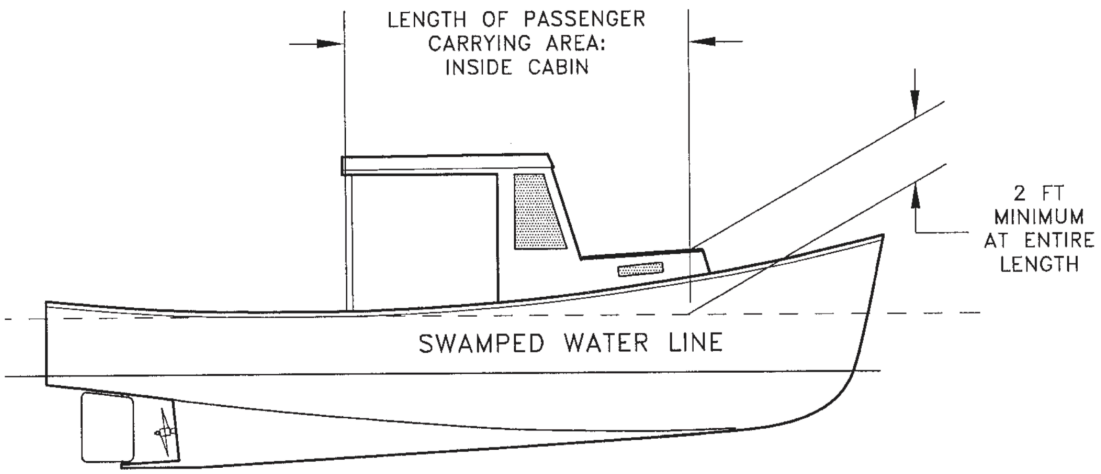


FIGURE 6 Reference Area

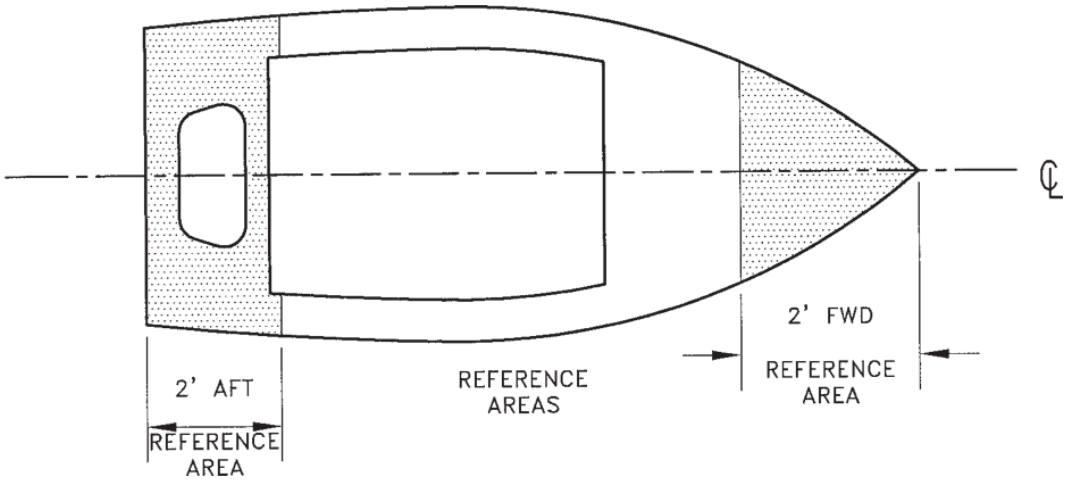


FIGURE 7 Reference Depth

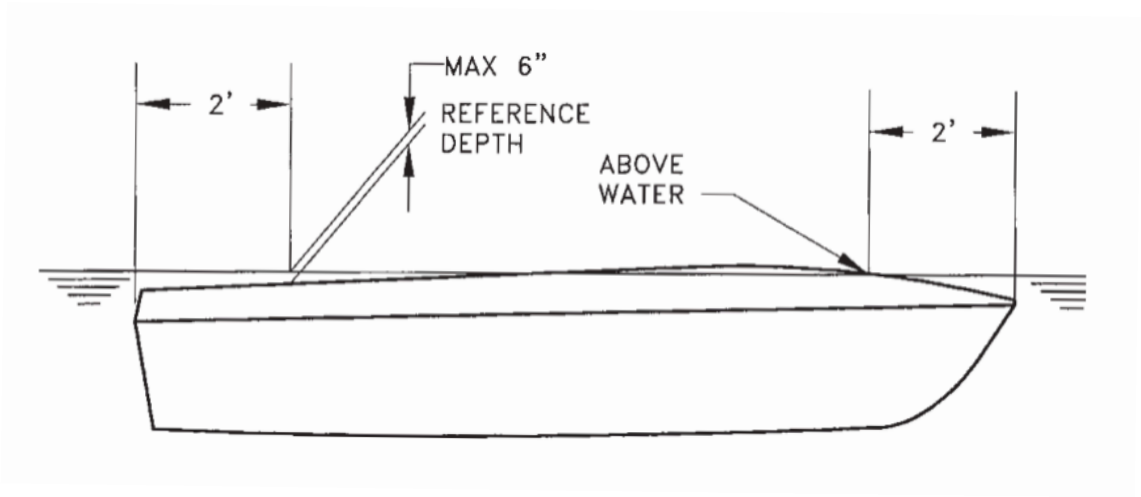


FIGURE 8 Static Floating Position

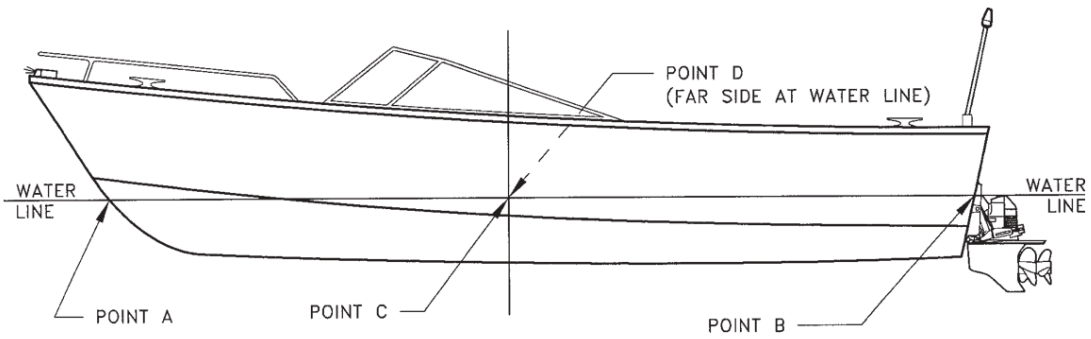
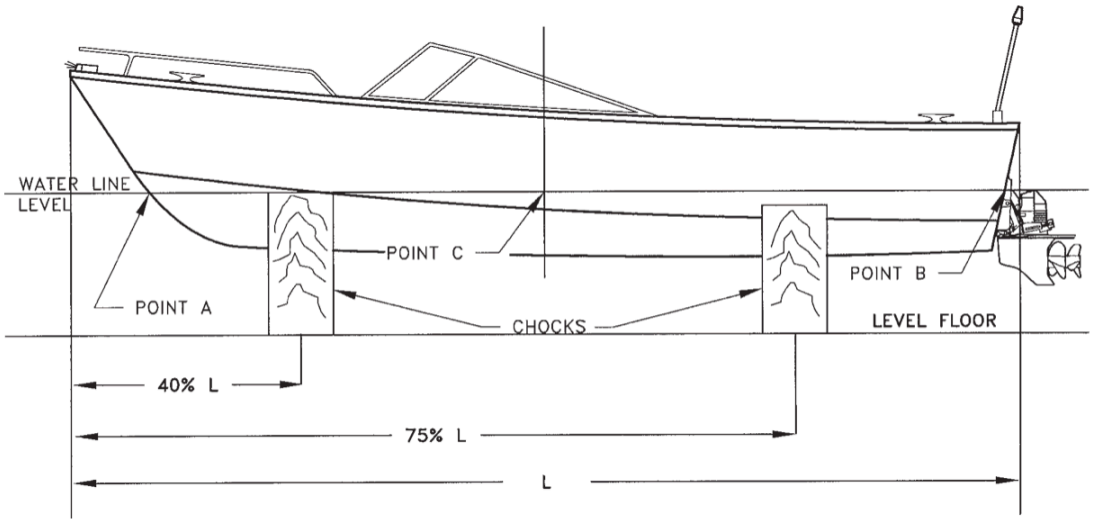
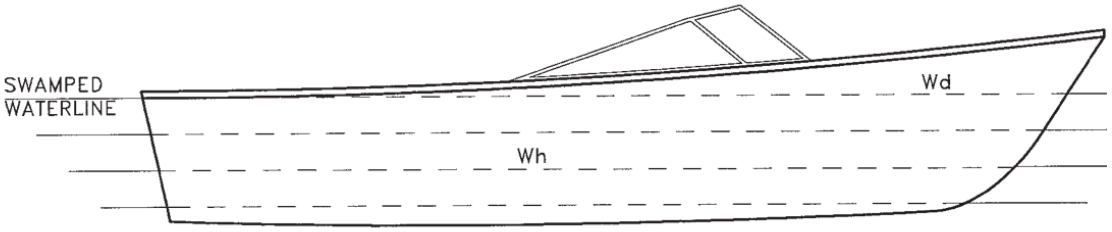


FIGURE 9 Location of Supports for Level Boat



NOTE:
Point A is exactly at the waterline at the Bow; Point B, exactly at the intersection of the waterline and the centerline of the transom. Points C and D are at the waterline amidships, at either side. If the boat is mounted in chocks, this line should be horizontal.

FIGURE 10 Swamped Waterline



3.0 FLOTATION AND STABILITY TESTS

The CFR specify how the three categories of boats are to pass the flotation and stability tests. Those regulations are discussed in this section; the next section of this guideline will cover how to estimate the quantity of flotation material needed for the boat to pass these tests.

3.1 PERSONS AND GEAR WEIGHT

> Per 183.105 – Regulations for the persons and gear loads for flotation tests for inboards, stern-drives, and airboats for a submerged boat to keep any portion of the boat above the surface of

An inboard / sterndrive will be loaded with weights equal to:

- 2/15 of the maximum persons capacity (MPC)
- 25% of gear weight (that is: MWC – MPC)

> Per 183.220 – Regulations for the persons, gear, swamped engine loads for the flotation and stability tests for outboards over 2 HP to keep the boat level and stable.

An outboard over 2 HP will be loaded with weights equal to:

- 50% of first 550 pounds of MPC & 12 ½% of remainder of MPC
- 25% of gear weight (that is: MWC – MPC – Table 183.75 column 9
- swamped weight of engine (and controls) per Table 183.75
- submerged weight of battery per Table 183.75
- (filled) permanent fuel tank

> Per 183.320 – Regulations for the persons and gear loads for the flotation and stability tests for boats rated for manual propulsion or outboard engines of 2 HP or less.

A manually propelled boat or outboard of 2 HP or less will be loaded with weights equal to:

- 2/15 of the MPC
- 25% of gear weight (that is: MWC – MPC – Table 183.74, column 9)
- swamped engine weight per Table 183.75 (if applicable)

3.2 PRECONDITIONING

Regardless of the flotation system, or the type of flotation materials used, the boat must be prepared and then pre-conditioned before beginning the test procedure. The boat must be complete with all permanent components in place. To prepare for preconditioning, the following must be done:

- For inboards/sterndrives the two largest air chambers, if used, must be vented at their high and low points; for outboards over 2 HP the two larges air chambers and all air chambers integral with the hull must be vented (air chambers are allowed for rowboats and outboards of 2 HP or less).
- The CFR says to fill fuel tanks with fuel; standard USCG testing is to place the equivalent weight centered on the top of permanent fuel tanks
- Water tanks and holding tanks must be filled with water.
- Provisions for flooded bait well, storage and iceboxes, and dry wells must be made.
- All compartments that may entrap air must be thoroughly vented.
- Seats, seat cushions, and upholstery items must be vented so that they cannot entrap air.
- Attempt to remove entrapped air from the swamped boat by drilling relief holes in the gunwale and decks.

Following preparation as outlined above, the boat must be pre-conditioned. Preconditioning consists of swamping the boat for 18 hours. Weights to simulate the outboard motor, controls and battery where applicable (outboard boats), the persons capacity, and the gear weight in accordance with the type of flotation system must be in place. At the end of the pre-conditioning, testing may begin. The type of test(s) to be performed will be determined by the type of flotation system used, i.e.: Basic, Level or Modified Level.

For the level flotation with swampted persons weights, the designated quantity of swamped persons weights must be placed in the center of the boat within the 40% box of the passenger carrying area as shown in Figure 11.

For the stability tests half the swamped persons weight is removed and the remaining half is moved to the side. Those swamped persons weights must be placed within 70% of the shaded area as shown in Figure 12. See Figure 13 regarding the swamped persons weight shift and Figure 14 regarding placement of weights on seats.

3.3 PASSING FLOTATION & STABILITY TEST CRITERIA

Per 183.105 – Gives the flotation passing criterion for inboards and sterndrives

Inboards and sterndrives must have sufficient flotation to keep any portion of the boat above the surface of the water. BASIC FLOTATION

Per 183.225 / .230 / .235 – Gives the flotation & stability passing criteria for outboard over 2 HP; the same criteria for manual propulsion and outboards of 2 HP or less are listed in 183.325 / .330 / .325.

Manually propelled boats and outboards of all HP must meet the following test criteria. That is, the passing criteria are the same for LEVEL FLOTATION AND MODIFIED LEVEL FLOTATION.

Level flotation with swamped persons weight / Level flotation without persons weight tests.

- No more than a 10 degree angle of heel – and:
- Any point of forward or aft reference area above water / reference depth no more than 6 inches on the opposite end.

Starboard stability / Port stability tests. See Figure 3.6.

- No more than a 30 degree angle of heel – and:
- Any point of forward or aft reference area above water / reference depth no more than 12 inches on the opposite end (measured at centerline of boat).

The following Figures 11 through 16 show the weight placement and passing criteria for the rowboat and outboard powered boat tests.

FIGURE 11 Loading Area

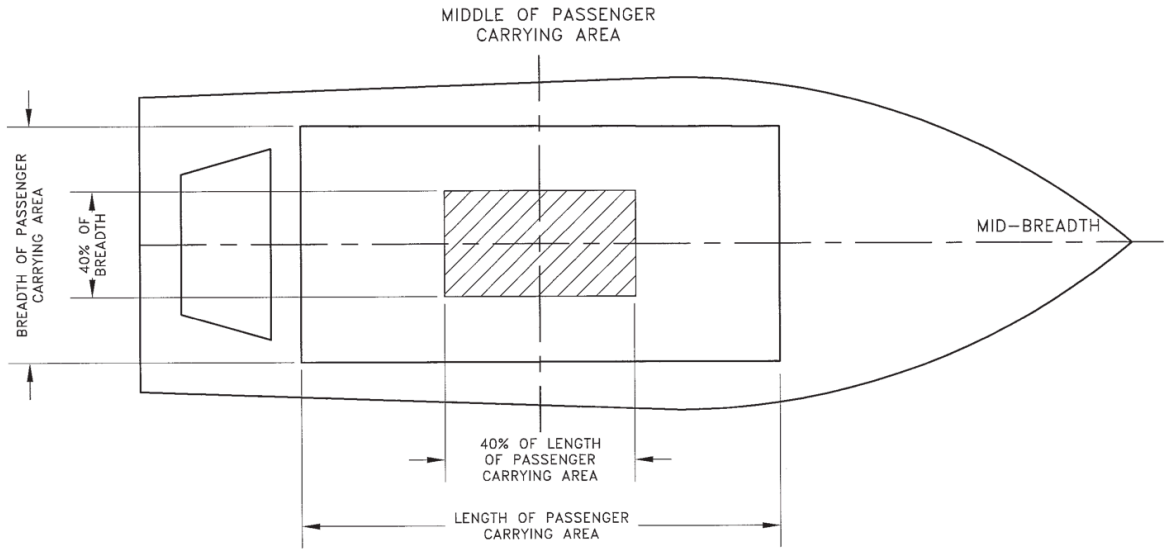


FIGURE 12 Center of Gravity of Weights

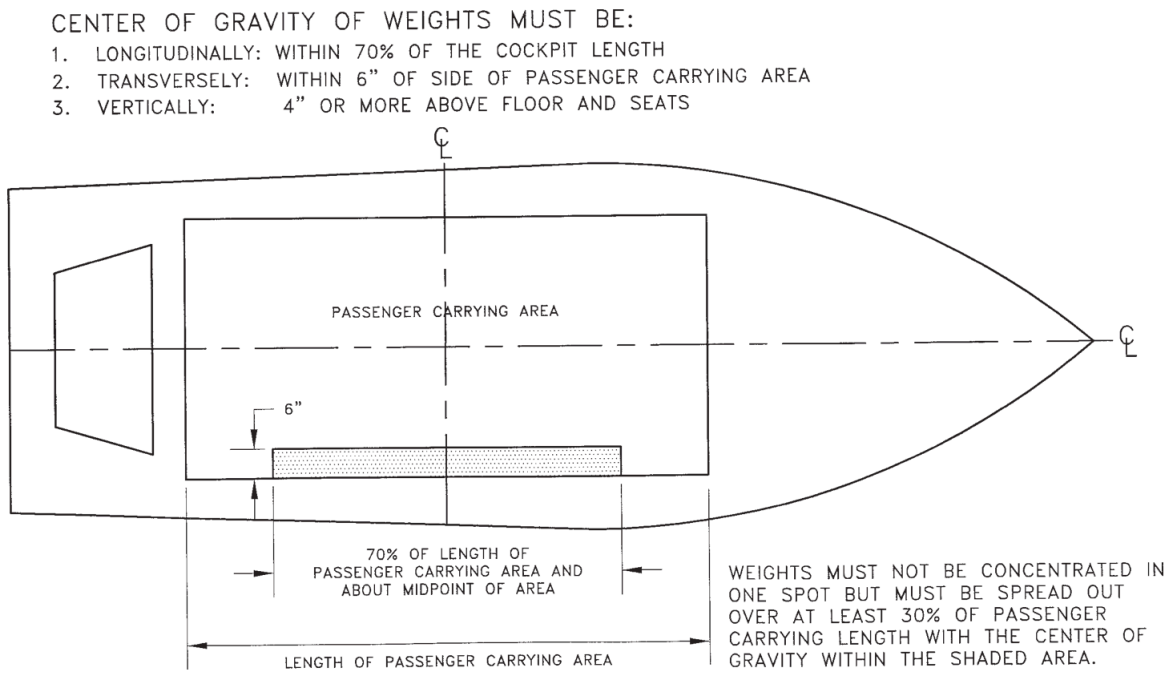


FIGURE 13 Weight Shift for Stability Tests

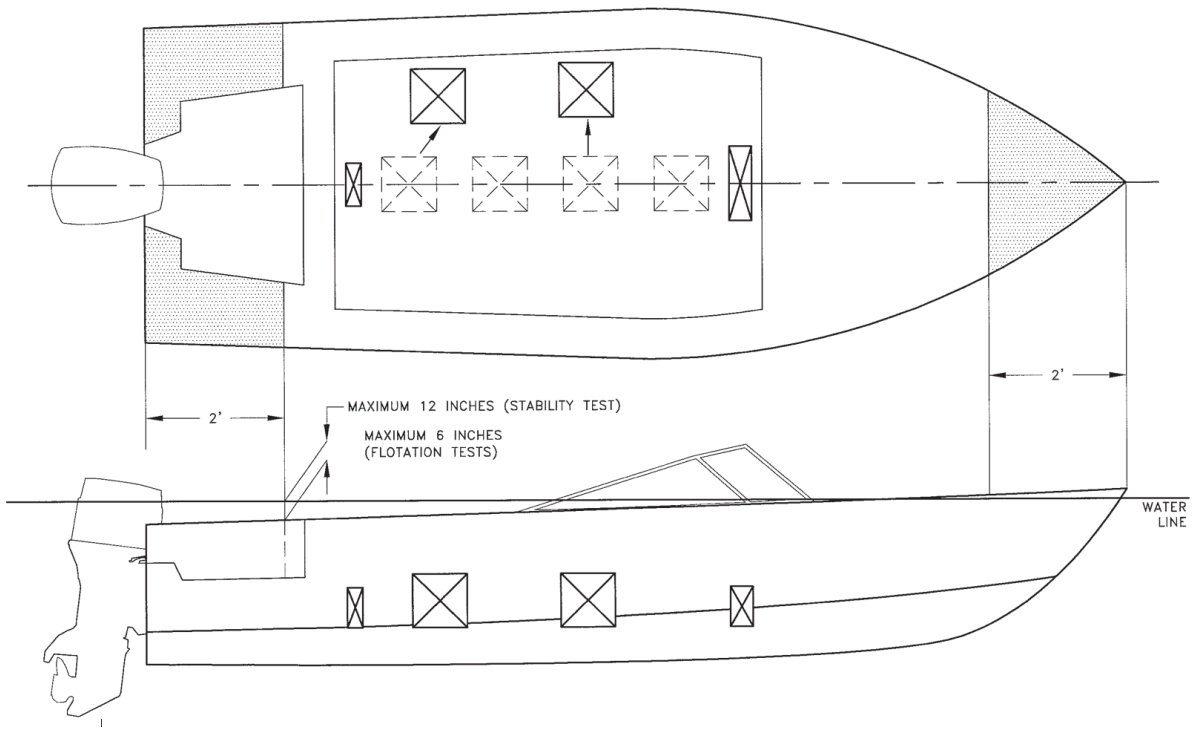


FIGURE 14 Center of Gravity of Weight on Seats

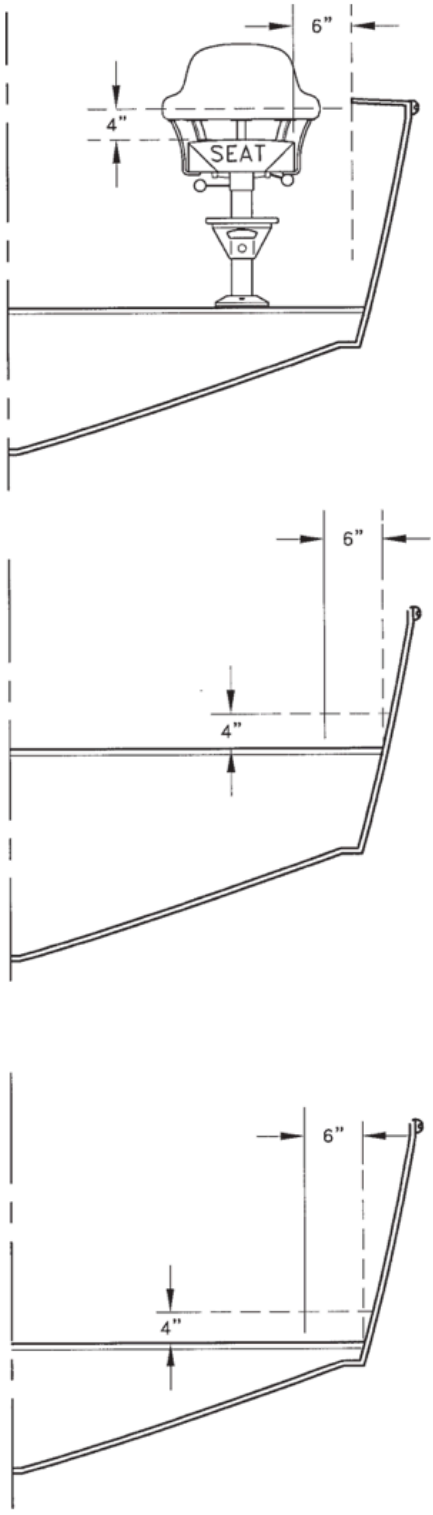


FIGURE 15 Flotation Test

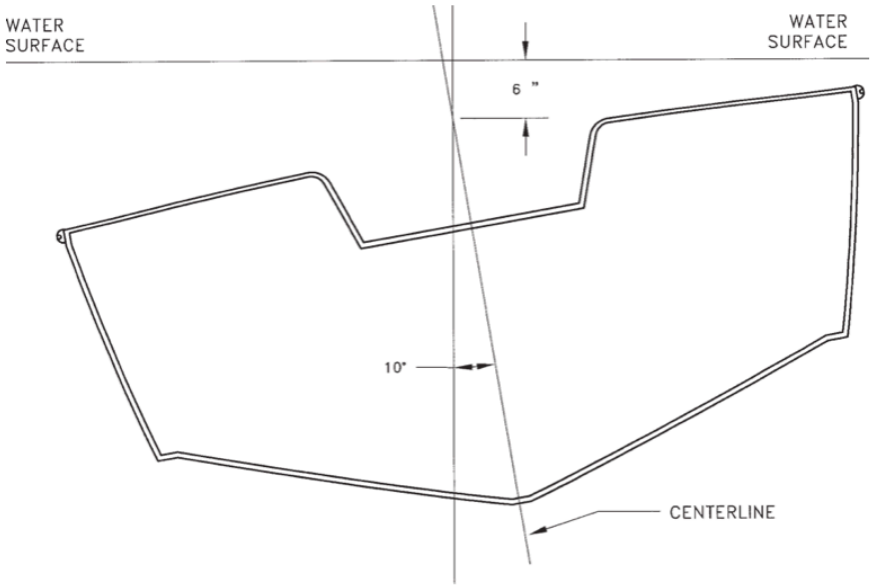
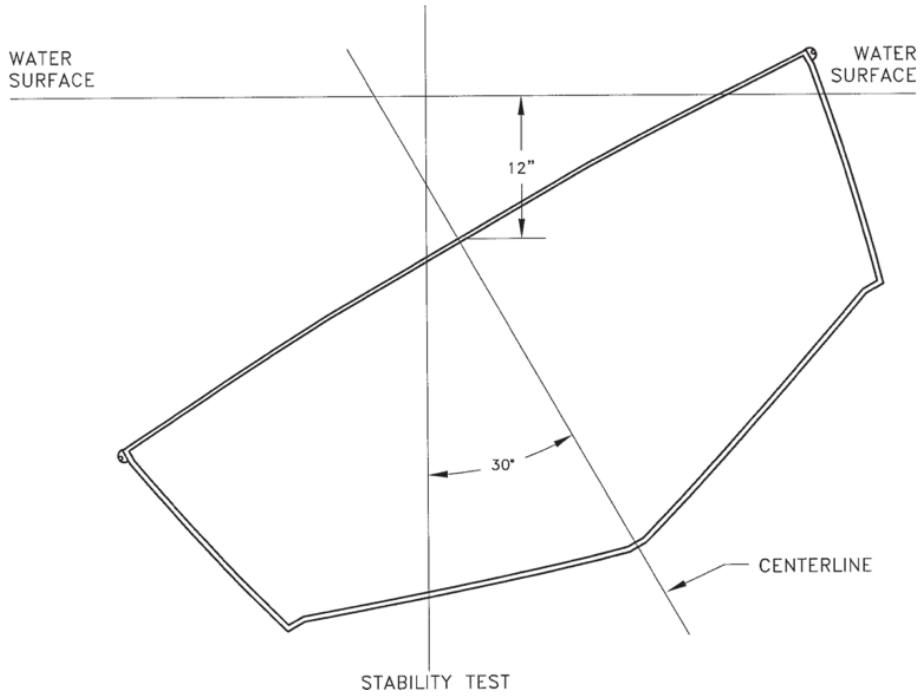


FIGURE 16 Stability Test



4.0 ESTIMATING THE REQUIRED QUANTITY OF FLOTATION

The previous section covered flotation and stability test criteria. This section of the guideline serves to explain how to estimate the quantity (and placement) of flotation material – so the boat will pass the four flotation and stability tests.

The flotation material must support:

- the boat (partly submerged / partly out of the water);
- the propulsion equipment & battery;
- a portion of the passenger and gear loads;

The total flotation material needed is the sum of the three components above.

4.1 BASIC FLOTATION

Boats requiring Basic Flotation are fitted with buoyant materials or acceptable flotation systems in at least the minimum quantity as determined below. Void compartments or air chambers integral with the hull shall not be included as part of the required flotation materials.

If non-integral air chambers are used for flotation, the requirements for Basic Flotation shall be met excluding the two largest air chambers.

Calculations: To determine the total flotation material needed to support the boat, the flotation needed to support the boat (hull and deck), the propulsion machinery and the passengers (persons capacity) and gear are calculated separately – and then added.

Total flotation: $\mathbf{F = F_b + F_p + F_c}$

F_b = Flotation for the submerged boat
F_p = Flotation for the submerged propulsion machinery
F_c = Flotation for the persons capacity & gear

When estimating the minimum required amount of flotation for Basic Flotation boat builders only need to consider only the submerged weights of the various boat components as the minimum standard is to have only a small portion of the boat out of the water.

Step 1: Determine the flotation needed to support the submerged boat (Fb).

$$F_b = ([W_h \times K] + [W_d \times K] + .69W_e) \div B$$

Where: F_b = flotation needed (cu ft)
W_h = dry weight of hull (lb)
W_d = dry weight of deck and superstructure (lb)
We = dry weight of factory installed equipment, hardware and accessories
K = conversion factor for material used. See Table 4.1 below
B = buoyancy of one cubic foot of flotation material (lb/cu ft)

The weight of fresh water is 62.4 pounds per cubic foot. When submerged, one cubic foot of flotation material will provide a flotation force of 62.4 pounds minus the weight of one cubic foot of the material. Typical flotation material that weighs 2 pounds per cubic foot will provide a flotation force of 60.4 pounds per cubic foot. That is the figure for 'B' used in the various example calculations in this guideline. Use of a foam of a different weight density would require an adjustment of the buoyancy figure as appropriate.

Use of polyurethane flotation foam with a density lower than 2 pounds per cubic foot is not recommended because such foams have thin cell walls that are prone to rupture over time, leading to water logging and loss of its buoyancy characteristic. Although the use of higher density polyurethane foam is acceptable it comes with the cost penalty for the amount of buoyance provided.

Builders must consider the loss of foam buoyancy over time. Such a loss could result in a costly recall correction campaign.

The submerged weight of the hull is the result of adding the weights of each component multiplied by each component 'K' factor listed in Table I below. K is a value (based on the material specific gravity) used to derive the submerged weight of each component. For example: fiberglass x 0.33; fir plywood x –0.81; aluminum tanks x 0.63.

Step 2: Determine the flotation material needed to support the submerged propulsion equipment (F_p).

$$F_p = G \div B$$

Where: G = 75% of the installed weight of the engine, drive and battery (inboard), or the engine, outdrive and battery (sterndrive) — in pounds to the nearest whole number;
B = Buoyancy of 1 cu.ft. of flotation material used in pounds./cu ft

Step 3: Determine the flotation material needed to support the persons capacity (Fc).

$$F_c = .25 \text{ (MWC)} \div B$$

Where: MWC = Maximum weight capacity.
B = Buoyancy of 1 cu.ft. of flotation material used in pounds./ cu ft

The regulation calls for 2/15 (13%) of the MPC and 25% of gear weight (MWC – MPC). This Guideline uses 25% of MWC (i.e., 25% of both MPC and gear) resulting in slightly more flotation in the boat. This safety factor will help to ensure that the boat meets the minimum requirement in the event of minor weight changes during construction

Step 4: Determine the total flotation material needed (F) to support the boat.

$$F = F_b + F_p + F_c$$

Regarding Table I. The factors in Table I are calculated using the following formula:

$$\text{Factor} = \frac{\text{Specific gravity - 1}}{\text{Specific gravity}}$$

The specific gravity is the ratio of the density of a substance to the density of fresh water. Water has a specific gravity of 1.00 (and thus a K factor of zero). Materials that float will have a negative K factor and will provide a buoyant force. Materials heavier than water will have a positive K factor and will require other buoyant material for flotation support.

This formula may be used to obtain the factor for materials not listed in Table 4.1.

Example – The K factor for new boat building material Cooper (with a specific gravity of 3.53):

$$\text{Factor} = \frac{\text{Specific gravity} - 1}{\text{Specific gravity}} = \frac{3.53 - 1}{3.53} = 0.72$$

Table 1 Factors (K) for Converting Various Boat Materials from Dry to Submerged Weight

MATERIAL	SPECIFIC GRAVITY	FACTOR (K)	POUNDS/ CUBIC FT
Lead	11.38	0.91	710
Copper	8.91	0.89	556
Monel Metal	8.91	0.89	556
Bronze	8.88	0.89	554
Nickel	8.61	0.88	537
Brass	8.56	0.88	534
Stainless Steel	8.00	0.88	500
Steel	7.85	0.88	490
Cast Iron	7.08	0.86	442
Zinc-Cast Alloy	6.63	0.85	414
Aluminum	2.73	0.63	170
Glass	2.60	0.62	162
Ferro-Cement	2.40	0.58	150
Rubber	1.51	0.34	94
Fiberglass (Laminate)	1.50	0.33	94
Kevlar	1.30	0.24	81
Plexiglass-Lucite	1.20	0.17	75
Linoleum*	1.17	0.15	72
A.B.S.	1.12	0.11	70
Teak	0.99	–0.01	62
Oak-White	0.85	–0.18	53
Oil-Diesel	0.85	–0.18	53
Gasoline	0.73	–0.37	45
Oak	0.63	–0.56	39
Blandex	0.58	–0.70	36
Mahogany — Philippine	0.58	–0.72	36
Mahogany — Honduras	0.56	–0.78	35
Ash	0.56	–0.78	35
Yellow Pine	0.55	–0.81	34
Fir Plywood	0.55	–0.81	34
Mahogany Plywood	0.54	–0.83	34
Royalex	0.50	–0.95	31
Mahogany — African	0.51	–0.96	32
Fir	0.51	–0.96	32
Cedar — Port Orford	0.48	–1.08	30
Pine — White	0.42	–1.38	26
Cedar — White	0.33	–1.95	21
Cork	0.24	–3.17	15
Balsa — End Grain	0.16	–5.24	10

**1.5 pounds/square foot for 1/4 inch thick linoleum.*

4.1.1 Example of Basic Flotation Calculations

Assume a sterndrive runabout with the following specifications:

Length Overall	18′–6″
Beam	7′–3″
Propulsion	210 HP sterndrive
Machinery weights	1,075 lb.
Maximum weight capacity	1,400 lb.
Maximum persons capacity	1,100 lb. or 8 persons
Dry hull weight	800 lb. (fiberglass 650 lb. + plywood 150 lb.)
Dry deck weight	300 lb. (fiberglass 245 lb. + plywood 55 lb.)
Deck hardware	228 lb. (Mostly aluminum)
Hull hardware	110 lb. (Aluminum 80 lb. + stainless steel 30 lb.)
Total weight	2,513 lb.

This boat will have to comply with the Basic Flotation requirement. This means the boat only needs to float at any angle with the boat and equipment loads - and a certain percentage of the passenger load.

For basic flotation, it is safe to assume the entire boat to be submerged. There is no swamped water line, and consequently all the components will be affected by the conversion factors in Table I.

Step 1: Flotation needed to support the submerged boat.

$$F_b = ([W_h \times K1] + [W_d \times K2] \text{ etc. } + .69We) \div B$$

Identify the components and determine their weights when submerged:

Part Description	Table 4.1		'K' Factor		Weight
Wh= Weight of fiberglass hull	650	x	0.33	=	214.5
+					
Weight of hull fir plywood	150	x	–0.81	=	–121.5
+					
Weight of hull aluminum hardware	80	x	0.63	=	50.4
+					
Weight of hull steel hardware	30	x	0.88	=	26.4

W_h = Submerged weight of hull = 169.8 lb.

Part Description	Table 4.1		'K' Factor		Weight
Wd = Weight of fiberglass deck	245	x	0.33	=	80.8
+					
Weight of fir plywood in deck	55	x	–0.81	=	–44.5
Wd = Submerged weight of deck = 36.3 lb.					
We=Weight of factory installed equipment	228	x	0.63	=	143.6

We = Submerged weight of factory installed equipment, etc. = 143.6 lb

B will be calculated as follows (assuming use of Polyurethane foam of 2.0 lb. density)

B = 62.4 – 2.0 = 60.4;

B = 60.4 lb./cu ft

Substituting in the formula:

F_b = ([169.8] + [36.3] + [143.6]) ÷ 60.4

F_b = 5.8 cubic feet of foam (to support the boat)

Step 2: Flotation needed to support the submerged propulsion equipment.

$F_p = G \div B$

G = 75% of 1075 lb. (engine, outdrive and battery) = 806.2 B = 60.4 lb.

F_p = 806.2 ÷ 60.4

F_p = 13.3 cubic feet of foam

Step 3: Flotation needed to support the passengers & gear.

$F_c = 0.25$ (MWC) ÷ B

F_c = 0.25 X 1400 ÷ 60.4

F_c = 5.8 cubic feet of foam

Step 4: Total flotation needed for Basic Flotation.

$F = F_b + F_p + F_c$

F = 5.8 + 13.4 + 5.8 = 25

F = 25 cubic feet of foam

The Basic Flotation requirements do not address where the foam is located in the boat. The location is not as critical to meet basic flotation but it is still a good policy to place the flotation material to support the boat needs to be widely distributed about the boat. The flotation material needed to support the engine needs to be balanced about the load. The flotation needed to support the persons and gear load needs to be distributed about the passenger carrying area.

The manufacturer must be sure that the boat will float, in any position, when loaded according to the regulation. The flotation material estimate calculation is a good indication if the outfitted boat will pass basic flotation. Boat builders may still opt to pre-condition the boat and load it with the weights prescribed to ensure that the swamped boat floats.

4.2 LEVEL FLOTATION

The objective of this Guideline is to help the manufacturer calculate first how much foam will be needed to support each of the components (the boat, the machinery, and a portion of the passengers and gear loads) and then indicate where that flotation material must be installed to pass the required tests. Following these steps carefully will result in successfully floating the boat in the manner prescribed.

Boats requiring Level Flotation must be fitted with buoyant materials or acceptable flotation systems in at least the minimum quantity as determined below. Void compartments or air chambers that are integral with the hull shall not be included as part of the flotation required.

Flotation material located at the sides, as far aft and as high as possible, will help make boats with machinery located aft float level when swamped. Some boats may require the keel area inside the boat to be void of flotation material so that the space can flood from either end to provide proper balance in the swamped condition.

Integral air chambers cannot be counted toward meeting the Level Flotation requirements. If non-integral air chambers are used for flotation, the Level Flotation requirements must be met excluding the two largest air chambers.

Flotation material is needed to support the following components when the boat is swamped:

- the swamped boat;
- the swamped outboard engine and submerged battery;
- a portion of the persons capacity and gear weight.

The total flotation material needed is the sum of the three components. The boat must float at a level attitude and pass a stability test.

$$F = F_b + F_p + F_c$$

Where: F = Total flotation material
F_b = Flotation for the swamped boat
F_p = Flotation for the submerged propulsion machinery
F_c = Flotation for a portion of people and gear weight

The boat, without its propulsion equipment and passengers, will have to be swamped and supported with a certain amount of flotation material distributed symmetrically so as to keep it relatively level. When you add the propulsion systems, the boat will be disproportionately heavier aft and consequently the flotation material needed to support the engine and drive will have to be located far aft to counter this unbalance. Finally, the flotation material needed to support the portion of the passengers (persons capacity) and gear must be located out on the boat's sides and as high as possible. This is so that the boat may pass the stability test's maximum permitted heel angle.

Symmetrical location criteria for the flotation system are established for each of the three quantities above. For example, one cubic foot of flotation material three feet forward of the boat's balance point (when out of the water) can be balanced by three cubic feet of flotation material one foot aft of the boat's balance point. The symmetry may, and should, be varied to account for equipment (such as batteries) if located off-center.

Step 1: Determine the flotation needed to support the swamped boat (Fb).

$$F_b = [(W_h \times K) + W_d] \div B$$

Where: W_h = dry weight of the hull (Everything below the swamped waterline)
W_d = dry weight of deck (everything above the swamped waterline, including factory supplied windshield, hardware and accessories)
K = conversion factors for materials used, from Table 4.1
B = buoyancy of flotation materials used, in pounds per cubic foot

Since the hull will be submerged (as in section 4.0), Wh is the sum of the weight of the different components of the hull (fiberglass, wood, steel, etc.) that are each multiplied by the conversion factor in Table I. Wd, however, is the sum of the dry weights of the deck components since the deck will remain above water. The flotation material must support the full weight of the components above the water surface. This is a simplification for estimation of the amount of flotation material needed to support the swamped boat. Typically, neither the entire hull is submerged nor is the entire deck dry.

This flotation material should be located symmetrically about the balance point of the boat.

Figures 17, 18, and 19 following show the principle of symmetry about the balance point of the boat.

FIGURE 17 Placement of Flotation Material

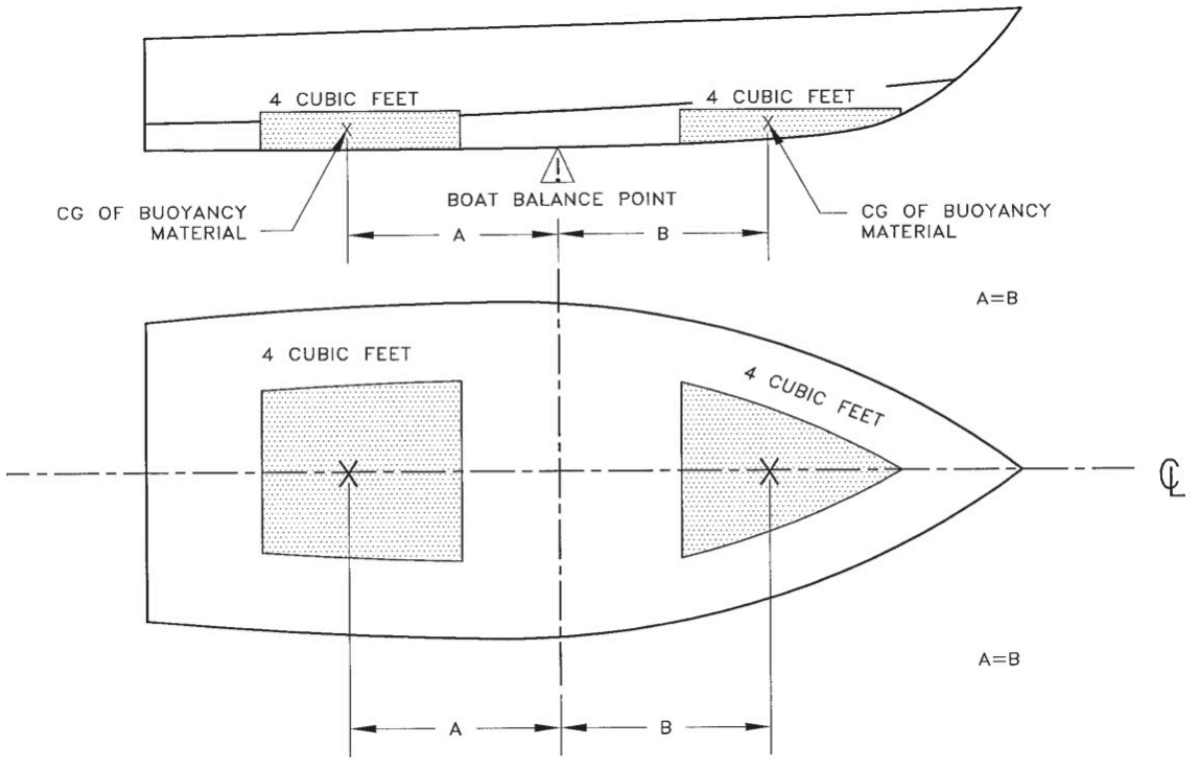


FIGURE 18 Placement of Flotation Material

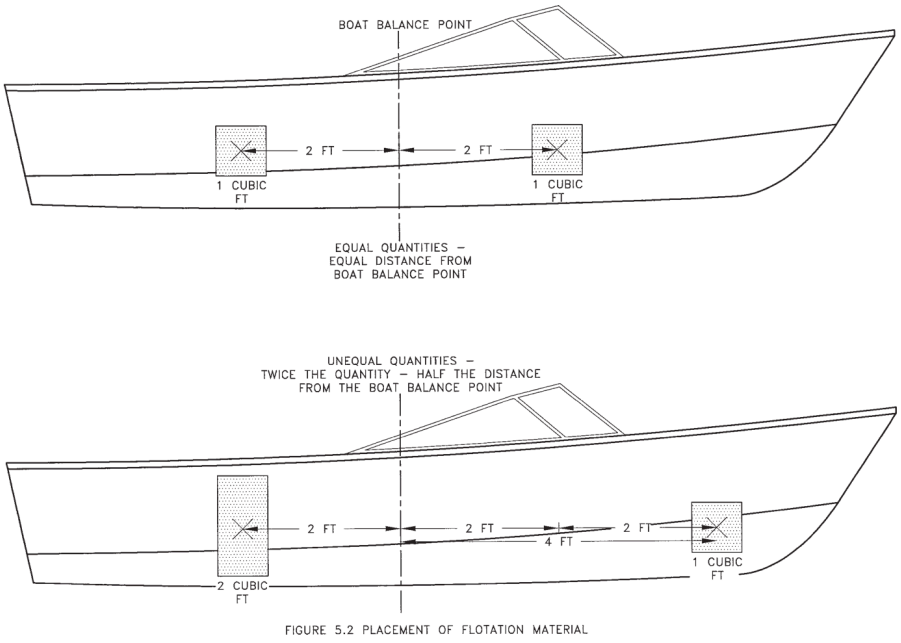
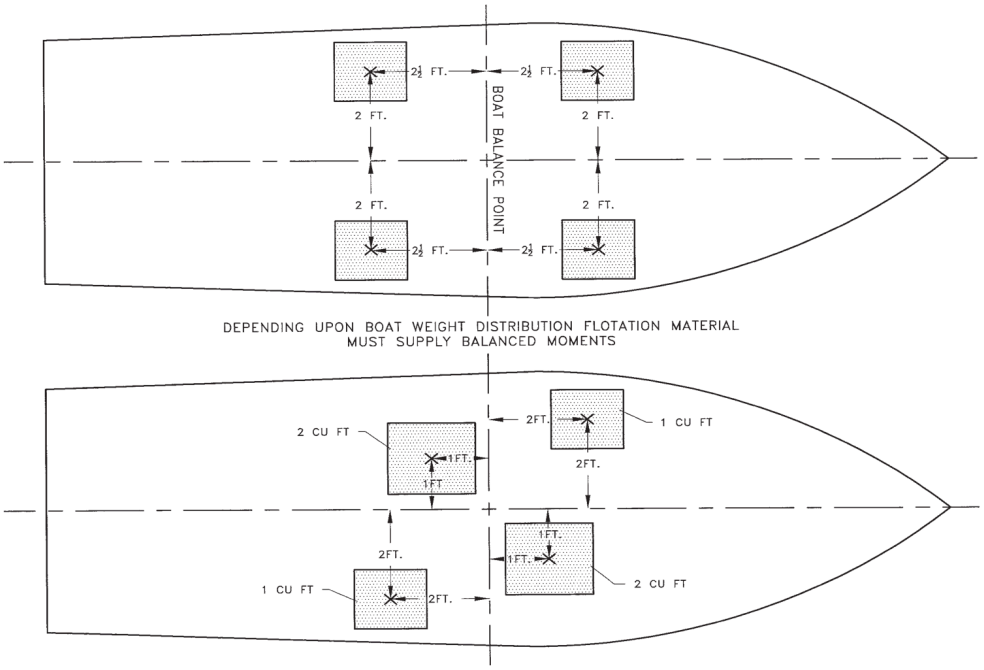


FIGURE 5.2 PLACEMENT OF FLOTATION MATERIAL

FIGURE 19 Placement of Flotation Material



Step 2. Determine the flotation material needed to support the swamped propulsion equipment (Fp).

$$F_p = S \div B$$

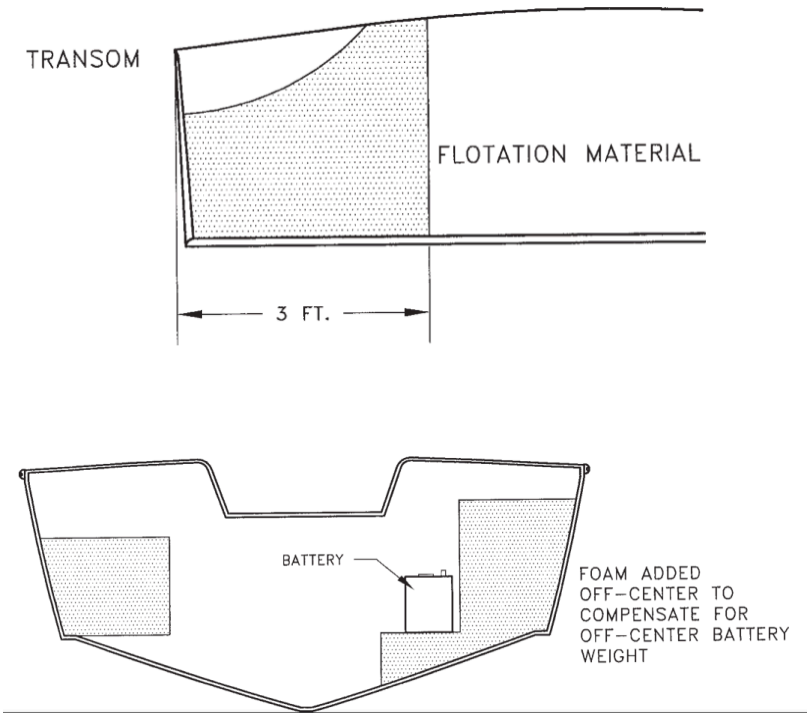
Where: S = The swamped weight of the maximum horsepower capacity engine for which the boat is rated on the capacity label, plus the submerged weight of the battery. All are found in Table 183.75, columns 4 and 7 (see Subpart E).
B = The buoyancy of the flotation material in pounds per cubic foot.

The Coast Guard has been given authority to randomly check boats for compliance with the flotation requirements. When this check is conducted, simulated outboard engine weights are used rather than an actual outboard engine. The weight used during this check is obtained from the outboard engine weight table included Subpart E, Table 183.75

It is recommended to distribute this material symmetrically within 36 inches (30 inches for boats of less than 15 feet in length) of the outside of the transom top at the motor-mounting area or around the propulsion system if engines are not stern mounted.

In small boats, sometimes it is difficult to pack the flotation material in the compartments prescribed here. Use the space on the deck aft, but stay within the 36-inch area (30 for boats under 15 ft.).

FIGURE 20 Flotation Material for Propulsion System



Step 3: Determine the flotation needed to support the persons and gear capacity (Fc)

Fc = [0.5(first 550 lb. of MPC) + 0.125(remaining) + 0.25 gear] / B

Where: Gear weight = MWC – MPC – Table 183.75 column 9 (for posted HP rating)
B = Buoyancy of flotation material in pounds per cubic foot.

The reason for the regulation requiring the manufacturer to support only part of the passenger load is that the assumption is that the passengers will be partially submerged and weigh less.

Gear weight is discussed in detail in the Safe Loading chapter, section 6.0. If the gear weight calculation is a negative number, the gear weight to be used in testing is zero pounds. This would only be possible if the posted MWC is down-rated from the test value and the posted MPC figure is based on the higher test value of weight capacity. Builders are encouraged to always show a proper differential between the posted MWC and MPC figures (based on the Table 183.75 required differential) – then the gear weight calculation would never be a negative number.

This calculation uses the maximum persons capacity shown on the boat's capacity plate.

In order to achieve a level attitude when conducting the flotation tests, it will be necessary to distribute this portion of the flotation material symmetrically on both sides and fore and aft of the passenger carrying area mid-point at the hull sides as close to the sheer line as possible. It should be located outside a vertical plane that is parallel to the keel, and within 6 inches of the hull sides at the widest point on the floor line. This will assure the necessary righting moments to pass the stability test. The flotation material must be as far out and as high in the gunwales as possible.

Step 4: Determine the total flotation material needed (F)

F = Fb + Fp+ Fc

The total flotation material required is the sum of the results in steps 1, 2, and 3 above.

FIGURE 21 Flotation Material Placement

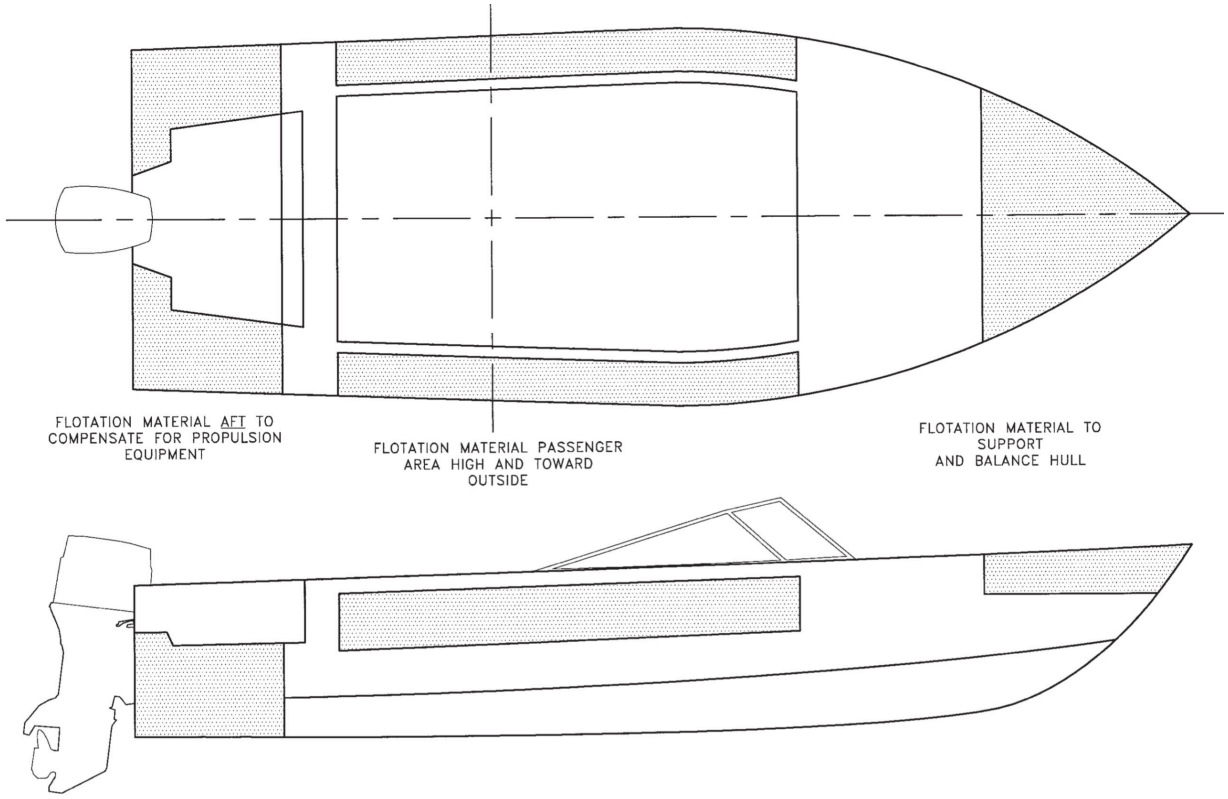


FIGURE 22 Placement of Passenger Support Flotation Material

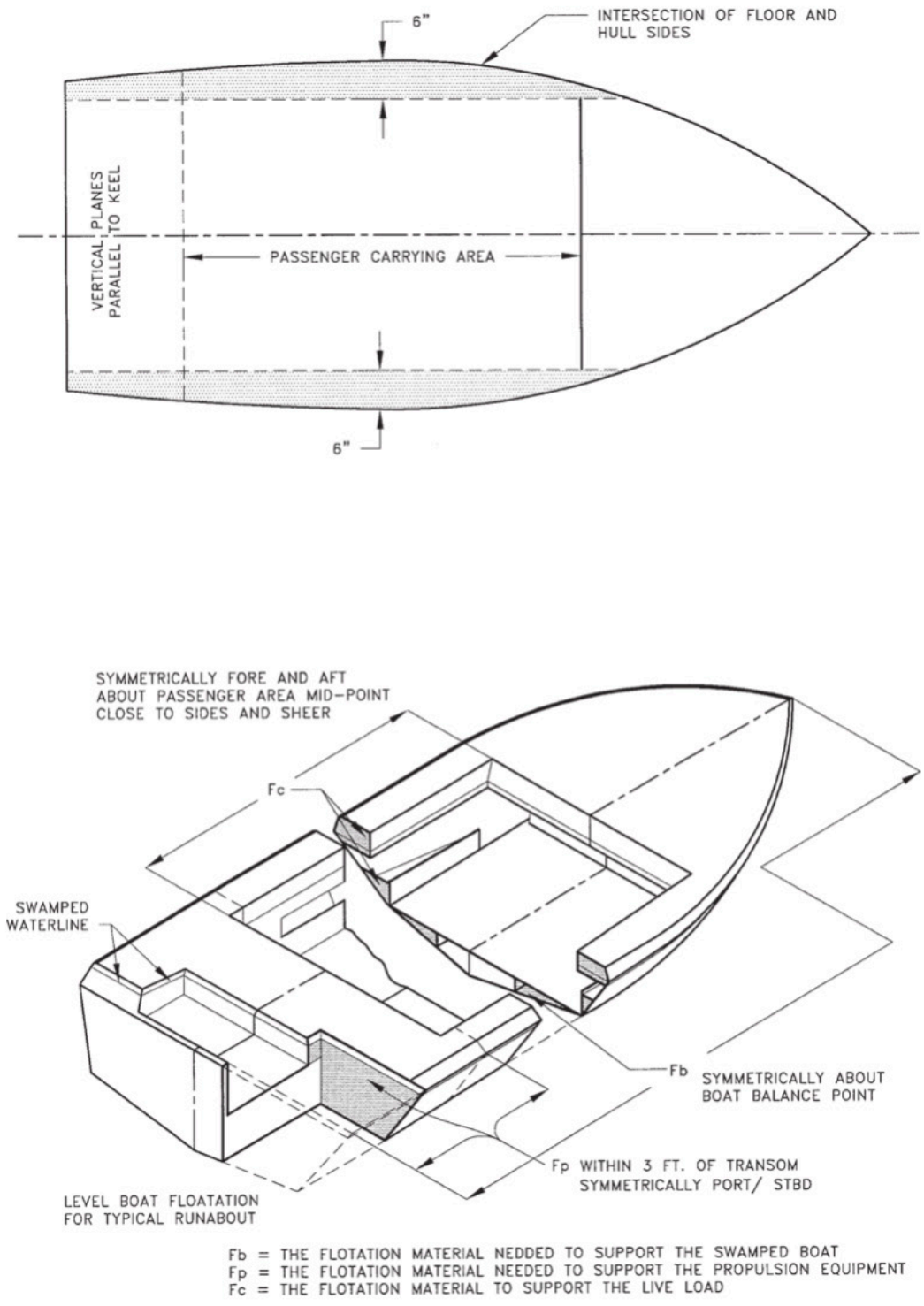
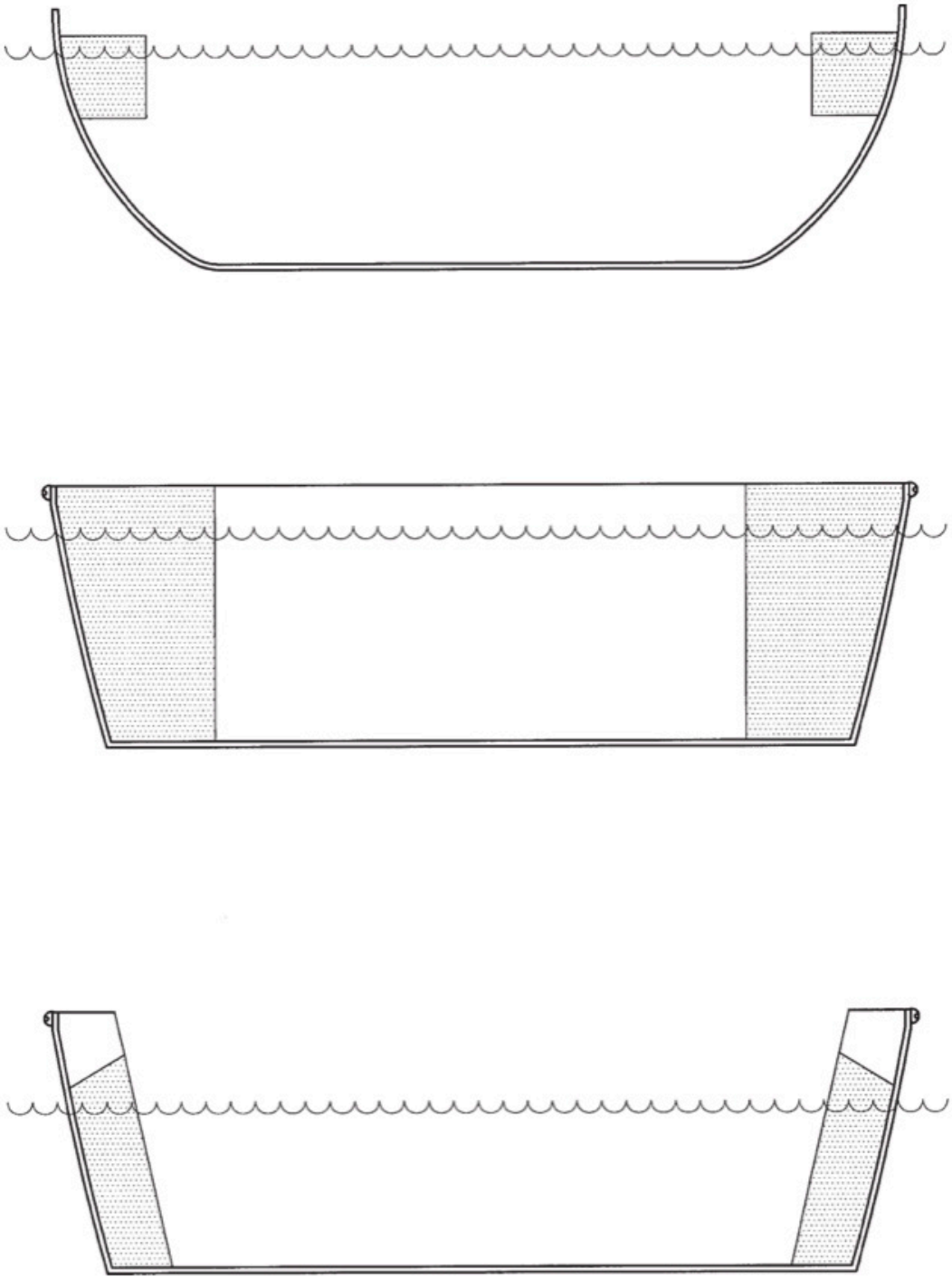


FIGURE 22 Flotation Material Placement



4.2.1 EXAMPLE OF LEVEL FLOTATION CALCULATIONS

Assume an outboard engine-powered runabout with the following specifications:

Length Overall	18′–6″
Beam	7′–3″
Propulsion	140 HP Outboard engine
Engine weight	457 lb. (including controls and battery)
Transom height	23 in.
Fuel	Portable fuel tank
Maximum weight capacity	1,400 lb.
Maximum persons capacity	5 persons or 660 pounds
Dry Hull weight	800 lb. (fiberglass 650 lb. + plywood 150 lb.)
Dry deck weight	300 lb. (fiberglass 245 lb. + plywood 55 lb.)
Deck Factory installed hardware	228 lb. (Mostly aluminum)
Hull hardware	110 lb. (Aluminum 80 lb. + stainless steel 30 lb.)
Boat weight	1438 lb.
Total weight	1,895 lb.

This boat must comply with the Level Flotation requirements. It is an outboard powered, more than 2 HP, mono-hull boat under 20 feet in length, and the requirements include a Level Flotation system and some tests to determine its compliance.

In Level Flotation we must establish a swamped waterline, or the position in which the boat will float after preconditioning and swamped for 18 hours (see regulation). We will assume in this example that this swamped line is at the hull sheer or deck-to-hull joint; therefore, the hull will be considered swamped and its component's weight converted to submerged weight, while the deck will be considered as dry weight since it will be out of the water.

Step 1: Flotation material needed to support the swamped boat.

$Fb = [(W_h \times K) + W_d] \div B$

Part Description	Table 4.1		'K' Factor		Weight
W_h = Weight of fiberglass hull	650	x	0.33	=	214.5
+					
Weight of hull fir plywood	150	x	–0.81	=	–121.5
+					
Weight of hull aluminum hardware	80	x	0.63	=	50.4
+					
Weight of hull steel hardware	30	x	0.88	=	26.4

Wh = Swamped weight of hull 169.8 lb.

W_d = Weight of fiberglass deck	245
+	
Weight of fir plywood on deck	55
+	
Weight of factory installed equipment (dry)	228

W_d = Weight of dry deck 528 lb.

B will be calculated as follows (assuming use of Polyurethane foam of 2.0 lb. density):

B = 62.4 – 2.0 = 60.4;

B = 60.4 lb./cu ft

Substituting in the formula above:

F_b = (169.8 + 528) ÷ 60.4 = 11.57

F_b =11.6 cubic feet of foam

Step 2: Determine the flotation material needed to support the swamped propulsion equipment (Fp).

$F_p = S \div B$

Where: S = The swamped weight of the maximum horsepower capacity engine for which the boat is rated on the capacity label, plus the submerged weight of the battery.

B = The buoyancy of the flotation material in pounds per cubic foot.

The boat has been rated for a 140 HP outboard engine. When the boat is swamped, this engine will be partially submerged to the power head or the cowling — approximately. The builder does not need to weigh the engine and battery, bur simply refer to Table 183.75 (in Subpart E). As discussed, the Table has notes allowing for a reduction in engine weight if the transom height is less than 20 inches and for a reduction of the portable fuel tank weight if the boat is equipped with a permanent fuel tank. In this example neither reduction is allowed. The 140 HP engine falls in the 105.0 – 144.9 range

Per Table 183.75, for this example boat, the column 9 required differential between the MWC and MPC (to account for the engine / controls / battery / full portable fuel tank) is 628 pounds.

Per Table 183.75, the (column 4) swamped engine weight is 469 pounds and the (column 7) submerged battery weight is 25 pounds.

Therefore, S = 469 + 25 = 494 pounds

F_p = 494 / 60.4 = 8.2 cubic feet of foam

This is the portion of the total foam that must be carefully located inside the volume formed by the portion of the boat forward of the top of the transom, where the engine is mounted.

Step 3: Determine the flotation material needed to support the swamped persons and gear capacity (F_c).

F_c = [0.5(first 550 lb. of MWC) + 0.125(remaining) + 0.25 gear weight] / B

Where: Gear weight = MWC – MPC – Table 183.75 column 9 (for posted HP rating)
B = Buoyancy of flotation material in pounds per cubic foot.

Look at the specifications. The boat has been rated for:

- Persons capacity in pounds = 660 pounds
- Maximum weight capacity = 1,400 pounds
- Table 183.75 column 9 figure for 140 HP engine = 723 pounds

F_c = 0.5 of the first 550 lb. of persons capacity = 0.50 x 550 = 275 lb

+

0.125 of the remaining persons capacity = 0.125 (660 – 550) = 13.75 lb.

+

0.25 (gear wt) = 0.25 (1400 – 660 – 723) = 0.25 (17) = 4.25 pounds

---

F_c = (275 lb. + 13.75 lb. + 4.25) ÷ 60.4 = 4.9 cubic feet of foam

This foam should be distributed along the hull sides and under the deck gunwales in the passenger carrying areas.

Step 4: Determine the total flotation material needed for Level Flotation.

$F = F_b + F_p + F_c$

F = 11.6 + 8.2 + 4.9 = 24.7 cubic ft. of foam flotation

4.3 MODIFIED LEVEL FLOTATION

Boats requiring Modified Level Flotation shall be fitted with buoyant materials or acceptable flotation systems in at least the minimum quantities determined below.

Boats with outboard engines of 2 HP or less, as well as manually propelled boats, may use integral air chambers for flotation. For testing purposes, these need not be punctured.

Calculations for Modified Level Flotation

Step 1: Determine the flotation needed to support the swamped boat (Fb)

$$F_b = [(W_h \times K) + Wd] \div B$$

Where: W_h = dry weight of hull (everything below swamped waterline)
W_d = dry weight of deck and superstructure
K = conversion factors for materials used
B = buoyancy of flotation materials used, in pounds per cubic foot

If air is used, B will simply be 62.4 pounds (the weight of fresh water displaced by 1 cu ft). If foam is used, B will equal the weight of 1 cu. ft. of fresh water, minus the weight of one cu. ft. of the foam used. The builder can use this example to determine the necessary quantity of 2 # flotation material (with a buoyancy of 60.4 lb/cu ft or to determine the volume of air chambers needed at 62.4 lb / cu ft.

This flotation material shall be distributed symmetrically about the balance point of the boat.

Step 2: Determine the flotation needed to support the swamped propulsion equipment (Fp)

If the boat is manually propelled only, proceed to Step 3.

$$F_p = S \div B$$

Where: S = swamped weight for 2.0 HP outboard, from Table 183.75
(submerged battery weight and portable fuel tank weights for 2 HP are zero)
B = buoyancy of flotation materials used, in pounds per cubic foot

This flotation material should be distributed symmetrically within 30 inches of the outside of the transom top at the motor mounting area.

Step 3: Determine the flotation material needed to support the swamped persons and gear capacity (F_c)

$$F_c = 0.25 \text{ MWC} \div B$$

Where: MWC (maximum weight capacity)
B = buoyancy of flotation materials used, in pounds per cubic foot

The regulations call for 2/15 (13%) of the maximum persons capacity and 25% of the gear weight. This guideline example uses 25% for both the MPC and gear weight, resulting in slightly more flotation material for the boat – and easier math.

The flotation material should be distributed symmetrically, transversely and fore and aft of the midpoint of the passenger carrying area, and at the hull sides as close to the gunwales as possible. This will help the boat float in a level attitude when swamped.

Step 4: Determine the total flotation material needed (F)

$$F = F_b + F_p + F_c$$

Where: F_b = flotation for the boat
F_p = flotation for outboard motor, 2 HP or less
F_c = flotation for persons capacity and gear

4.3.1 Examples of Modified Flotation Calculations (2 HP first & then rowboat)

Example 1: Boat rated for 2 horsepower. Assume a boat with the following specifications:

Wh weight of hull (fiberglass) - submerged	80 lb.
Wd weight of deck (fir plywood) - dry	5 lb.
Transom height	16 in.
Portable fuel tank	
Boat is rated for	2 HP
S (swamped weight of 2 HP engine)	24 lb. (See Appendix A, Table 4) Table 183
Maximum weight capacity	300 lb.
Maximum persons capacity	230 lb.

Step 1: Determine flotation needed to support the swamped boat (Fb).

F_b = Wh x K) + Wd] ÷ B
F_b = [(80 x 0.33) + 5] ÷ 60.4
F_b = [(26.4) + 5] ÷ 60.4

F_b = 0.5 cu. ft.

Step 2: Determine flotation needed to support the propulsion equipment (Fp).

F_p = S ÷ B
F_p = 24 ÷ 60.4 (value of S for swamped 2 HP engine from Table 183.75)

F_p = 0.3 cu. ft.

Step 3: Determine the flotation needed to support the persons capacity (Fc).

F_c = 0.25 (MWC) ÷ B
F_c = 0.25 (300) ÷ 60.4

F_c = 1.2 cu. ft.

Step 4: Determine the total flotation material needed.

F = Fb + Fp + Fc
F = 0.5 + 0.3 + 1.2

F = 2.0 cu. ft.

IF GOING BY THE BOOK:
It was noted that this guideline determines the flotation material needed to support the persons and gear weight as 25% of the MWC to give a cushion as to the amount of flotation. In this example the flotation material to support the persons and gear was found to be 1.2 cu ft.

Using the CFR standard of 2/15 of MPC and 25% of gear weight:

MPC = 230 pounds
Gear weight = (MWC – MPC – Table 183.75 column 9) = 300 – 230 – 24 = 46 pounds.

The flotation for the persons and gear would be:

Persons:	2/15 (230) / 60.4 = 0.5 cu ft
	+
Gear:	0.25 (46) / 60.4 = 0.2 cu ft

For a total of 0.7 cu ft. Thus, the earlier figure of 1.2 cu ft gives a larger safety margin.

Example 2: Boat rated for manual propulsion only.

Assume the same boat as in example 1 above, but rated for manual propulsion.

Step 1: Determine flotation needed to support the swamped boat (Fb).

$$F_b = [(Wh \times K) + Wd] \div B$$

$F_b = [(80 \times 0.33) + 5] \div 60.4$
$F_b = [(26.4) + 5] \div 60.4$

$$F_b = 0.5 \text{ cu. ft.}$$

Step 2: Flotation for engine: (Not applicable).

Step 3: Determine the flotation needed to support the persons capacity (Fc).

$F_c = 0.25 (MWC) \div B$

$F_c = 0.25 (300) \div 60.4$

$F_c = 1.\ 2$ cu. ft.

Step 4: Determine the total flotation material needed.

$F = F_b + F_c$

$F = 0.5 + 1.2$

F = 1.7 cu ft

5.0 FLOTATION MATERIALS

There are specific performance specifications for flotation materials based upon their location in a boat. The level of performance required depends on the degree of exposure to detrimental agents.

> Per 183.114 – Explains various tests that flotation material must pass - as a function of the location in the boat.

5.1 FLOTATION MATERIAL TESTS

Boat builders must insure their flotation material suppliers provide compliance materials – and provide documentation that the material will withstand the various vapor and gasoline / oil / bilge cleaner immersion tests.

Simply stated – flotation materials installed in the bilge must be able to retain buoyancy in that environment. Uncut installed flotation material is preferable to minimize the potential for water logging of the foam.

The terms "bilge", "engine room bilge" and "engine room" have been defined (see section 2.0). The first step will be to establish the bilge and engine room bilge areas within the boat.

With the unloaded boat in calm, fresh water and transversely level (static floating position):

- The bilge is the volume located below a line parallel to the reference waterline. This line is located 4" up from the lowest point where water may accumulate in the boat.
- The engine room bilge is the volume located below a line parallel to the reference waterline. This line is located 12" up from the lowest point where water may accumulate within this compartment (or connected compartments).

FIGURE 24 Flotation Material Placement

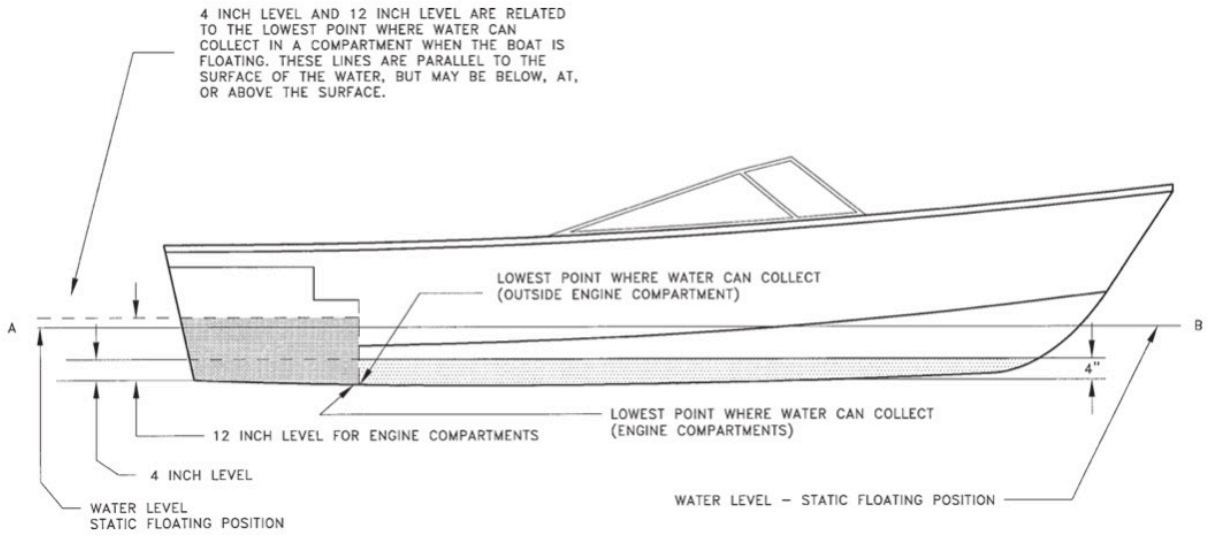


Table II. (CFR Table 183.114) Flotation Performance Tests

	AREA 183.110		
	(b) Engine-room bilge	(c) Engine-room unless open to atmosphere	(d) Bilge
(a) Vapor test		X	
(b) 24 hour gasoline test			X
(c) 30 day gasoline test	X		
(d) 24 hour oil test			X
(e) 30 day oil test	X		
(f) 24 hour bilge cleaner test			X
(g) 30 day bilge cleaner test	X		

1) The change in volume and buoyancy is measured in accordance with ASTM D-2842. The maximum size of a test sample shall be 6" x 6" x 3" and cut by the same method used to shape it for use in the boat.

2) Flotation material does not have to be gasoline, oil, gasoline vapor or trisodium solution-resistant if:

a. Used in manually propelled boats;

b. Installed outside the engine compartment more than 4 inches above the lowest point where liquid can collect when the boat is in its static floating position; or

c. Enclosed or encased in an enclosure that permits no more than one-quarter ounce of fresh water per hour to enter when the enclosure is submerged to a depth of 12 inches.

3) Cellular plastic used to encase fuel tanks is allowed to count as a flotation material, but it must not change volume by more than 5% or dissolve when immersed in ASTM liquids (see 33 CFR 183.516 for test specifications) and must not absorb water beyond the 183.516 standard.

4) For the purposes of these tests, ASTM oils and ASTM fuels, and a trisodium phosphate solution have been selected which approximate typical marine products with which flotation material may come in contact in actual service.

5) ASTM reference fuel B provides typical swelling effects produced by commercial gasoline, and ASTM No. 2 reference oil has been chosen since it characterizes the nearest aniline point of a petroleum- based oil used in marine service. The aniline point of petroleum oil determines the swelling action of the oil. Reference fuel B consists of 70% Isooctane and 30% Toluene, in volume (Isooctane conforming to Section Annex A2.8, Motor Fuels Section of 1973-74 ASTM Manual for Rating Motor, Diesel and Aviation Fuels; Toluene conforming to ASTM D-362 for Industrial Grade Toluene).

6) For a full explanation of the test fuels, refer to ASTM D-471.

5.2 FLOTATION MATERIAL INSTALLATION REQUIREMENTS

Air Chambers

Air chambers shall maintain their integrity under pre-test conditioning and under flotation test conditions. They shall not leak when subjected to an internal air pressure test and shall not allow the ingress of water when submerged to at least a depth equal to that required in the flotation test.

Plastic Foam Blocks and Other Shapes

A method of identifying foam blocks and other shapes must be employed to assure that each boat gets the correct amount of flotation in the correct location.

Expanded polystyrene foam must not come in contact with uncured polyester resin or fumes. Polystyrene should not be used in the bilge of the boat or the bilge of the engine room because it is not resistant to gasoline.

Foam blocks and other shapes must be secured so that no movement in any direction occurs that will affect the flotation's performance.

Installation must be in a manner that will prevent:

- damage from occupant contact.
- deterioration from exposure to direct sunlight.
- damage from normal use of the boat.
- removal from the boat by the user.

The space provided for the installation of foam blocks must be large enough to prevent the necessity of using force that will deform the shape of the block during the installation process. Deformation will lower the volume, and therefore the total buoyancy, of the foam block. The foam blocks must be permanently glued or mechanically fixed to its intended location because sloshing foam blocks will not perform consistently.

Sprayed or Poured Liquid Mix

When liquid flotation material is installed directly in place, constraints must be provided in the form of bulkheads, boxes or dams to ensure the proper volume, and to ensure that the centers of buoyancy are correctly placed.

Clearance around and passages through, the foam should be provided for:

- routing controls, cables and wires, and hoses,
- access to windshield fasteners, cleat and chock fasteners, rail fasteners, ventilation ducts, other deck hardware and standard fittings;
- bilge drainage; water trapped on top of or around the flotation foam will likely cause waterlogging of the foam which requires an extensive and expensive replacement. Besides the negative effect of a heavier boat and the loss of buoyance property, waterlogged foam will also corrode metals – such as an aluminum hull – in contact with the foam. The hull can corrode from the inside out, undetected.
- drainage of the top of metallic fuel tanks (see Fuel Systems Compliance Guideline).

APPENDIX 1. FLOTATION REFERENCES AND RESOURCES

The following standards are referenced in the regulations:

ASTM D 471 "Standard Test Method for Rubber Property Effect of Liquids"- sections 183.114 and 183.516.

ASTM D 2842 "Standard Test Method for Water Absorption of Rigid Cellular Plastics"-section 183.114.

MIL P-21929C Plastic Material, Cellular Polyurethane, Foam-in-Place (2 Pounds Per Cubic Foot)"- section 183.516.

ASTM D 1621 "Standard Test Method for Compressive Properties of Rigid Cellular Plastics" - section 183.516.

ASTM D 1622 "Standard Test Method for Apparent Density of Rigid Cellular Plastics" - section 183.516.

APPENDIX 2. 33 CFR SUBPART F - FLOTATION REQUIREMENTS FOR INBOARD BOATS, INBOARD/OUTDRIVE BOATS, AND AIRBOATS

§ 183.101 APPLICABILITY.

This subpart applies to monohull inboard boats, inboard/outdrive boats, and airboats less than 20 feet in length, except sailboats, canoes, kayaks, inflatable boats, submersibles, surface effect vessels, amphibious vessels, and raceboats.

[CGD 75-168, 42 FR 20243, Apr. 18, 1977, as amended by USCG-1999-5832, 64 FR 34716, June 29, 1999]

§ 183.105 QUANTITY OF FLOTATION REQUIRED.

(a) Each boat must have enough flotation to keep any portion of the boat above the surface of the water when the boat has been submerged in calm, fresh water for at least 18 hours and loaded with:

(1) A weight that, when submerged, equals two-fifteenths of the persons capacity marked on the boat;

(2) A weight that, when submerged, equals 25 percent of the dead weight; and

(3) A weight in pounds that, when submerged, equals 62.4 times the volume in cubic feet of the two largest air chambers, if air chambers are used for flotation.

(b) For the purpose of this section, "dead weight" means the maximum weight capacity marked on the boat minus the persons capacity marked on the boat.

§ 183.110 DEFINITIONS.

For the purpose of this subpart:

Bilge means the area in the boat, below a height of 4 inches measured from the lowest point in the boat where liquid can collect when the boat is in its static floating position, except engine rooms.

Connected means allowing a flow of water in excess of one-quarter ounce per hour from the engine room bilge into any other compartment with a 12 inch head of water on the engine room side of the bulkhead.

Engine room bilge means the area in the engine room or a connected compartment below a height of 12 inches measured from the lowest point where liquid can collect in these compartments when the boat is in its static floating position.

Engine room means the compartment where a permanently installed gasoline or diesel engine is installed, including connected compartments.

Open to atmosphere means a compartment that has at least 15 square inches of open area directly exposed to the atmosphere for each cubic foot of net compartment volume.

Sealed compartment means an enclosure that can resist an exterior water level of 12 inches without seepage of more than one-quarter fluid ounce per hour.

§ 183.112 FLOTATION MATERIAL AND AIR CHAMBERS.

(a) Flotation materials must meet the requirements in § 183.114 as listed in Table 183.114 when used in the: (1) Engine room bilge, (2) engine room, or (3) bilge, unless located in a sealed compartment.

(b) Air chambers used to meet the flotation requirements of this subpart must not be integral with the hull.

§ 183.114 TEST OF FLOTATION MATERIALS.

(a) Vapor test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed in a fully saturated gasoline vapor atmosphere for 30 days at a minimum temperature of 38 °C.

(b) 24-hour gasoline test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed for 24 hours at 23 plus or minus 2 °C in reference fuel B, of ASTM D 471 (incorporated by reference, see § 183.5).

(c) 30-day gasoline test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed for 30 days at 23 plus or minus 2 °C in reference fuel B, of ASTM D 471 (incorporated by reference, see § 183.5).

(d) 24-hour oil test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed for 24 hours at 23 plus or minus 2 °C in reference oil No. 2, of ASTM D 471 (incorporated by reference, see § 183.5).

(e) 30-day oil test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed for 30 days at 23 plus or minus 2 °C in reference oil No. 2, of ASTM D 471 (incorporated by reference, see § 183.5).

(f) 24-hour bilge cleaner test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed for 24 hours at 23 plus or minus 2 °C in a 5-percent solution of trisodium phosphate in water.

(g) 30-day bilge cleaner test. The flotation material must not reduce in buoyant force more than 5 percent after being immersed for 30 days at 23 plus or minus 2 °C in a 5-percent solution of trisodium phosphate in water.

(h) The buoyant force reduction in paragraphs (a) through (g) of this section is measured in accordance with ASTM D 2842 (incorporated by reference, see § 183.5).

Table 183.114 - Flotation Performance Tests

	AREA 183.110		
	(b) Engine-room bilge	(c) Engine-room unless open to atmosphere	(d) Bilge
(a) Vapor test		X	
(b) 24 hour gasoline test			X
(c) 30 day gasoline test	X		
(d) 24 hour oil test			X
(e) 30 day oil test	X		
(f) 24 hour bilge cleaner test			X
(g) 30 day bilge cleaner test	X		

APPENDIX 3. 33 CFR SUBPART G – FLOTATION REQUIREMENTS FOR OUTBOARD BOATS RATED FOR ENGINES OF MORE THAN 2 HORSEPOWER

§ 183.201 APPLICABILITY.

(a) This subpart applies to monohull outboard boats that are:

(1) Less than 20 feet in length; and

(2) Rated for outboard engines of more than 2 horsepower.

(b) This subpart does not apply to sailboats, canoes, kayaks, inflatable boats, submersibles, surface effect vessels, amphibious vessels, and raceboats.

§ 183.202 FLOTATION AND CERTIFICATION REQUIREMENTS.

Each boat to which this subpart applies must be manufactured, constructed, or assembled to pass the stability and flotation tests prescribed in §§ 183.225(a), 183.230(a), and 183.235(a).

§ 183.205 PASSENGER CARRYING AREA.

(a) For the purpose of this section a boat is level when it is supported on its keel at the two points shown in Figure 2.

(b) As used in this subpart, the term "passenger carrying area" means each area in a boat in which persons can sit in a normal sitting position or stand while the boat is in operation. Passenger carrying areas are illustrated in Figures 3 through 8.

(c) The length of the passenger carrying area is the distance along the centerline of the boat between two vertical lines, one at the forward end and one at the aft end of the passenger carrying area when the boat is level as illustrated in Figures 3 and 4. For boats with a curved stem inside the passenger carrying area, the forward vertical line is where a line 45 degrees to the horizontal when the boat is level is tangent to the curve of the stem, as illustrated in Figure 5. For boats with cabins, the forward vertical line is where there is a minimum distance of two feet between the inside top of the cabin and the water line formed when the boat is swamped and loaded with weights under § 183.220 as illustrated in Figure 6.

(d) The breadth of each passenger carrying area is the distance between two vertical lines at the mid-length, excluding consoles, of the passenger carrying area when the boat is level as illustrated in Figures 7 and 8. For boats with round chines inside the passenger carrying area, the vertical line is where a transverse line 45 degrees to the horizontal is tangent to the arc of the chine, as illustrated in Figure 8.

§ 183.210 REFERENCE AREAS.

(a) The forward reference area of a boat is the forward most 2 feet of the top surface of the hull or deck, as illustrated in Figure 9.

(b) The aft reference area of a boat is the aft most two feet of the top surface of the hull or deck, as illustrated in Figure 9.

§ 183.215 REFERENCE DEPTH.

Reference depth is the minimum distance between the uppermost surface of the submerged reference area of a boat and the surface of the water measured at the centerline of the boat, as illustrated in Figure 10. If there is no deck surface at the centerline of the boat from which a measurement can be made, the reference depth is the average of two depth measurements made on opposite sides of, and at an equal distance from, the centerline of the boat.

§ 183.220 PRECONDITIONING FOR TESTS.

A boat must meet the following conditions for at least 18 hours before the tests required by §§ 183.225, 183,230, and 183.235:

(a) Manufacturer supplied permanent appurtenances such as windshields and convertible tops must be installed on the boat.

(b) The boat must be loaded with a quantity of weight that, when submerged, is equal to the sum of the following:

(1) The sum of 50 percent of the first 550 pounds of the persons capacity marked on the boat and 12 1/2 percent of the remainder of the persons capacity.

(2) Twenty-five percent of the result of the following calculation, but not less than zero: The maximum weight capacity marked on the boat; less the weight shown in Column 9 of Table 183.75 for maximum horsepower marked on the boat; less the persons capacity marked on the boat.

(c) The weights required by paragraph (b) of this section must be placed in the boat so that the center of gravity of each amount of weight required by paragraphs (b)(1) and (b)(2) of this section is within the shaded area illustrated in Figure 11. The location and dimensions of the shaded area are as follows:

(1) The shaded area is centered at the mid-length of the passenger carrying area and at the mid-breadth of the boat;

(2) The length of the shaded area, measured along the centerline of the boat, is equal to 40 percent of the length of the passenger carrying area of the boat; and

(3) The breadth of the shaded area, measured at the midlength of the passenger carrying area, is equal to 40 percent of the breadth of the passenger carrying area of the boat.

(d) Weight must be placed in the normal operating position of the motor and controls and the battery in lieu of this equipment. The required quantity of weight used for this purpose depends

upon the maximum rated horsepower of the boat being tested and is specified in Columns 4 and 7 of Table 183.75 for the swamped weight of the motor and controls and for the submerged weight of the battery, respectively.

(e) Permanent fuel tanks must be filled with fuel and each external opening into the fuel tank must be sealed.

(f) The boat must be keel down in the water.

(g) The boat must be swamped, allowing water to flow between the inside and outside of the boat, either over the sides, through a hull opening, or both. Entrapped air in the flooded portion of the boat must be eliminated.

(h) Water must flood the two largest air chambers and all air chambers integral with the hull.

§ 183.222 FLOTATION MATERIAL AND AIR CHAMBERS.

(a) Flotation materials must meet the requirements in § 183.114 as listed in Table 183.114 when used in the bilge, unless located in a sealed compartment.

(b) Air chambers used to meet the flotation requirements of this subpart must not be integral with the hull.

§ 183.225 FLOTATION TEST FOR PERSONS CAPACITY.

Flotation standard. When the conditions prescribed in § 183.220 are met, the boat must float in fresh, calm water as follows:

(a) The angle of heel does not exceed 10 degrees from the horizontal.

(b) Any point on either the forward or aft reference area is above the surface of the water.

(c) The reference depth at the reference area that is opposite the reference area that is above the surface of the water is 6 inches or less.

§ 183.230 STABILITY TEST.

(a) Flotation standard. When the conditions prescribed in § 183.220 (a), (d) through (h) and paragraphs (b) and (c) of this section are met, the boat must float in fresh, calm water as follows:

(1) The angle of heel does not exceed 30 degrees from the horizontal.

(2) Any point on either the forward or aft reference area is above the surface of the water.

(3) The reference depth at the reference area that is opposite the reference area that is above the surface of the water is 12 inches or less.

(b) Quantity of weight used. Load the boat with a quantity of weight that, when submerged, is equal to the sum of the following:

(1) One-half of the quantity of weight required by § 183.220(b)(1).

(2) The quantity of weight required by § 183.220(b)(2).

(c) Placement of quantity of weight: starboard side. Place the weight required by paragraph (b) of this

section in the boat so that:

(1) The quantity of weight required by § 183.220(b)(2) is positioned in accordance with § 183.220(c); and

(2) One-half the quantity of weight required by § 183.220(b)(1) is uniformly distributed over a distance along the outboard perimeter of the starboard side of the passenger carrying area that is equal to at least 30 percent of the length of the passenger carrying area so that the center of gravity of the quantity of weight is located within the shaded area illustrated in Figure 12, the center of gravity of the amount of weight placed on the floor of the boat is at least 4 inches above the floor, and the center of gravity of the amount of weight placed on a seat is at least 4 inches above the seat. The location and dimensions of the shaded area are as follows:

(i) The shaded area is centered at the mid-length of the passenger carrying area;

(ii) The length of the shaded area is equal to 70 percent of the length of the passenger carrying area; and

(iii) The breadth of the shaded area is 6 inches from:

(A) For weights placed on the floor, the outboard perimeter of the passenger carrying area; and

(B) For weights placed on a seat, a vertical line inside the passenger carrying area as illustrated in Figure 13.

(d) Placement of quantity of weight: port side. The quantity of weight required by paragraph (b)(1) of this section is placed along the port side of the passenger carrying area in accordance with the conditions prescribed in paragraph (c)(2) of this section.

§ 183.235 LEVEL FLOTATION TEST WITHOUT WEIGHTS FOR PERSONS CAPACITY.

When the conditions prescribed in § 183.220 (a) and (d) through (h) are met, the boat must float in fresh, calm water as follows:

(a) The angle of heel does not exceed 10 degrees from the horizontal.

(b) Any point on either the forward or aft reference area is above the surface of the water.

(c) The reference depth at the reference area that is opposite the reference area that is above the surface of the water is 6 inches or less.

APPENDIX 4. 33 CFR SUBPART H – FLOTATION REQUIREMENTS FOR OUTBOARD BOATS RATED FOR ENGINES OF 2 HORSEPOWER OR LESS

§ 183.301 APPLICABILITY.

(a) This subpart applies to monohull outboard boats that are:

(1) Less than 20 feet in length; and

(2) Rated for manual propulsion or outboard engines of 2 horsepower or less.

(b) This subpart does not apply to sailboats, canoes, kayaks, inflatable boats, submersibles, surface effect vessels, amphibious vessels, and raceboats.

§ 183.302 FLOTATION REQUIREMENTS.

Each boat to which this subpart applies must be manufactured, constructed, or assembled to pass the stability and flotation tests prescribed in §§ 183.325(a), 183.330(a), and 183.335(a).

§ 183.305 PASSENGER CARRYING AREA.

(a) For the purpose of this section, a boat is level when it is supported on its keel at the two points shown in Figure 2.

(b) As used in this subpart, the term "passenger carrying area" means each area in a boat in which persons can sit in a normal sitting position or stand while the boat is in operation. Passenger carrying areas are illustrated in Figures 3 through 8.

(c) The length of each passenger carrying area is the distance along the centerline of the boat between two vertical lines, one at the forward end and one at the aft end of the passenger carrying area, when the boat is level, as illustrated in Figures 3 and 4. For boats with a curved stem inside the passenger carrying area, the forward vertical line is where a line 45 degrees to the horizontal when the boat is level is tangent to the curve of the stem, as illustrated in Figure 5. For boats with cabins, the forward vertical line is where there is a minimum distance of two feet between the inside top of the cabin and the water line formed when the boat is swamped and loaded with weights under § 183.320 as illustrated in Figure 6.

(d) The breadth of the passenger carrying area is the distance beteen two vertical lines at the mid-length, excluding consoles, of the passenger carrying area when the boat is level as illustrated in Figures **7** and 8. For boats with round chines inside the passenger carrying area, the vertical line is where a transverse line 45 degrees to the horizontal is tangent to the arc of the chine, as illustrated in Figure 7.

§ 183.310 REFERENCE AREAS.

(a) The forward reference area of a boat is the forwardmost 2 feet of the top surface of the hull or deck as illustrated in Figure 9.

(b) The aft reference area of a boat is the aftmost two feet of the top surface of the hull or deck, as illustrated in Figure 9.

§ 183.315 REFERENCE DEPTH.

Reference depth is the minimum distance between the uppermost surface of the submerged reference area of a boat and the surface of the water measured at the centerline of the boat, as illustrated in Figure 10. If there is no deck surface at the centerline of the boat from which a measurement can be made, the reference depth is the average of two depth measurements made on opposite sides of, and at an equal distance from, the centerline of the boat.

§ 183.320 PRECONDITIONING FOR TESTS.

A boat must meet the following conditions for at least 18 hours before the tests required by §§ 183.325, 183.330, and 183.335:

(a) Manufacturer supplied permanent appurtenances such as windshields, and convertible tops must be installed on the boat.

(b) The boat must be loaded with a quantity of weight that, when submerged, is equal to the sum of the following:

(1) Two-fifteenths of the persons capacity marked on the boat.

(2) Twenty-five percent of the result of the following calculation, but not less than zero: the maximum weight capacity marked on the boat; less the weight shown in Column 9 of Table 183.75 for the maximum horsepower marked on the boat; less the persons capacity marked on the boat.

(c) The weights required by paragraph (b) of this section are placed in the boat so that the center of gravity of each amount of weight required by paragraphs (b)(1) and (b)(2) of this section is within the shaded area illustrated in Figure 11. The location and dimensions of the shaded area are as follows:

(1) The shaded area is centered at the mid-length of the passenger carrying area and at the mid-breadth of the boat;

(2) The length of the shaded area, measured along the centerline of the boat, is equal to 40 percent of the length of the passenger carrying area of the boat; and

(3) The breadth of the shaded area, measured at the mid-length of the passenger carrying area, is equal to 40 percent of the breadth of the passenger carrying area of the boat.

(d) Weight must be placed in the normal operating position of the motor and controls in lieu of this equipment. The quantity of weight used for this purpose depends upon the maximum rated horsepower of the boat being tested and is specified in Column 4 of Table 183.75 for the swamped weight of the

motor and controls.

(e) Permanent fuel tanks must be filled with fuel and each external opening into the fuel tank must be sealed.

(f) The boat must be keel down in the water.

(g) The boat must be swamped, allowing water to flow between the inside and the outside of the boat, either over the sides, through a hull opening, or both. Entrapped air in the flooded portion of the boat must be eliminated.

§ 183.322 FLOTATION MATERIALS.

(a) Flotation materials must meet the requirements in § 183.114 as listed in Table 183.114 when used in the bilge, unless located in a sealed compartment.

§ 183.325 FLOTATION TEST FOR PERSONS CAPACITY.

Flotation standard. When the conditions prescribed in § 183.320 are met, the boat must float in fresh, calm water as follows:

(a) The angle of heel does not exceed 10 degrees from the horizontal.

(b) Any point on either the forward or aft reference area is above the surface of the water.

(c) The reference depth at the reference area that is opposite the reference area that is above the surface of the water is 6 inches or less.

§ 183.330 STABILITY TEST.

(a) Flotation standard. When the conditions prescribed in § 183.320 (a), (d) through (g) and paragraphs (b) and (c) of this section are met, the boat must float in fresh, calm water as follows:

(1) The angle of heel does not exceed 30 degrees from the horizontal.

(2) Any point on either the forward or aft reference area is above the surface of the water.

(3) The reference depth at the reference area that is opposite the reference area that is above the surface of the water is 12 inches or less.

(b) Quantity of weight used. Load the boat with quantity of weight that, when submerged, is equal to the sum of the following:

(1) One-half the quantity of weight required by § 183.320(b)(1).

(2) The quantity of weight required by § 183.320(b)(2).

(c) Placement of quantity of weight: starboard side. Place the quantity of weight required by paragraph **(b)** of this section in the boat so that:

(1) The quantity of weight required by § 183.320(b)(2) is positioned in accordance with § 183.320(c);

and

(2) One-half the quantity of weight required by § 183.320(b)(1) is uniformly distributed over a distance along the outboard perimeter of the starboard side of the passenger carrying area that is equal to at least 30 percent of the length of the passenger carrying area so that the center of gravity of the quantity of weight is located within the shaded area illustrated in Figure 12, the center of gravity of the amount of weight placed on the floor of the boat is at least 4 inches above the floor and the center of gravity of the amount of weight placed on a seat is at least 4 inches above the seat. The location and dimensions of the shaded area are as follows:

(i) The shaded area is centered at the mid-length of the passenger carrying area;

(ii) The length of the shaded area is equal to 70 percent of the length of the passenger carrying area; and

(iii) The breadth of the shaded area is 6 inches from:

(a) For weights placed on the floor, the outboard perimeter of the passenger carrying area; and

(b) For weights placed on a seat, a vertical line inside the passenger carrying area as illustrated in Figure 13.

(d) Placement of quantity of weight: port side. The quantity of weight required by paragraph (b)(1) of this section is placed along the port side of the passenger carrying area in accordance with the conditions prescribed in paragraph (c)(2) of this section.

§ 183.335 LEVEL FLOTATION TEST WITHOUT WEIGHTS FOR PERSONS CAPACITY.

When the conditions prescribed in § 183.320 (a) and (d) through (g) are met, the boat must float in fresh, calm water as follows:

(a) The angle of heel does not exceed 10 degrees from the horizontal.

(b) Any point on either the forward or aft reference area is above the surface of the water.

(c) The reference depth at the reference area that is opposite the reference area that is above the surface of the water is 6 inches or less.

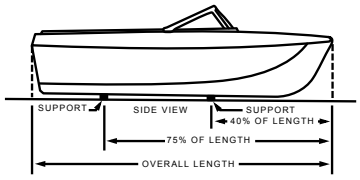


FIGURE 2. LOCATION OF SUPPORT° FOR LEVEL BOAT

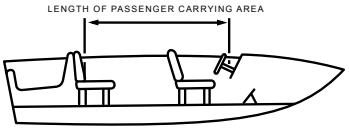


FIGURE 3. BOAT WITH DECK

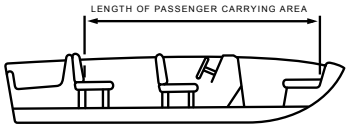


FIGURE 4. BOAT WITH CENTER CONSOLE

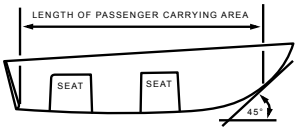


FIGURE 5. OPEN BOAT WITH CURVED STEM

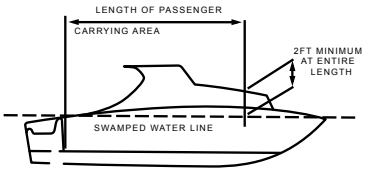


FIGURE 6. BOAT WITH CABIN

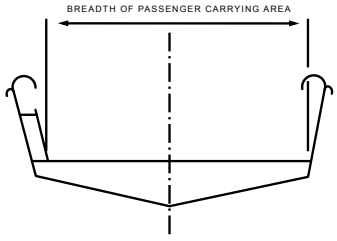


FIGURE 7.

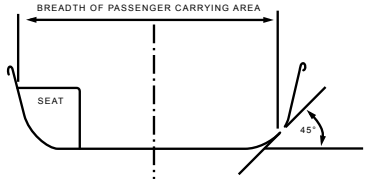


FIGURE 8. BOAT WITH ROUND CHINE

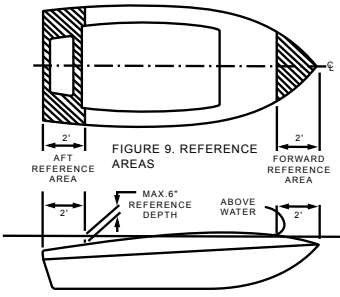


FIGURE 9. REFERENCE AREAS

FIGURE 10. REFERENCE DEPTH

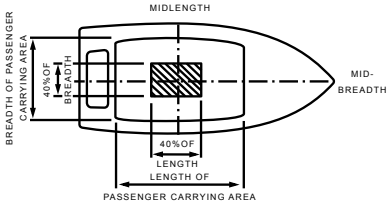


FIGURE 11. PASSENGER CARRYING AREA: LOCATION OF CENTER OF GRAVITY OF WEIGHTS

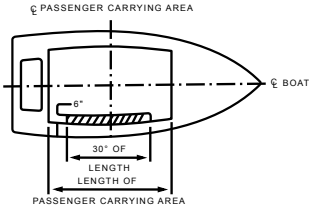


FIGURE 12. STABILITY TEST LOCATION OF CENTER OF GRAVITY OF WEIGHTS: STARBOARD SIDE

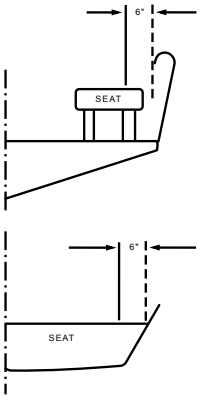


FIGURE 12. LOCATION OF CENTER OF GRAVITY OF WEIGHTS ON SEATS