Manual of Petroleum Measurement Standards Chapter 2—Tank Calibration

Section 7—Calibration of Barge Tanks

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Manual of Petroleum Measurement Standards
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Measurement Coordination Department

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FOREWORD

This standard has been prepared as a guide for the calibration of barge tanks for coastal and inland waterway service by linear measurement, liquid calibration, or barge drawings. This document and 2.8A, "Calibration of Tanks on Ships and Oceangoing Barges," of the API *Manual of Petroleum Measurement Standards* (MPMS) supersede the previous API Standard 2553, "Standard Method for Measurement and Calibration of Barges" (ASTM D 1407).

Other sections of Chapter 2 contain an overview of tank calibration, detailed procedures for calibrating various types of tanks, and a detailed discussion of liquid calibration. Upon revision Chapter 2 will be divided into eleven sections, as follows:

2.1 Introduction to Tank Calibration.
2.2A Calibration of Upright Cylindrical Tanks (API Standard 2550).
2.2B Calibration of Upright Cylindrical Tanks Using the Optical Reference Line Method.
2.3 Calibration of Underground Tanks.
2.4 Calibration of Horizontal Tanks.
2.5 Calibration of Tank Cars and Trucks.
2.6 Calibration of Spherical and Spheroidal Tanks.
2.7 Calibration of Barge Tanks.
2.8A Calibration of Tanks on Ships and Oceangoing Barges.
2.8B Recommended Practice for the Establishment of the Location of the Reference Gauge Point and the Reference Gauge Height of Tanks on Marine Tank Vessels.
2.9 Liquid Calibration.

Note: Users of this chapter and any of its sections should be aware of and comply with any federal, state, or municipal regulations that have a bearing on the procedures, including, in particular, those regulations dealing with the safe handling of volatile materials, worker safety, and environmental protection.

This standard requires the purchaser to specify certain details and features. Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of the standard, it is strongly recommended that such modifications, deletions, and amplification be made by supplementing this standard rather than by rewriting or incorporating sections of this standard into another complete standard.

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Suggested revisions are invited and should be submitted to the director of the Measurement Coordination Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Chapter 2—Tank Calibration

SECTION 7—CALIBRATION OF BARGE TANKS

2.7.1 Scope

This standard describes three methods for determining the total and incremental volumes of liquids in barge tanks for coastal and inland waterway service that have integral hull tanks. The three methods are:

a. Liquid calibration.
b. Calibration by linear measurement.
c. Calibration from barge drawings.

Sections 2.7.7 through 2.7.9 describe procedures and equipment for obtaining the requisite field measurement data and suggestions for the orderly and complete recording of field data. Sections 2.7.10 through 2.7.12 include procedures for calculating the total and incremental tank capacities from field data and suggestions for the presentation of capacity tables. Examples of typical calculations are presented in Appendix A. Terms specific to the maritime industry are defined in Appendix B.

For barges having independent tanks, refer to other sections of Chapter 2 for a similar discussion of horizontal, spherical, upright, and other mobile tanks. For the larger oceangoing barges and integrated tug barge units, refer to Chapter 2.8A.

This standard addresses liquid calibration procedures pertaining to barges. For details relating to metering systems, installation, meter proving requirements, and other guidelines relating to liquid calibration, refer to API Standard 2555.

The capacity tables should be computed so that volume is given at standard conditions, that is, at 60°F (15°C). Appropriate liquid and tape temperature corrections to 60°F (15°C) should be applied. API Standard 2543 and Chapter 17 shall be consulted for temperature determination in the marine environment.

2.7.2 Field of Application

The procedures described here are intended primarily for the calibration of integral hull tanks for carrying cargo and ballast on barges for coastal and inland waterway service.

2.7.3 Safety

Before entering any compartment, permission must be obtained from the vessel's master, senior deck officer, authorized shipyard official, or other responsible person in charge. This responsible person should supply information regarding particular materials and conditions or the applicable Material Safety Data Sheet (MSDS).

Due consideration should be given to applicable safety procedures. Safety considerations include, but are not limited to, potential electrostatic hazards, potential personnel exposure (and associated protective clothing and equipment requirements), and potential explosive and toxic hazards associated with a cargo tank's atmosphere. The physical characteristics of the cargo and existing operational conditions should be evaluated, and applicable international, federal, state, and local regulations should be observed.

In addition, before entering a compartment, a valid marine chemist's certificate must be obtained and indicate that the compartment is "Safe for Workers" and/or "Safe for Hot Work," as prescribed in NFPA 306, U.S. Coast Guard, OSHA, or other international, federal, state, or local regulations that may apply. Such testing must be made at least every 24 hours or more frequently when changing conditions warrant.

In addition, safety procedures designated by the employer, the vessel operator, and other concerned parties should also be observed. Internationally, the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT), and publications of the Oil Companies International Marine Forum and API provide additional safety information and should be consulted. See Appendix C.

Furthermore, another person should stand watch at the compartment entrance for the duration of an entry and sound an alarm if an emergency occurs. Appropriate protective clothing and equipment should be used. Normal safety precautions with respect to staging and ladders must also be observed.

2.7.4 Referenced Publications

The most recent editions of the following standards, codes, and specifications are cited in this chapter.

API

Manual of Petroleum Measurement Standards, Chapter 1, "Vocabulary"; Chapter 2, "Tank Calibration," Section 8A, "Calibration of Tanks or Ships and Oceangoing Barges"; Chapter 17, "Marine Measurement"

Publ 2026	Safe Descent onto Floating Roofs of Tanks in Petroleum Service
Publ 2217	Guidelines for Confined Space Work in the Petroleum Industry
Std 2543	Method of Measuring the Temperature of Petroleum and Petroleum Products (ANSI/ASTM[1] D1086)

[1]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Std 2550 Measurement and Calibration of Upright Cylindrical Tanks (ANSI/ASTM D 1220)

IP[2]

202/69 *Petroleum Measurement Manual* Part II, "Tank Calibration"; Section 1, "Vertical Cylindrical Tanks—Measurement Methods"

NFPA[3]

306 Control of Gas Hazards on Vessels

OSHA[4]

Occupational Safety and Health Standards (29 *Code of Federal Regulations* Sections 1910.1000 and following)

2.7.5 Significance and Use

An accurate calibration of barge tanks is essential for accurate determination of volume of cargoes loaded or discharged from the barge tanks, whether full or partial cargoes. This standard provides three methods for developing such calibrations of barge tanks.

2.7.6 Nomenclature

C = Camber
D = Molded depth of barge
d = Depth of double bottom
G = Reference gauge height
H = Deadrise
I_M = Innage as measured at reference gauge point
I_T = Innage at desired transverse frames a, b, c, ... (I_a, I_b, I_c ...)
K = Distance of reference gauge point from aft bulkhead
L = Length between draft marks
L_T = Tank length
R_b = Bilge radius
T = Barge trim
U_M = Measured ullage
U_T = Ullage corrected for trim
W = Tank width
Y = Distance from the reference gauge point to the transverse frame (Y_a, Y_b, Y_c ...)

Note: All dimensions must be in consistent units.

2.7.7 Tank Measuring Equipment

The equipment used in dimensional tank calibration is described in 2.7.7.1 through 2.7.7.8. All measuring tapes shall be in one piece and free of kinks.

[2]Institute of Petroleum, 61 New Cavendish Street, London, W1M 8AR, England.
[3]National Fire Protection Association, Battery March Park, Quincy, Massachusetts 02269.
[4]Occupational Safety and Health Administration, U.S. Department of Labor. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402

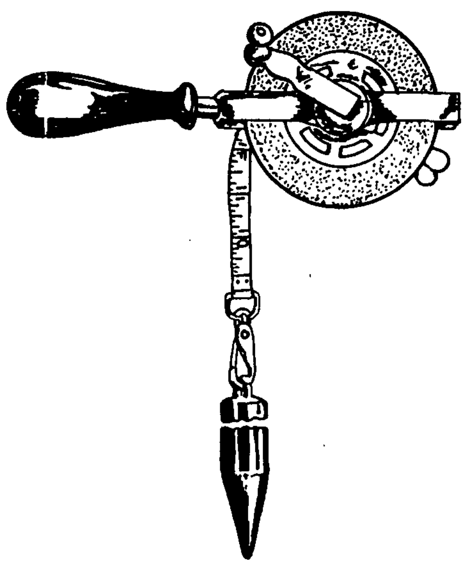


Figure 1—Height-Measuring Tape and Bob

2.7.7.1 TAPES FOR HEIGHT MEASUREMENT

For height measurements, a steel tape of convenient length is recommended and should be 0.375 or 0.500 inch wide and 0.008 to 0.012 inch thick, graduated in feet and inches to eighths of an inch, or in feet, tenths and hundredths of a foot. Tapes graduated in metric units must meet similar specifications. (For metric tapes, refer to IP 202/69.) The working tape shall be calibrated against a master tape in accordance with procedures outlined in API Standard 2550. An example of a commonly used measuring tape is shown in Figure 1.

2.7.7.2 TAPES FOR LENGTH AND WIDTH MEASUREMENTS

For length and width measurements, a steel tape of convenient length relative to the length or width of the tanks involved, usually 100 to 200 feet, is recommended, as shown in Figure 2.

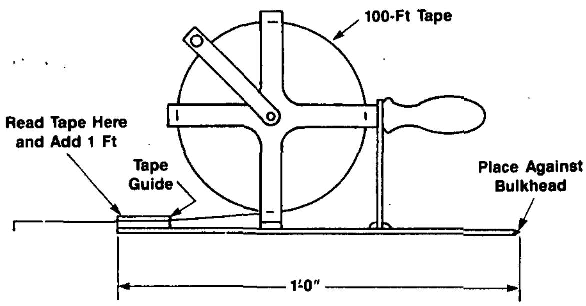


Figure 2—Length- and Width-Measuring Tape

The working tape should not be more than 0.25 inch wide, and approximately 0.01 inch thick. Graduations should be in feet and inches to eighths of an inch, or in feet, to tenths and hundredths of a foot. (For metric tapes, refer to IP 202/69.) The tapes shall be checked and conform with specified limits of accuracy when compared with the master tape as described in 2.7.7.3.

2.7.7.3 MASTER TAPES

The master tape that is used for calibrating working tapes for tank measurement should be identified with a Report of Calibration at 68°F by the National Institute of Standards and Technology. The Report of Calibration attests to the tape accuracy within 0.001 foot (approximately 1⁄64 inch) per 100 feet of length. The Report of Calibration also includes the factors and formulas necessary to correct tape length for use at either 60°F (or 15°C) under tension differing from that used during calibration and under conditions of sag in an unsupported tape.

2.7.7.4 REELS AND BRACKETS

Tapes shall be equipped with adequate reels and handles or 1-foot tape brackets with guides, whichever is appropriate for the tape to be used.

2.7.7.5 TAPE CLAMPS

To ensure a positive grip on the tape, clamps shall be used, as shown in Figure 3.

2.7.7.6 MEASURING DEVICES (TELESCOPING BARGE AND STRAPPING POLE)

The measuring devices shall be constructed of straight-grained hardwood, fiberglass, aluminum, or other suitable material. The scales along the faces of the measuring device shall be graduated in eighths of an inch or in tenths or hundredths of a foot. The measuring device shall be fabricated in two or more sections so that it may be readily adjusted to the required height. Two measuring devices are illustrated in Figure 4.

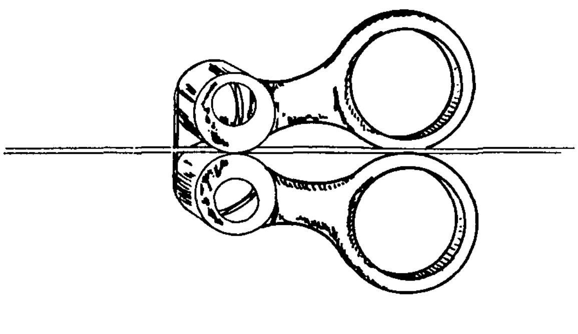


Figure 3—Tape Clamp

2.7.7.7 OTHER REQUIRED EQUIPMENT

A flexible steel ruler of suitable length, a line level or leveling device, and a depth gauge for determining strike plate thickness are also required.

2.7.7.8 ACCESSORY EQUIPMENT

The following supplementary equipment may also be needed:

a. Straightedge.
b. Crayon, awl, and scriber.
c. Cleaning instruments (for example, a putty knife).
d. Ladders.
e. Coil of wire or fishing line.

2.7.8 Measurement Conditions and Tolerances

2.7.8.1 MEASUREMENT CONDITIONS

Measurements should be taken only after all construction work has been completed. New tanks may be measured with staging in place. All tanks must be clean, gas-free, and safe for persons to enter the tank.

2.7.8.2 MEASUREMENT TOLERANCES

The procedures outlined below should be followed to ensure that measurements are within the proper tolerances:

a. All tape measurements should be read and recorded to the nearest 0.005 foot (or to the nearest 1 millimeter).
b. Temperature readings should be recorded to at least the nearest 1°F (or to the nearest 0.5°C).
c. Tank plate thickness should be determined to the nearest 0.02 inch (or to the nearest 0.5 millimeter).
d. Deadwood should be measured and located to the nearest even-numbered 0.125 inch (or to the nearest 3 millimeters).

2.7.9 Measurement Procedures

Tank calibration may be accomplished by three methods: liquid calibration, calibration by linear measurement, and calibration from barge drawings. All three methods have certain advantages and disadvantages in specific applications, and a combination of the three methods is recommended. For example, liquid calibration is desirable for tanks in the end rakes and for other tanks with a great deal of variation in shape and a considerable amount of internal structure, but liquid calibration may not be practical for the remainder of the barge. Calibration from barge drawings must be supplemented by as many linear measurements as possible and should be used only if tanks are inaccessible for linear or liquid measurement.

Barges should be recalibrated and new capacity tables prepared if any physical changes to the barge affected capacities. Such changes include, but are not limited to, structural alterations, deadwood alterations, or relocation of the reference gauge point.

2.7.9.1 LIQUID CALIBRATION BY METER METHOD

If the barge is to be calibrated by the use of meters, then calibration should be conducted in accordance with API Standard 2555.

Typical levels at which the barge should be filled are illustrated in Figure 5. Each level on the barge requires a preliminary as well as final gauge. Barge drafts or suitable freeboard measurements should be taken at the same time.

The preliminary gauges on the barge shall be taken when the liquid has been transferred into each barge tank to the approximate location desired. The final gauge shall be taken after all barge tanks are filled to the same approximate level and the barge tank has returned to even keel.

Temperatures of the liquid in the barge tanks should also be recorded during each level measurement. The exact location of the barge tank gauging points with reference to the centerline and transverse bulkheads of the barge shall also be recorded.

2.7.9.2 CALIBRATION BY LINEAR MEASUREMENT

2.7.9.2.1 Preliminary Measurements

Before entering the barge's tanks, measurements should be taken on deck. A line shall be stretched transversely across the deck, or a transit may be used, to determine the amount of camber. The distances from the line to the deck at the centerline and at each side of the barge (or at a measured

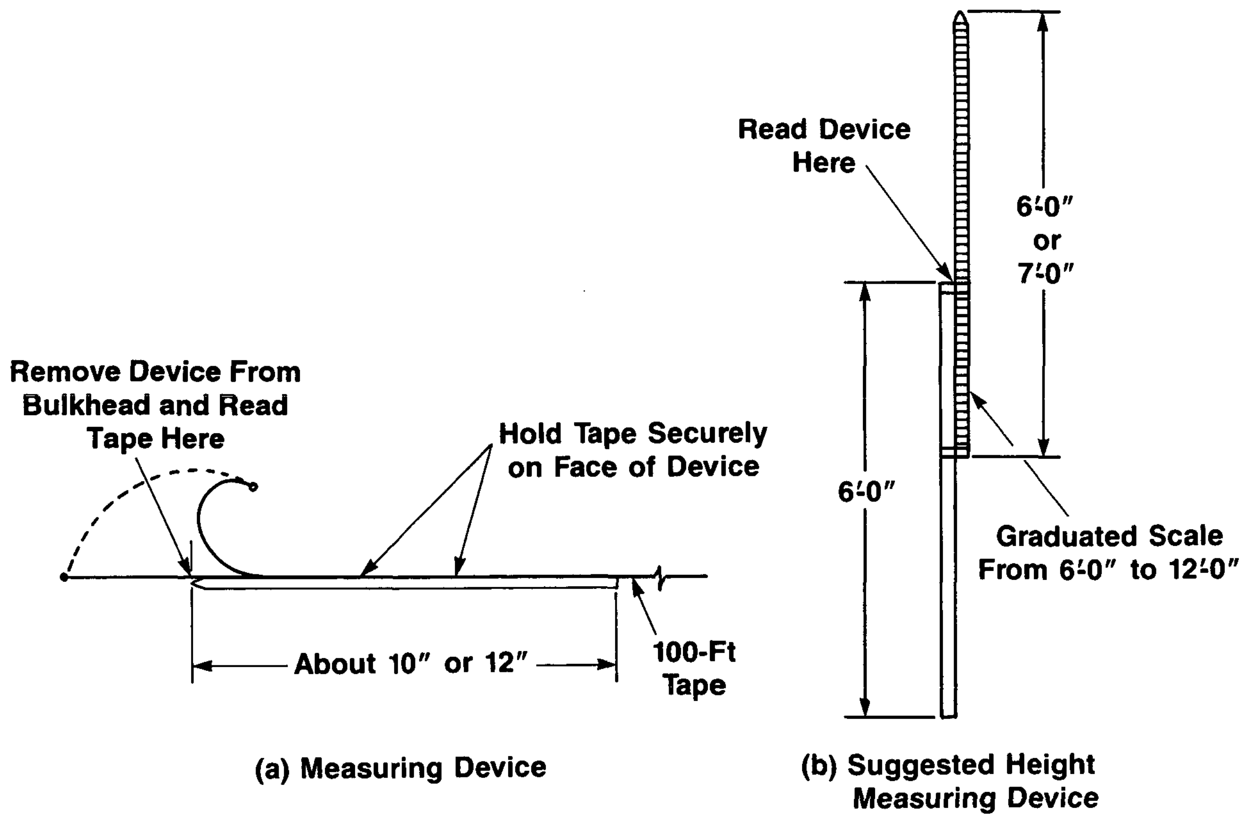


Figure 4—Measuring Devices

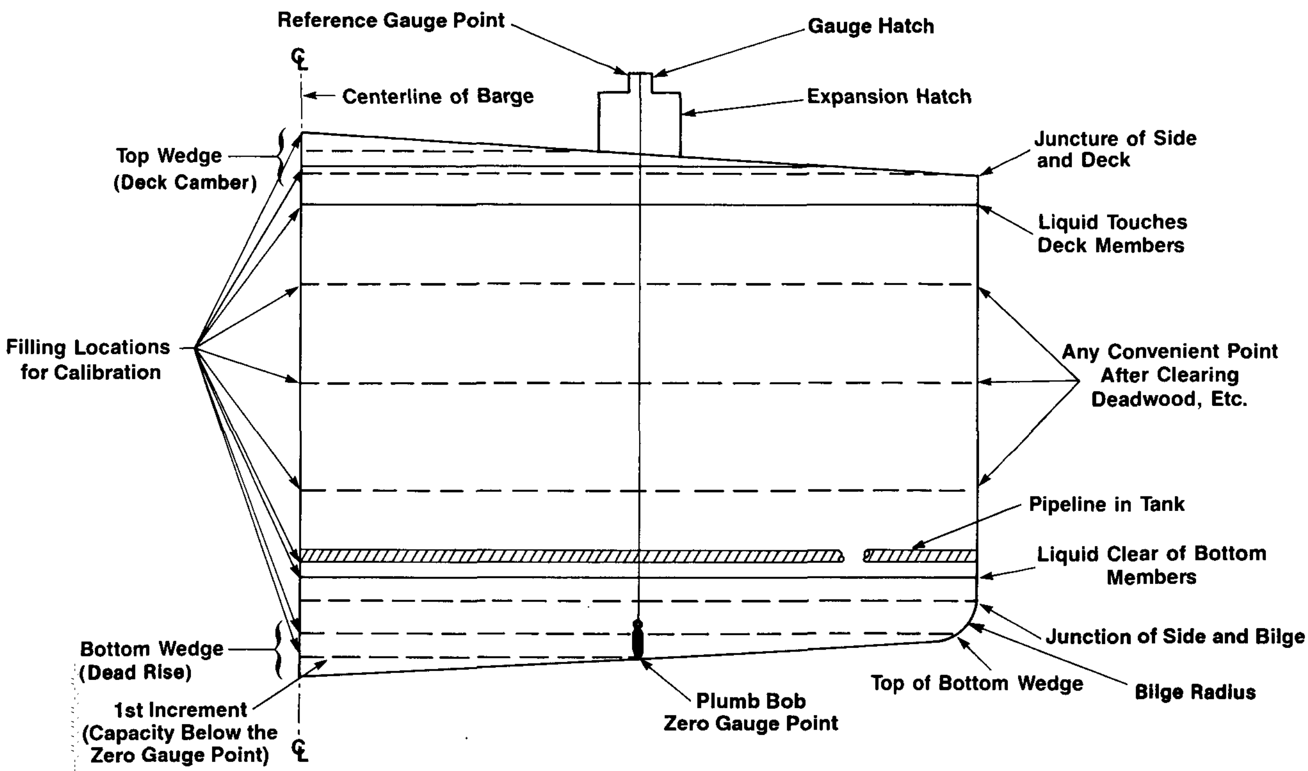


Figure 5—Filling Levels for Liquid Calibration

distance from the centerline) shall be measured. This camber should be established in at least two separate places on the barge's deck.

The forward and aft tanks on some barges may have longitudinal sheer, and it should be measured with a straight line or transit, fore and aft.

The size and height of the gauge hatches shall be measured, and their position shall be defined with respect to the centerline or longitudinal bulkhead and the nearest transverse bulkhead, as shown in Figure 6. The reference gauge heights of each tank shall also be measured and recorded at this time, as illustrated in Figure 6.

Note: When the gauge hatch is located on an expansion trunk, the overall reference gauge height of the tank may change with the opening and closing of the expansion trunk cover because of compression of the cover gasket.

Sample linear measurement calculations and a sample barge calibration form are illustrated in Appendix A. A typical measurement record for a barge may be found in Table A-1.

2.7.9.2.2 Internal Tank Measurements

When entering a barge tank, tape paths should be chosen that permit unobstructed measurements in the following locations, wherever possible:

a. Length measurements just above the bottom stiffeners or along the top of the inner bottom plating, if fitted:
1. Near the centerline bulkhead.
2. Middle of the tank.
3. Near the outboard bulkhead or shell.

b. Length measurements approximately 6 feet (2 meters) above the tank bottom:
1. Near the centerline bulkhead.
2. Middle of the tank.
3. Near the outboard bulkhead or shell.

Note: If either the forward end, aft end, or both transverse bulkheads of the tank are of corrugated construction, the length measurements are to be made and recorded as shown in Figure 7.

c. Width measurements just above the bilge or along the top of the inner bottom plating if fitted:
1. Near the forward bulkhead.
2. Middle of the tank.
3. Near the aft bulkhead.

d. Width measurements approximately 6 feet (2 meters) above the tank bottom:
1. Near the forward bulkhead.
2. Middle of the tank.
3. Near the aft bulkhead.

e. Height measurements at the forward bulkhead:
1. Against the centerline bulkhead.

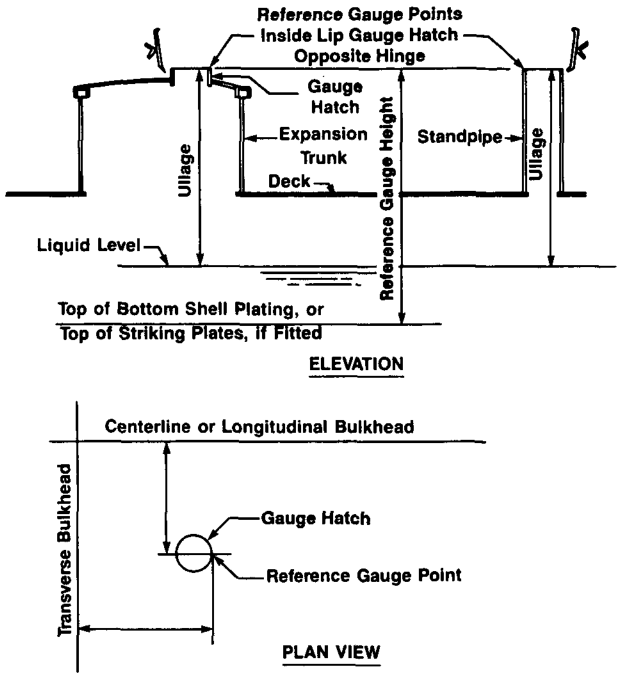


Figure 6—Reference Gauge Height and Location of Reference Gauge Point

2. A measured distance from the shell (usually just inside the bilge) or at the inner skin, if fitted.

f. Height measurements at midlength of the tank:
   1. Against the centerline bulkhead.
   2. A measured distance from the shell (usually just inside the bilge) or at the inner skin, if fitted.

g. Height measurements at the aft bulkhead:
   1. Against the centerline bulkhead.
   2. A measured distance from the shell (usually just inside the bilge) or at the inner skin, if fitted.

Note: When widths, lengths, and heights are recorded, measuring locations should be referenced. See Appendix A.

2.7.9.2.3 Other Measurements

The bilge radius amidships may be determined by establishing a plumb line at the point of bilge tangency to the bottom shell plating and by measuring from the side shell to the plumb line.

If the barge is in drydock at the time of measurement, the deadrise amidships may be determined by establishing a transverse level line under the barge's bottom and by measuring heights at the centerline and at the tangent point of the bilge radius to the bottom shell plating. The slope thus obtained must be projected to the molded half-breadth of the hull to obtain the deadrise. If such measurements are not possible, the deadrise and bilge radius may be taken from the barge's drawings.

All internal deadwood shall be measured, described, and located with respect to height as measured from the bottom shell or deck. The items comprising deadwood and the allocation of deadwood to zones is accomplished as described in 2.7.10.3.

For end wing tanks with a great deal of variation in shape, width measurements should be taken at least at each transverse frame if possible, or at closer intervals if necessary, and at the height of each longitudinal frame from the bottom to the deck. These measurements describe the shape of the hull at each frame from which the transverse area to any given depth of liquid may be determined. The volume to a given depth of liquid is then determined by integration or by any other numerical methods.

2.7.9.3 CALIBRATION FROM BARGE DRAWINGS

Adequate detailed drawings depicting the barge's construction, including deadwood and tank dimensions, may be available for some barges on which gauge tables are to be prepared. Use of these data is restricted to barges that are in service but are not considered safe to enter for actual measurements or that are unavailable for liquid calibration. Changes occur during construction that may not be included on the drawings; therefore, as many check measurements as possible must be made on board to verify dimensions shown on the drawings. In particular, the total gauge height, the height of gauge point above deck, inside height of deck above tank bottom in way of gauge point, length between forward and aft draft marks, and location in reference to the barge centerline and aft transverse bulkhead shall be measured and recorded for each tank, as illustrated in Figure 6. The inside lip of the gauge hatch should not be confused with the fire screen retainer ring. (Refer to 2.7.12.)

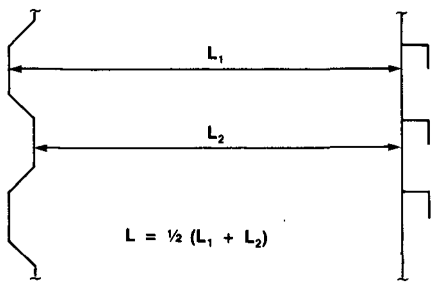
2.7.10 Calculations

2.7.10.1 CALCULATIONS FOR LIQUID CALIBRATION PROCEDURES

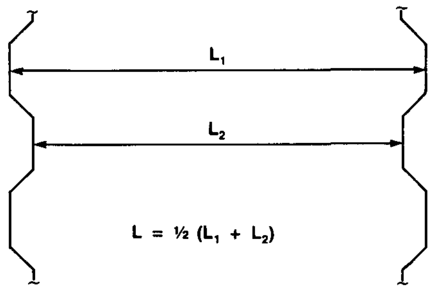
Refer to API Standard 2555 for an explanation of calculations for liquid calibration procedures.

2.7.10.2 CALCULATIONS FOR CALIBRATION BY LINEAR MEASUREMENT AND BY BARGE DRAWINGS

The dimensions of all transverse sections of the barge may be obtained from the field report or from the barge's drawings as described in 2.7.9.3. The deadrise is determined by subtracting the measured deck camber from the difference between the corrected inboard and outboard tank heights. The corrected heights are those that have been extended on a determined slope to the point at which they were intended to



Length of tank with one corrugated and one flat bulkhead



Length of tank with both bulkheads corrugated

Figure 7—Length of Tanks With One or Two Corrugated Bulkheads

be used, that is, the centerline bulkhead and shell. Measurements may be made with working tapes that have been calibrated with a master tape whose length is based on 68°F; however, measurements recorded on this temperature basis must be mathematically corrected to the equivalent 60°F value to compute capacity table as described in 2.7.7.3.

A series of transverse barge tank sections are then developed for each tank; each is determined from an average of the applicable measurements. Figure 8 shows a typical transverse section. All measurements should be read and recorded in consistent units.

The basic volume of a barge tank is expressed in cubic feet or cubic meters as follows:

$$\text{Basic Volume} = L_T \times W \times (D - H) \tag{1}$$

The volume gained by deadrise and camber must be added to the basic volume. The volume due to the bilge radius must be deducted from the basic volume. The addition of deadrise may be expressed in cubic feet or cubic meters as follows:

$$\text{Addition} = \tfrac{1}{2} \times L_T \times W \times H \tag{1A}$$

This addition for deadrise is spread incrementally and linearly from the bottom up through the extent of deadrise. If the gauge point is somewhere other than at the low point of the bottom, the volume below the zero gauge point should be determined and recorded.

The deduction for bilge radius may be expressed approximately in cubic feet or cubic meters as indicated in Figure 8A and as follows:

$$\text{Deduction} = L_T\left\{R_b^2 - \pi\frac{R_b^2}{4}\right\} \tag{1B}$$

This deduction for bilge radius is spread incrementally and linearly from the bottom up through the extent of such radius.

The addition for camber volume may be calculated from Figure 8B, and the addition spread incrementally and linearly through the extent of such camber.

$$\text{Addition} = \tfrac{1}{2} \times L_T \times W \times C \tag{1C}$$

Some barges are constructed with an inner bottom, and others are constructed with both an inner bottom and double skin sides. See Figure 8C. The basic volume for these barges is computed by substituting the expression (D-d) for D in Equation 1 where d is the depth of double bottom (distance from the top of the bottom shell plating at centerline to underside of inner bottom of plating). W is the width as shown in Figure 8C. (The addition for camber volume must still be made, but the corrections for deadrise and bilge radius would apply only for the calibration of the void tank below the inner bottom. See 2.7.10.3)

The volume calculations should be made at intervals of 1 inch from the bottom of the barge to the top of Zone II. See Figure 9.

From this point to the top of Zone III of Figure 9, the intervals may be taken every 3.0 inches (75 millimeters). From the top of Zone III to the deck, the intervals should revert to 1 inch. A curve of capacity versus depth may then be plotted and the capacities obtained for each 0.25 inch of ullage. The vertical extent of the zones are defined in 2.7.10.3. For barges with inner bottoms, refer to Figure 9A for the extent of zones.

2.7.10.3 CALCULATIONS FOR DEADWOOD

When calibration is by liquid measurement, no further calculation for deadwood is required. When calibration is by linear measurement or from the barge's drawings, deadwood must be deducted from the molded volumes described in 2.7.10.2. and in accordance with the following procedure.

To calculate and allocate the volume of deadwood in a tank properly, the depth of each tank is divided into four zones (Figure 9):

a. Zone I—From the top of the bottom shell plating up to and including the top flange or face plate of the bottom shell longitudinals. If an inner bottom is fitted, Zone I extends from the top of the bottom shell plating to the underside of the inner bottom. (Refer to Figure 9A.)

b. Zone II—From the top of Zone I up to and including the top face plate of the bottom transverse web frames. If an inner

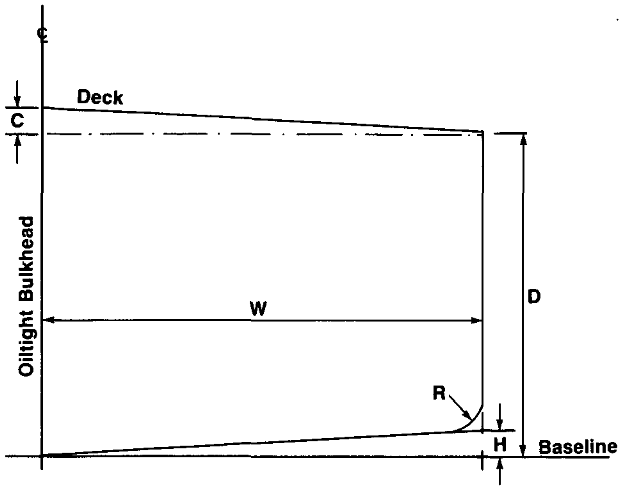


Figure 8—Typical Transverse Section

bottom is fitted, Zone II extends from the top of the inner bottom plating to the top of the first horizontal shell or bulkhead stiffener above the inner bottom.

c. Zone III—From the top of Zone II up to the underside of the face plate of the deck transverse web frames.

d. Zone IV—From the top of Zone III up to the underside of the deck plating.

The volume of deadwood in each of these zones is calculated and distributed over the depth of the zone by 0.25-inch (6-millimeter) increments. These incremental volumes are deducted from the corresponding incremental molded volumes within the zone to obtain the actual internal volume available for liquid at a given innage or ullage height.

The following items are included in deadwood volumes allocated to the proper zone:

a. All internal steel structure. When the calculations are made from drawings, the deadwood in each zone in each tank includes the volume of the plating of one transverse bulkhead. On a centerline oil-tight bulkhead, the volume of the plating is allocated to the appropriate zone in the tank in which the stiffeners are fitted.

b. Volume of the outside diameter of heater coils, if fitted, including risers.

c. Volume of the outside diameter of the closed cargo piping and volume of the wall thickness of the open-ended piping.

d. Volume of miscellaneous deadwood, including ladders, platforms, reach rods, hydraulic piping to valves, and internally mounted tank cleaning machines including their supports and piping.

e. Volume of immersed deepwell pumps to outer diameter of outer barrel.

2.7.10.4 CALCULATIONS FOR TRIM CORRECTIONS

The capacity tables must contain correction tables for the observed gauges obtained when the barge is other than on an even keel longitudinally and the liquid is in contact with all four bulkheads but not with the underside of the deck. See Figure 10. No correction for list for barges is considered necessary. For a barge out of trim by the stern, the measured ullage U_M should be corrected for trim as shown in Equation 2. Conditions of trim by the head will reverse the sign, as shown in Equation 2A.

$$U_T = \left\{U_M \frac{\sqrt{L^2 + T^2}}{L}\right\} + \frac{T}{L}\left\{\frac{L_T}{2} - K\right\} \tag{2}$$

$$U_T = \left\{U_M \frac{\sqrt{L^2 + T^2}}{L}\right\} - \frac{T}{L}\left\{\frac{L_T}{2} - K\right\} \tag{2A}$$

2.7.11 Calibration of Tanks for Wedge Volumes

The capacity tables shall contain wedge tables to show the tank capacities for varied trim of the barge when the entire bottom of the tank is not covered by liquid. These tables shall be prepared from the line drawings of the barge and should consider the shape of the hull with respect to deadrise, bilge radius, end rake, and stern notch, wherever applicable. These tables shall be prepared for various trims up to about 2.5 percent of the length of the barge by increments of not more than 1 foot (300 millimeters) and for innages by 0.02-foot (6-millimeter) increments from zero up to an innage that results when the entire bottom of the tank is covered by liquid. The tables are prepared on the assumption that this small volume is entirely a free-flowing liquid.

Such tables are prepared by dividing the length of the tank into an equally spaced station; these stations are most conveniently located at the transverse frames in the tank. Figure 11 shows the longitudinal section through the tank through a reference gauge point.

An observed innage is converted into a true innage at each one of these transverse frames using the following formula:

$$I = I_M + \left\{ Y - \frac{GT}{L} \right\} \frac{T}{L} \tag{3}$$

The lines of the hull must be obtained either from the builder's line drawing or from internal measurements in the tank. If the calculated innage is taken at each frame, the transverse areas of the tank at each frame from the bottom up to such innage are determined from the hull lines. These areas are then integrated by Simpson's Rule or by equivalent numerical integration methods to obtain a volume from which a deduction for deadwood must be made to obtain the true volume of the wedge.

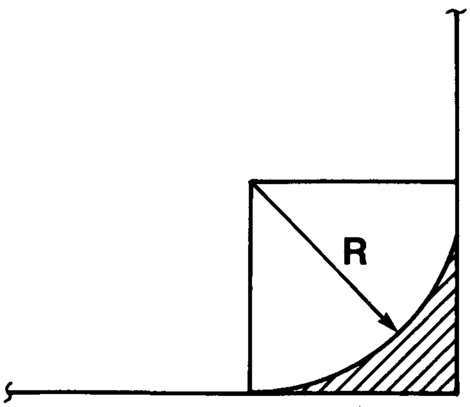


Figure 8A—Deduction for Bilge Radius

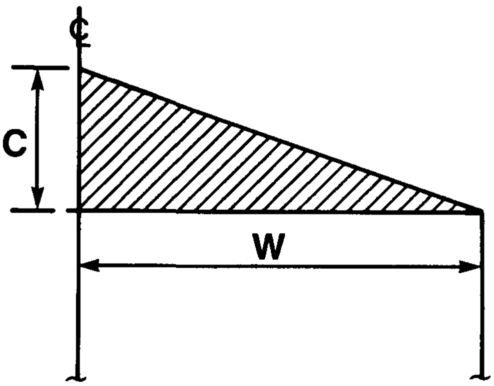


Figure 8B—Addition for Camber

The application of the wedge volume determination procedures for a typical wing tank is illustrated in Figure 12. This tank is assumed to extend between oil-tight transverse bulkheads at frame 9 and at frame 14 of the barge, and frames are spaced 4 feet 9 inches apart giving a wing tank length of 23 feet 9 inches. Other pertinent data for the barge are as follows:

a. Length between draft marks: 232 feet 11 5/8 inches.
b. Reference gauge height of the tank: 15 feet.
c. Trim: 4 feet.
d. Location of reference gauge point from the aft bulkhead: 7 feet 2.5 inches.
e. Innage at the reference gauge point: 2.5 inches.
f. Frames: 9 (aft), 10, 11, 12, 13, and 14 (forward).

Innages calculated at each frame using Figure 11 and Equation 3 are tabulated in Table 1.

Table 1—Computed Innages at Frames

Frame No.	Innage (inches)	Innage (feet)
9	4.038	0.337
10	3.060	0.255
11	2.081	0.173
12	1.102	0.092
13	0.124	0.010
14	0.000	0.000

The lines of the hull as previously selected at each frame are illustrated in Figure 13.

These innages are plotted on each transverse frame as shown in Figures 14 through 18. The transverse area of the liquid at each frame is determined by planimeter or other means. These areas are then integrated by Simpson's Rule to obtain the molded volume, as shown in Table 2.

The deadwood in Zone I for this barge is 2.68 percent of the molded volume, or in this case, 1.25 cubic feet. Deducting this number from the molded volume results in 45.55 cubic feet or 8.12 barrels of liquid in the wedge.

This example has been presented in a longhand and graphic manner to demonstrate the procedure and only covers an input of one trim and one innage. For practical application, when a series of innages and a range of trims are required, the above calculations should be established in a computer program. The program input would cover the appropriate barge characteristics, including the length of the barge between draft marks and the location of the reference gauge point.

The program would also include the width of the tank at closely spaced increments of tank depth at each frame. The area of each increment would be the tank width at that depth multiplied by the depth of the increment. If these incremental areas are added and if the variables of innage at the reference gauge point and the trim are entered, the areas of liquid at each frame are produced. The areas are then integrated to give the molded volume. If the volume of deadwood in this region of the tank is deducted, the true volume of the liquid in the wedge is produced.

Table 2—Calculation of Wedge Volume

Frame No.	Area (square feet)	Simpson's Multiplier	f(V)
9	5.15	1	5.15
10	3.71	4	14.84
11	2.39	2	4.78
12	1.17	4	4.68
13	0.11	1	0.11
		$\Sigma f(V) = 29.56$	

Molded volume = 29.56 x 475 x 1/3 = 46.80 cubic feet

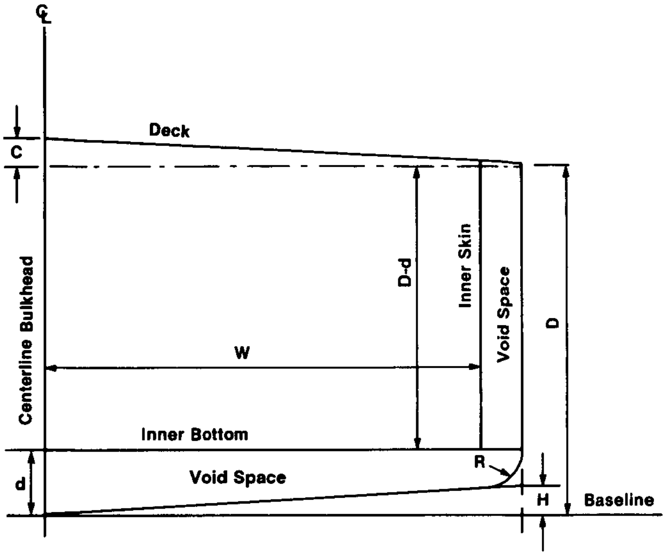


Figure 8C—Typical Transverse Section With Double Bottom and Double Skin Sides

2.7.12 Presentation of Capacity Tables

Capacity tables must contain either a notation or a sketch similar to the plan view of Figure 6 and provide the fore and aft and transverse location of the reference gauge point for each tank dimensioned in feet or meters from suitable reference points such as oil-tight bulkheads or the barge centerline. The notation or sketch must also indicate the reference gauge height for each tank, expressed in feet or meters, from the reference gauge point (top inside lip of the gauge hatch at a point opposite the hinge of the gauge hatch cover) to the top of the bottom shell plating or to the top of the striking plate, if fitted. The flame screen retainer ring should have a notch located below the reference gauge point to permit tape passage.

When the reference gauge height is measured on an existing barge that has the gauge hatch in the expansion trunk cover, the cover should be dogged down as in normal operation. With the cover in this position, a check measurement should be made from the lip of the cover to the deck. Because this dimension varies around the circumference of the expansion trunk due to the deck camber, the measurement should be taken in line with the reference gauge point as shown in Figure 5. The measured gauge heights and ullages are then corrected for this particular gasket compression.

The capacity tables for each tank shall indicate a volume corresponding to each 0.25 inch (6 millimeters) of ullage for the full height of the tank. The volume of liquid below the zero gauge point should be indicated for each tank. When the ullage opening is located in the cover of the expansion trunk, the capacity tables shall be carried up to show capacities up to zero ullage at the reference gauge point. If the ullage location is on a standpipe, the capacity tables shall be carried up to the deck, and this finding shall be noted in the tables. Volumes are to be expressed in barrels of 42 U.S. gallons; however, at the owner's option, additional columns may be included giving the volumes in cubic feet, cubic meters, U.S. gallons, Imperial gallons, and/or long tons or metric tons of salt water or fresh water.

The internal volume of closed pipelines on the tanks shall be indicated in the capacity tables as a footnote. It should be clearly stated whether the pipelines are considered empty or full in the development of the capacity tables.

The capacity tables shall note the length of the barge between draft marks. They should also note the method used in calibration.

Trim correction tables should be prepared for various trims up to a trim of 2.5 percent of the length of the barge by increments not to exceed 1 foot (300 millimeters). If desired, tank capacities may also be presented as innages using similar procedures.

2.7.13 Calibration Information Plates

In addition to the information described here, each tank on each barge should be provided with a calibration information plate bearing the following information:

a. Identification of the tank.

b. Reference gauge height (total gauge height) of the tank in feet, inches, or equivalent metric units.

c. Number of the calibration certificate, followed by the last two figures of the year in which the calibration was made and preceded by the name or acronym of the institution that carried out the calibration.

d. A statement indicating that the tank is calibrated based on ullage or innage.

The calibration information plate must be made of metal that is impervious to corrosion by atmospheric conditions or by the cargo and that is resistant to mechanical damage. The plate shall be permanently attached to an integral part of the tank and readily visible. If the ullage opening is located on the cover of the expansion trunk, the plate should be attached to the cover; if the ullage opening is a standpipe, the plate should be located on the standpipe. The plate should be installed on the side of the ullage opening designated as the reference gauge point.

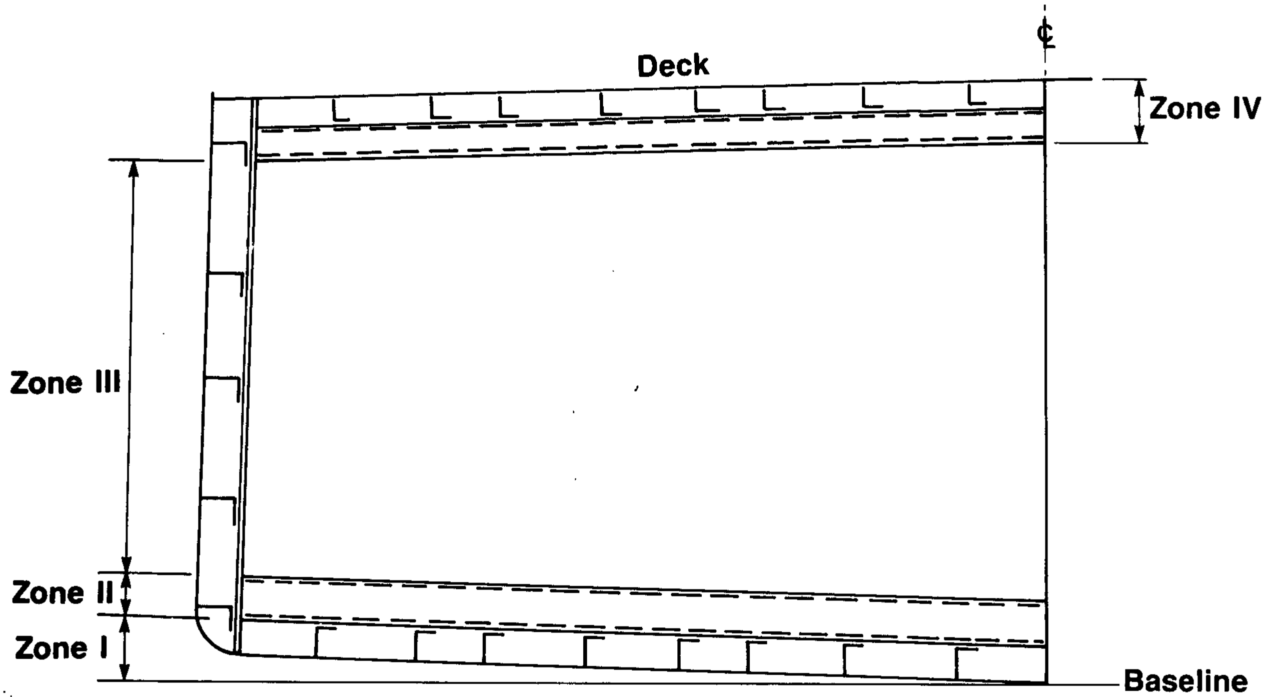


Figure 9—Zones of Transverse Section

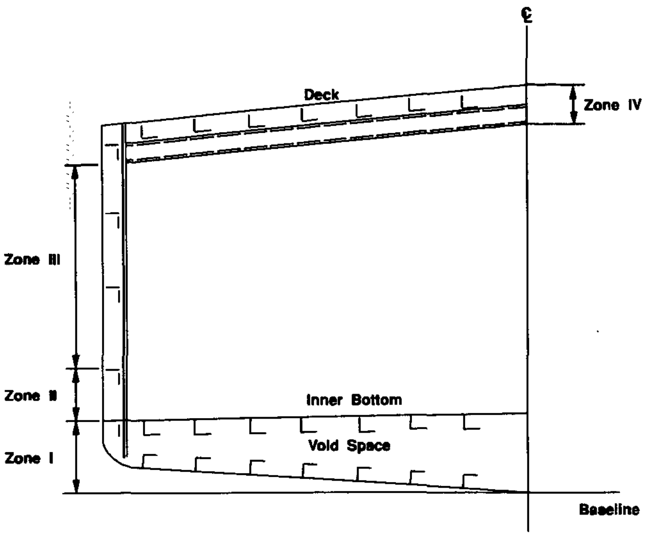


Figure 9A—Zones of Transverse Section With Inner Bottom

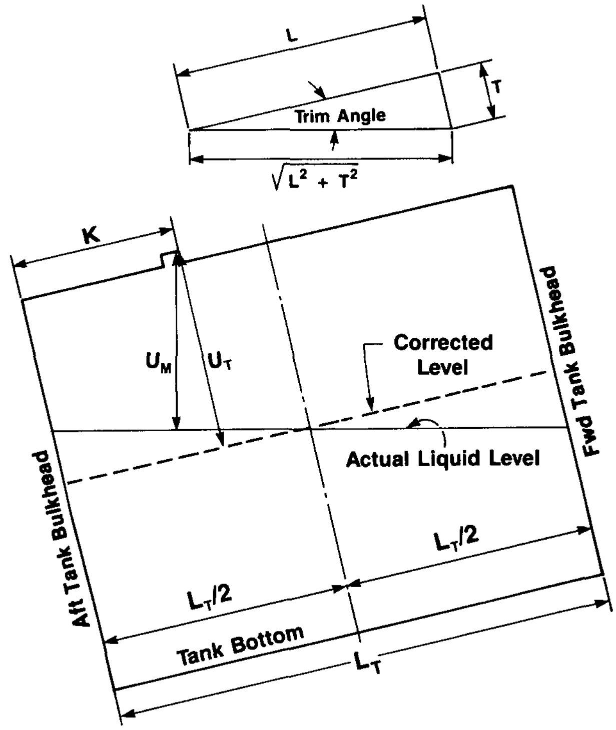


Figure 10—Trim Corrections

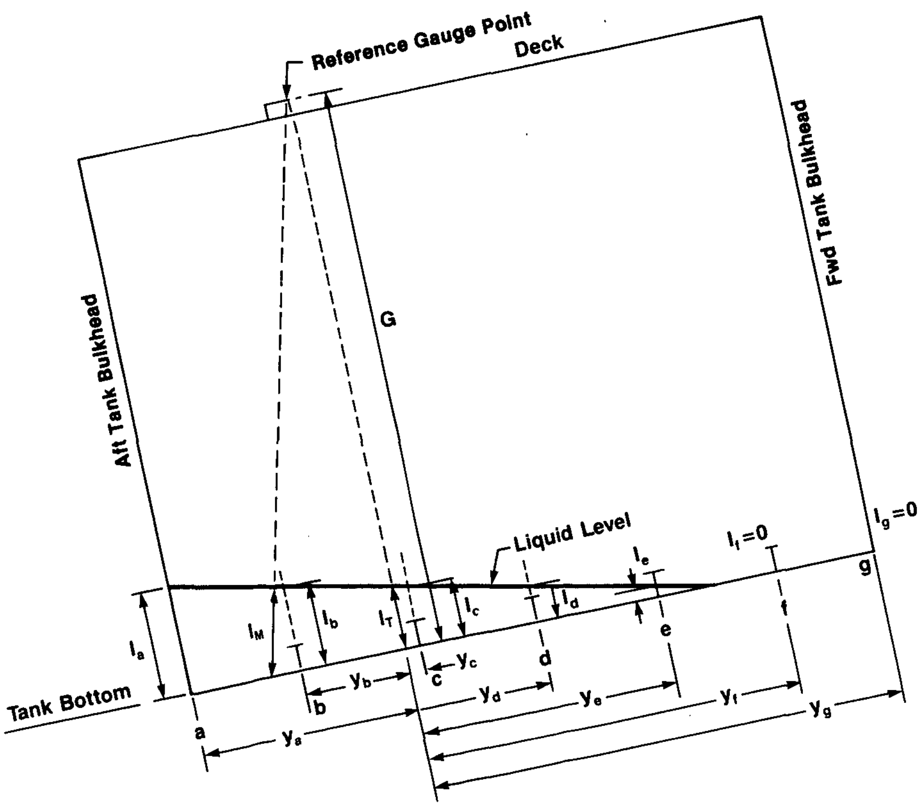


Figure 11—Longitudinal Section of Tank

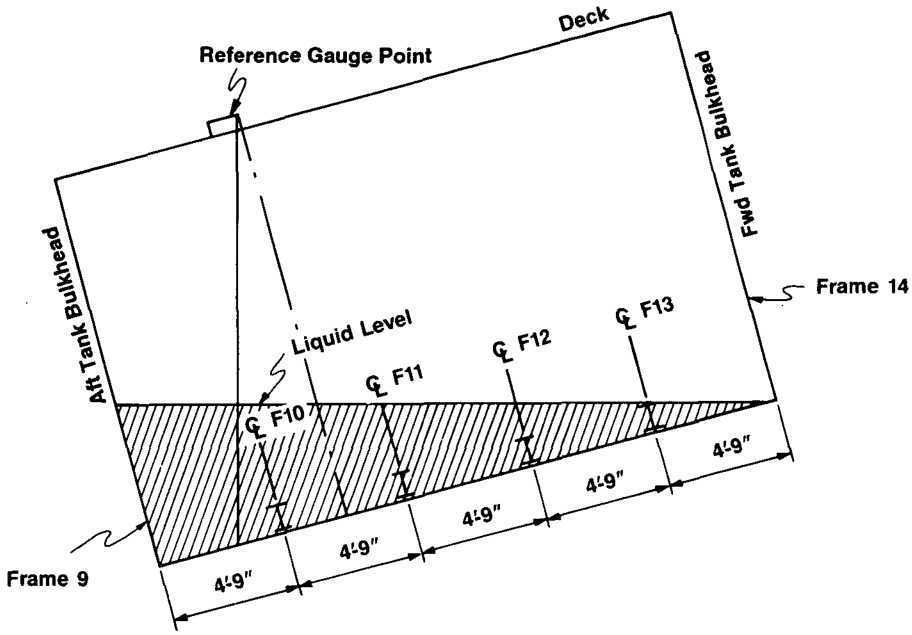


Figure 12—Calculation of Wedge Volume

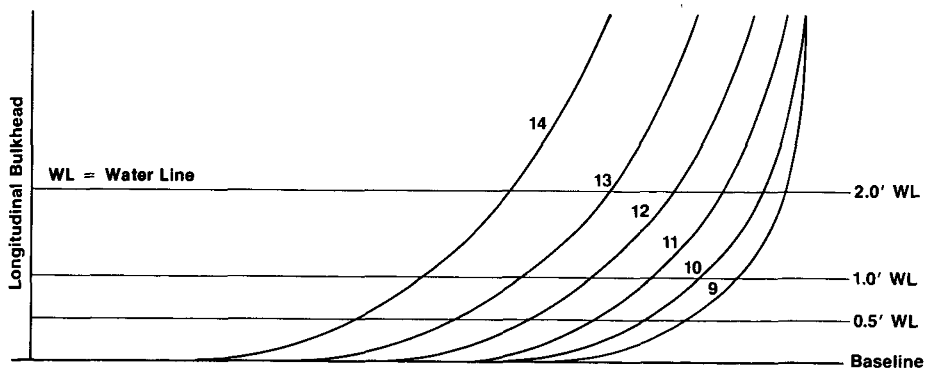


Figure 13—Lines of Hull

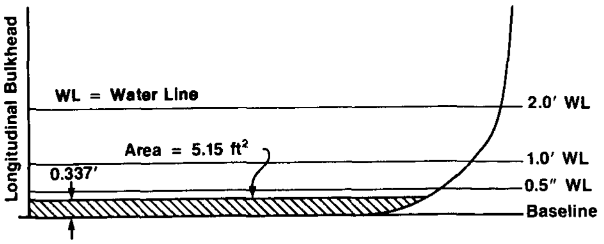


Figure 14—Area of Liquid at Frame 9

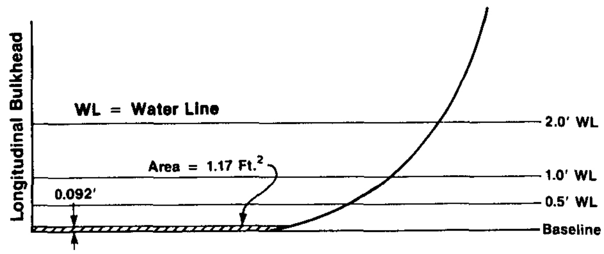


Figure 17—Area of Liquid at Frame 12

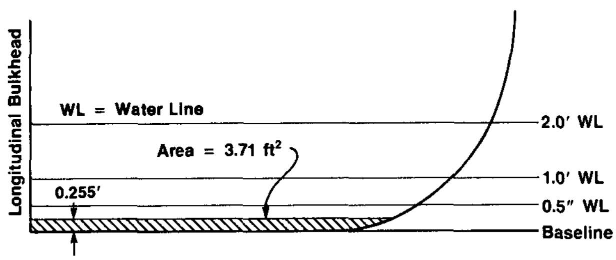


Figure 15—Area of Liquid at Frame 10

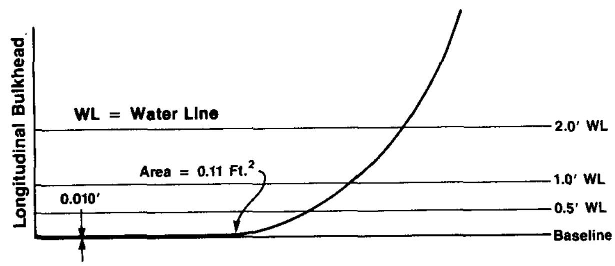


Figure 18—Area of Liquid at Frame 13

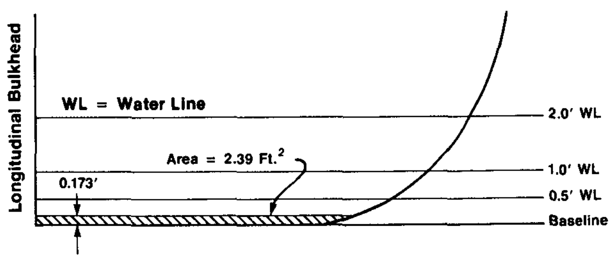


Figure 16—Area of Liquid at Frame 11

APPENDIX A—LINEAR MEASUREMENT CALCULATIONS

Table A-1—Typical Measurement Record of a Barge Tank

BARGE CALIBRATION FORM

NAME OF BARGE Barge No. 20

OWNER XYZ Oil Company — CONTRACT NO. 011312

LOCATION Port Arthur, Texas — HULL NO. 103

BUILT BY Builders Shipyard, Port Arthur, Tx. — CALIBRATED BY ER, DH

LENGTH BETWEEN DRAFT MARKS 160.3 ft. — DATE CALIBRATED March, 1984

TYPE CAPACITY TABLE: (Circle Those Required)

Barrels: ~~Gallons: Cubic Meters~~

~~1/8"~~, 1/4", ~~0.005 ft.~~

Innage, ~~Ullage~~

TANK NO.: 2 PORT [A]

REFERENCE GAUGE HEIGHT: 17 ft. 0 5/8 in.

HEIGHT FROM REFERENCE GAUGE POINT TO TOP OF DECK 2 ft. 6 3/8 in.

LOCATION OF REFERENCE GAUGE POINT: FROM AFT BULKHEAD 16 ft. 0. in.

FROM CENTER BULKHEAD OR CENTER LINE 9 ft. 6 in.

LOCATED ON: Standpipe or expansion trunk hatch cover (circle one)

Size of Expansion Hatch 30 in. diameter

LENGTH MEASUREMENTS	Above Bottom Stiffeners	Six Feet above Bottom
1. NEAR CENTERLINE BULKHEAD	31.96 ft.	31.95 ft.
2. CENTER OF TANK	31.95 ft.	31.96 ft.
3. NEAR OUTBOARD BULKHEAD	31.94 ft.	31.95 ft.
WIDTH MEASUREMENTS		
1. NEAR FORWARD BULKHEAD	18.97 ft.	18.99 ft.
2. CENTER OF TANK	19.00 ft.	18.99 ft.
3. NEAR AFT BULKHEAD	19.00 ft.	19.015 ft.

HEIGHT MEASUREMENTS	NEAR CENTER BULKHEAD *	NEAR OUTBOARD BULKHEAD *
1. AT FORWARD END	14 ft. 7 1/8 in. (12 in.) 13 ft. 9 3/4 in.	
2. AT CENTER	14 ft. 7 3/16 in. (12 in.) 13 ft. 9 5/16 in.	
3. AT AFT END	14 ft. 7 1/4 in. (12 in.) 13 ft. 10 1/8 in.	

HEIGHT AT REFERENCE GAUGE POINT 14 ft. 6 in.

(* Show distance away from bulkhead)

[A] See Figure A-1 for an illustration of example calculation measurement.

Table A-1—(continued)

Deadwood

1. 9- 12 in. × 32 ft. 0 in. (serrated) bottom stiffeners .... from 0 ft. 0 in. to 0 ft. 11 1/4 in.
2. 3- 12 in. × 19 ft. 0 in. (serrated) bottom stiffeners .... from 0 ft. 9 in. to 1 ft. 11 1/4 in.
3. 6- 12 in. × 14 ft. 3 in. vertical bulkhead stiffeners .... from 0 ft. 0 in. to 14 ft. 3 in.
4. 6- 6 in. × 6 in. × 3/8 in. × 14 ft. 3 in. vertical deck stiffeners .... from 0 ft. 0 in. to 14 ft. 3. in.
5. 9- 4 in. × 6 in. × 3/8 in. × 7 ft. 9 in. diagonal bracing .... from 3 ft. 0 in. to 10 ft. 0 in.
6. 3- 6 in. × 4 in. × 3/8 in. × 7 ft. 9 in. diagonal bracing .... from 3 ft. 0 in. to 10 ft. 0 in.
7. 13- 9 in. × 32 ft. 0 in. longitudinal bulkhead and shell stiffeners .... from 0 ft. 0 in. to 14 ft. 3 in.
8. 9- 1 1/2 in. pipe × 32 ft. 0 in. heating coils .... from 0 ft. 2 in. to 0 ft. 5 1/2 in.
9. 7- 9 in. × 19 ft. 0 in. (serrated) bulkhead stiffeners .... from 2 ft. 0 in. to 12 ft. 7 1/4 in.
10. 3/8 in. strike plate

Deck camber

Elevation of line level at shell = 12 in.

Elevation of line level at center = $\frac{4\ 1/4 \text{ in.}}{7\ 3/4 \text{ in.}}$

Bilge radius = 12 in.

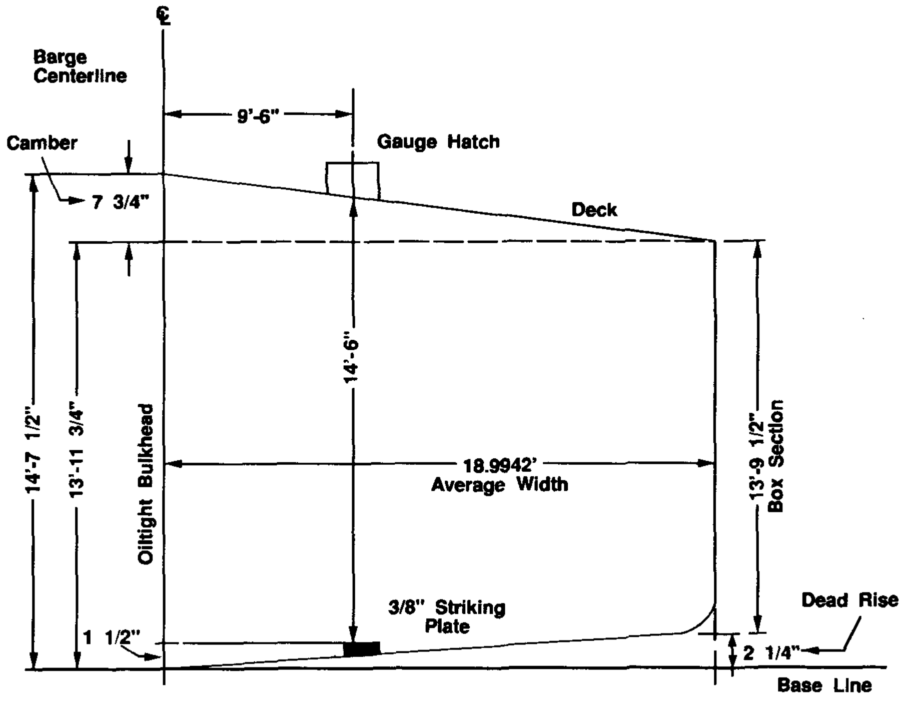


Figure A-1—Tank No. 2 Port Dimensions

Table A-2—Volume Calculations

Average length	= 31.9517 (383.42 in.)
Average width	= 18.9942 ft. (227.93 in.)
Average outboard height	= 13.8281 ft. (13 ft. 10 in.)
Average inboard height	= 14.5990 ft. (14 ft. 7 ¼ in.)

Horizontal distance between height measurements = 17.5000 ft.

Slope of barge deck and bottom = (14.5990 ft. - 13.8281 ft.) = 0.7709 ft.
0.7709 ft. ÷ 17.5000 = 0.0441 in. per ft.

Outboard heights taken 1 ft. 0 in. from shell

Corrected outboard heights = 13.8281 ft.
Less (1.0000 × 0.0441) = 0.0441 ft.
Corrected = 13.7840 ft. (13 ft. 9 ½ in.)

Inboard heights taken 0 ft. 6 in. from centerline

Corrected inboard heights = 14.5990 ft.
Plus (0.5000 × 0.0441) = 0.0221 ft.
Corrected = 14.5211 ft. (14 ft. 7 ½ in.)

Total camber and deadrise = 14 ft. 7 ½ in.
Less 13 ft. 9 ½ in.
10 in.

Less measured camber deadrise 7 ¾ in.
Deadrise = 2 ¼ in.

Box height of tank = 13 ft. 9 ½ in. (corrected outboard height)

$$\text{Gross volume per } \tfrac{1}{4} \text{ inch increment} = \frac{\text{length (in.)} \times \text{width (in.)}}{9702 \times 4}$$

$$\frac{383.42 \text{ in.} \times 227.93 \text{ in.}}{9702 \times 4} = 2.2519 \text{ barrels per } \tfrac{1}{4} \text{ inch}$$

<u>Volume of Bottom Wedge (Deadrise)</u>

Deadrise = 2 ¼ in. high (9 increments)

Centerline tank heights: 0 ft. 0 in. to 0 ft. 2 ¼ in. (9 increments)

$$\text{Volume} = 2.2519 \text{ barrels per } \tfrac{1}{4} \text{ in.} \times \frac{9}{2} = 10.1336 \text{ barrels}$$

Spread volume over 2 ¼ inches

$$\text{Spread factor} = \frac{10.1336}{4} \div (2.25)^2 = 0.5004247$$

Increments	Centerline Tank Heights	Difference in Square	(Spread Factor × Difference Squares) Barrels per ¼ inch
4	0 ft. - 1 in.	1	0.5004
4	0 ft. - 2 in.	3	1.5013
1	0 ft. - 2 ¼ in.	(1.0625 × 4)	2.1268
			10.1336 Barrels

Table A-2 (continued)

Volume of Box Section

Corrected outboard height: (13 ft. 9 ½ in.)

Centerline tank heights: 0 ft. 2 ¼ in. to 13 ft. 11 ¼ in. (662 increments)

Volume = 2.2519 barrels per ¼ in. × 622 = 1490.7578 barrels

Volume of Deck Wedge (Camber)

Camber = 7 ¾ in. high

Centerline tank heights: 13 ft. 11 ¾ in. to 14 ft. 7 ½ in. (31 increments)

$$\text{Volume} = \frac{2.2519 \times 31}{2} = 34.9045 \text{ barrels}$$

Spread volume over 7 ¾ in.

$$\text{Spread factor} = \frac{34.9045}{4} = (7.75)^2 = 0.14528408$$

Increments	Centerline Tank Heights	Difference in squares	(Spread Factor × Diff. Square) Barrels per ¼ in.	Hatch	Total
4	14 ft. 0 ¾ in.	14.5	2.1066	0	2.1066
4	14 ft. 1 ¾ in.	12.5	1.8161	0	1.8161
4	14 ft. 2 ¾ in.	10.5	1.5255	0	1.5255
4	14 ft. 3 ¾ in.	8.5	1.2349	0	1.2349
4	14 ft. 4 ¾ in.	6.5	.9443	0	.9443
4	14 ft. 5 ¾ in.	4.5	.6538	0	.6538
4	14 ft. 6 ¾ in.	2.5	.3632	.0182	.3814
3	14 ft. 7 ½ in.	(.5625 × 4⁄3) = .75	.1090	.0182	.1272
			34.9046	.1274	35.0320 Bbl.

Hatch volume:

Diameter = 30 in.

$$\text{Barrels per } \tfrac{1}{4} \text{ in.} = \frac{(30)^2 \times 0.7854}{4 \times 9702} = 0.0182$$

Location of reference gauge point is 9 ft. 6 in. from centerline bulkhead.

Rise of tank bottom at reference gauge point =

$$\frac{0.1913 \text{ (deadrise)}}{18.9942 \text{ (width)}} \times 9.500 = 0.0957 \text{ ft.} + (\tfrac{3}{8} \text{ in. strike plate}) = 0.1270 \text{ ft.} (1\tfrac{1}{2} \text{ in.})$$

Molded Volume = 1535.9234 barrels

Table A-3—Deadwood Calculations

	Increments	Cubic Inches	Cubic Inches per 1/4 in.
0 ft. 0 in. to 1 ft. 10 1/4 in. bottom stiffener	89		296.75
9- serrated 12 in. at 20.7 lb. × 32 ft. 0 in. (longitudinal stiffeners)		10,420	
3- serrated 12 in. at 20.7 lb. × 19 ft. 0 in. (transverse stiffeners)		4,125	
1- $\frac{(24\text{ in.})^2 - [(24\text{ in.})^2 \times 0.7854]}{4}$ × 32 ft. 0 in. (bilge)		11,866	
		26,411	
0 ft. 9 in. to 14 ft. 7 1/2 in. miscellaneous stiffeners	702		36.04
6- 12 in. at 20.7 × 14 ft. 3 in. (vertical shell and bulkhead stiffeners)		6,187	
6- 6 in. × 6 in. × 3/8 in. × 14 ft. 3 in. (vertical deck stiffeners)		4,473	
9- 4 in. × 4 in. × 3/8 in. × 7 ft. 9 in. (diagonal bracing)		2,394	
3- 6 in. × 4 in. × 3/8 in. × 7 ft. 9 in. (diagonal bracing)		1,007	
1- 7 in. × 4 in. × 3/8 in. × 32 ft. 0 in. (longitudinal shell stiffeners)		1,532	
6- serrated 9 in. at 13.4 lb. × 32 ft. 0 in. (longitudinal shell stiffeners)		4,481	
7- serrated 9 in. at 13.4 lb. × 32 ft. 0 in. (longitudinal bulkhead stiffeners)		5,228	
		25,302	
0 ft. 2 in. to 0 ft. 5 1/2 in. heating coils	14		701.07
9- 1 1/2 in. ø pipe (closed) × 32 ft. 0 in.		9,815	
3 ft. 4 in. to 4 ft. 2 in. suction line	40		871.30
1- 10 in. ø pipe (closed) × 32 ft. 0 in.		34,852	
2 ft. 0 in. to 2 ft. 3 in. stripping line	12		307.84
1- 3 in. ø pipe (closed) × 32 ft. 0 in.		3,694	
2 ft. 0 in. to 12 ft. 7 1/2 in. transverse bulkhead stiffeners	509		6.10
7- serrated 9 in. at 13.4 lb. × 19 ft. 0 in.		3,104	
0 ft. 8 in. to 14 ft. 1 1/4 in. transverse bulkhead stiffeners	645		2.24
2- 10 in. at 15.3 × 13 ft. 5 5/8 in.		1,445	
12 ft. 10 1/4 in. to 14 ft. 7 1/2 in. deck stiffeners	83		104.47
3- 7 in. at 9.8 × 19 ft. 0 in. (transverse deck stiffeners)		1,949	
9- serrated 9 in. at 13.4 × 32 ft. 0 in. (longitudinal stiffeners)		6,722	
		8,671	
		113,294	113,292.60

Table A-4—Recapitulation of Deadwood

Increments	Heights	Cubic Inches Per 1/4 Inch	Barrels Per 1/4 Inch
8	0 ft. 2 in.	332.79	.0343
14	0 ft. 5 1/2 in.	1033.861	.1066
10	0 ft. 8 in.	332.79	.0343
57	1 ft. 10 1/4 in.	335.03	.0345
7	2 ft. 0 in.	38.28	.0039
12	2 ft. 3 in.	352.22	.0363
52	3 ft. 4 in.	44.38	.0046
40	4 ft. 2 in.	915.68	.0944
405	12 ft. 7 1/4 in.	44.38	.0046
14	12 ft. 10 3/4 in.	38.28	.0039
58	14 ft. 1 1/4 in.	142.75	.0147
25	14 ft. 7 1/2 in.	140.51	.0145
		113,292.60	11.6871 Barrels

Table A-5—Capacity Table Volume

Molded Volume	1535.9234 barrels
Deadwood	- 11.6871 barrels
Capacity Table Volume	1524.2363 barrels

(Refer to Figure A-2 for the capacity table generated.)

Table A-6—Run Sheet

Increments	Tank Heights	Table Heights	Gross bbls. per 1/4 in.	Deadwood	Net bbl. per 1/4 in.	Total
	0 ft. 1 in.					
1	1 1/2 ft.	0 ft. 0 in.	5.0042	.2058	4.7984	4.7984
2	2 ft	0 ft. 0 1/2 in.	1.5013	.0343	1.4670	7.7324
1	2 1/4 ft.	0 ft. 0 3/4 in.	2.1268	.1066	2.0202	9.7526
13	0 ft. 5 1/2 in.	4 in.	2.2519	.1066	2.1453	37.6415
10	0 ft. 8 in.	0 ft. 6 1/2 in.	2.2519	.0343	2.2176	59.8175
57	1 ft. 10 1/4 in.	1 ft. 8 3/4 in.	2.2519	.0345	2.2174	186.2093
7	2 ft. 0 in.	1 ft. 10 1/2 in.	2.2519	.0039	2.2480	201.9453
23	2 ft. 3 in.	2 ft. 1 1/2 in.	2.2519	.0363	2.2156	228.5325
52	3 ft. 4 in.	3 ft. 2 1/2 in.	2.2519	.0046	2.2473	345.3921
40	4 ft. 2 in.	4 ft. 0 1/2 in.	2.2519	.0944	2.1575	431.6921
405	12 ft. 7 1/4 in.	12 ft. 5 3/4 in.	2.2519	.0046	2.2473	1341.8486
14	12 ft. 10 3/4 in.	12 ft. 9 1/4 in.	2.2519	.0039	2.2480	1373.3206
52	13 ft. 11 3/4 in.	13 ft. 10 1/4 in.	2.2519	.0147	2.2372	1489.6550
4	14 ft. 0 3/4 in.	13 ft. 11 1/4 in.	2.1066	.0147	2.0919	1498.0226
2	14 ft. 1 1/4 in.	13 ft. 11 3/4 in.	1.8161	.0147	1.8014	1501.6254
2	14 ft. 1 3/4 in.	14 ft. 0 1/4 in.	1.8161	.0145	1.8016	1505.2286
4	14 ft. 2 3/4 in.	14 ft. 1 1/4 in.	1.5255	.0145	1.5110	1511.2726
4	14 ft. 3 3/4 in.	14 ft. 2 1/4 in.	1.2349	.0145	1.2204	1516.1542
4	14 ft. 4 3/4 in.	14 ft. 3 1/4 in.	.9443	.0145	.9298	1519.8734
4	14 ft. 5 3/4 in.	14 ft. 4 1/4 in.	.6538	.0145	.6393	1522.4306
4	14 ft. 6 3/4 in.	14 ft. 5 1/4 in.	.3814	.0145	.3669	1523.8982
3	14 ft. 7 1/2 in.	14 ft. 6 in.	.1272	.0145	.1127	1524.2363

XYZ OIL COMPANY

BARGE NO. 20

TANK NO. 2 PORT

INNAGE TABLE

TOTAL GAUGE HEIGHT: 17'00 5/8" LOCATED 16' 00 " FORWARD OF AFT BULKHEAD & 9'06" OFF OF CENTERLINE BULKHEAD.

IN.	0 FEET BARRELS	1 FEET BARRELS	2 FEET BARRELS	3 FEET BARRELS	4 FEET BARRELS	5 FEET BARRELS	6 FEET BARRELS	7 FEET BARRELS	8 FEET BARRELS	9 FEET BARRELS	10 FEET BARRELS	11 FEET BARRELS	12 FEET BARRELS	13 FEET BARRELS	14 FEET BARRELS
0	* 4.80	108.60	215.24	322.92	427.38	535.07	642.94	750.81	858.68	966.55	1074.42	1182.29	1290.16	1397.93	1503.43
1/4	6.27	110.82	217.45	325.17	429.53	537.32	645.19	753.06	860.93	968.80	1076.67	1184.54	1292.41	1400.17	1505.23
1/2	7.73	113.04	219.67	327.41	431.69	539.56	647.43	755.30	863.17	971.04	1078.91	1186.78	1294.66	1402.40	1506.74
3/4	9.75	115.25	221.89	329.66	433.94	541.81	649.68	757.55	865.42	973.29	1081.16	1189.03	1296.90	1404.64	1508.25
1	11.90	117.47	224.10	331.91	436.19	544.06	651.93	759.80	867.67	975.54	1083.41	1191.28	1299.15	1406.88	1509.76
1/4	14.04	119.69	226.32	334.16	438.43	546.30	654.17	762.05	869.92	977.79	1085.66	1193.53	1301.40	1409.12	1511.27
1/2	16.19	121.90	228.53	336.40	440.68	548.55	656.42	764.29	872.16	980.03	1087.90	1195.77	1303.64	1411.35	1512.49
3/4	18.33	124.12	230.78	338.65	442.93	550.80	658.67	766.54	874.41	982.28	1090.15	1198.02	1305.89	1413.59	1513.71
2	20.48	126.34	233.03	340.90	445.18	553.05	660.92	768.79	876.66	984.53	1092.40	1200.27	1308.14	1415.83	1514.93
1/4	22.62	128.56	235.27	343.14	447.42	555.29	663.16	771.03	878.90	986.78	1094.65	1202.52	1310.39	1418.06	1516.15
1/2	24.77	130.77	237.52	345.39	449.67	557.54	665.41	773.28	881.15	989.02	1096.89	1204.76	1312.63	1420.30	1517.08
3/4	26.92	132.99	239.77	347.55	451.92	559.79	667.66	775.53	883.40	991.27	1099.14	1207.01	1314.88	1422.54	1518.01
3	29.06	135.21	242.02	349.71	454.17	562.04	669.91	777.78	885.65	993.52	1101.39	1209.26	1317.13	1424.78	1518.94
1/4	31.21	137.43	244.26	351.86	456.41	564.28	672.15	780.02	887.89	995.76	1103.63	1211.51	1319.38	1427.01	1519.87
1/2	33.35	139.64	246.51	354.02	458.66	566.53	674.40	782.27	890.14	998.01	1105.88	1213.75	1321.62	1429.25	1520.51
3/4	35.50	141.86	248.76	356.18	460.91	568.78	676.65	784.52	892.39	1000.26	1108.13	1216.00	1323.87	1431.49	1521.15
4	37.64	144.08	251.01	358.34	463.15	571.02	678.90	786.77	894.64	1002.51	1110.38	1218.25	1326.12	1433.73	1521.79
1/4	39.86	146.30	253.25	360.49	465.40	573.27	681.14	789.01	896.88	1004.75	1112.62	1220.49	1328.36	1435.96	1522.43
1/2	42.08	148.51	255.50	362.65	467.65	575.52	683.39	791.26	899.13	1007.00	1114.87	1222.74	1330.61	1438.20	1522.80
3/4	44.29	150.73	257.75	364.81	469.90	577.77	685.64	793.51	901.38	1009.25	1117.12	1224.99	1332.86	1440.44	1523.16
5	46.51	152.95	259.99	366.97	472.14	580.01	687.88	795.75	903.63	1011.50	1119.37	1227.24	1335.11	1442.67	1523.53
1/4	48.73	155.17	262.24	369.12	474.39	582.26	690.13	798.00	905.87	1013.74	1121.61	1229.48	1337.35	1444.91	1523.90
1/2	50.95	157.38	264.49	371.28	476.64	584.51	692.38	800.25	908.12	1015.99	1123.86	1231.73	1339.60	1447.15	1524.01
3/4	53.16	159.60	266.74	373.44	478.89	586.76	694.63	802.50	910.37	1018.24	1126.11	1233.98	1341.85	1449.39	1524.12
6	55.38	161.82	268.98	375.60	481.13	589.00	696.87	804.74	912.61	1020.48	1128.36	1236.23	1344.10	1451.62	1524.24
1/4	57.60	164.04	271.23	377.75	483.38	591.25	699.12	806.99	914.86	1022.73	1130.60	1238.47	1346.34	1453.86	
1/2	59.82	166.25	273.48	379.91	485.63	593.50	701.37	809.24	917.11	1024.98	1132.85	1240.72	1348.59	1456.10	
3/4	62.03	168.47	275.73	382.07	487.87	595.75	703.62	811.49	919.36	1027.23	1135.10	1242.97	1350.84	1458.33	
7	64.25	170.69	277.97	384.23	490.12	597.99	705.86	813.73	921.60	1029.47	1137.34	1245.21	1353.09	1460.57	
1/4	66.47	172.90	280.22	386.38	492.37	600.24	708.11	815.98	923.85	1031.72	1139.59	1247.46	1355.34	1462.81	
1/2	68.69	175.12	282.47	388.54	494.62	602.49	710.36	818.23	926.10	1033.97	1141.84	1249.71	1357.58	1465.05	
3/4	70.90	177.34	284.72	390.70	496.86	604.73	712.60	820.48	928.35	1036.22	1144.09	1251.96	1359.83	1467.28	
8	73.12	179.56	286.96	392.86	499.11	606.98	714.85	822.72	930.59	1038.46	1146.33	1254.20	1362.08	1469.52	
1/4	75.34	181.77	289.21	395.01	501.36	609.23	717.10	824.97	932.84	1040.71	1148.58	1256.45	1364.33	1471.76	
1/2	77.56	183.99	291.46	397.17	503.61	611.48	719.35	827.22	935.09	1042.96	1150.83	1258.70	1366.58	1473.99	
3/4	79.77	186.21	293.70	399.33	505.85	613.72	721.59	829.46	937.33	1045.21	1153.08	1260.95	1368.82	1476.23	
9	81.99	188.46	295.95	401.49	508.10	615.97	723.84	831.71	939.58	1047.45	1155.32	1263.19	1371.07	1478.47	
1/4	84.21	190.71	298.20	403.64	510.35	618.22	726.09	833.96	941.83	1049.70	1157.57	1265.44	1373.32	1480.71	
1/2	86.43	192.95	300.45	405.80	512.59	620.47	728.34	836.21	944.08	1051.95	1159.82	1267.69	1375.56	1482.94	
3/4	88.64	195.20	302.69	407.96	514.84	622.71	730.58	838.45	946.32	1054.19	1162.06	1269.94	1377.80	1485.18	
10	90.86	197.45	304.94	410.12	517.09	624.96	732.83	840.70	948.57	1056.44	1164.31	1272.18	1380.03	1487.42	
1/4	93.08	199.70	307.19	412.27	519.34	627.21	735.08	842.95	950.82	1058.69	1166.56	1274.43	1382.27	1489.66	
1/2	95.30	201.95	309.44	414.43	521.58	629.45	737.32	845.20	953.07	1060.94	1168.81	1276.68	1384.51	1491.75	
3/4	97.51	204.16	311.68	416.59	523.83	631.70	739.57	847.44	955.31	1063.18	1171.05	1278.92	1386.74	1493.84	
11	99.73	206.38	313.93	418.75	526.08	633.95	741.82	849.69	957.56	1065.43	1173.30	1281.17	1388.98	1495.93	
1/4	101.95	208.59	316.18	420.90	528.33	636.20	744.07	851.94	959.81	1067.68	1175.55	1283.42	1391.22	1498.02	
1/2	104.17	210.81	318.42	423.06	530.57	638.44	746.31	854.18	962.05	1069.93	1177.80	1285.67	1393.46	1499.82	
3/4	106.38	213.02	320.67	425.22	532.82	640.69	748.56	856.43	964.30	1072.17	1180.04	1287.91	1395.69	1501.63	

* VOLUME BELOW STRIKE POINT.
GAUGE POINT: TO TOP LIP OF HATCH OPPOSITE HINGE.
CAPACITIES IN 42-U.S. GALLONS BARRELS
BARGE SHOULD BE GAUGED ON EVEN KEEL FOR MAXIMUM ACCURACY.
LENGTH BETWEEN DRAFT MARKS = 160.30'
TOTAL COMPARTMENT INTERNAL PIPELINE CAPACITY= 3.39 BARRELS , HAS NOT BEEN INCLUDED IN THIS TABLE.

STRAPPED BY: E8,DM MARCH 19,1984
COMPUTED BY: ____________

COMPANY : ____________

Figure A-2—Tank No. 2 Port Capacity Table

APPENDIX B—VOCABULARY

Section 2.7 necessarily includes some terminology specific to the maritime industry. The definitions of the terms used in the text are given below. For other definitions, refer to Chapter 1.

B.1 Terms

The *baseline* is the fore and aft reference line at the upper surface of the flat plate keel at the centerline for flush shell plate vessels, or the thickness of the garboard strake above that level for vessels having lap seam shell plating.

The *bilge radius* is the radius of the rounded portion of the vessel's shell that connects the bottom to the sides.

The *breadth, extreme,* is the maximum breadth of the hull measured to the outside surfaces of the side shell plating or to the outside of the guards, if fitted.

The *breadth, molded,* is the maximum breadth of the hull measured between the inside surfaces of the side shell plating of flush plated vessels or between the inside surfaces of the inside strakes of lap seam plated vessels.

Bulkhead is a term applied to the vertical partition walls that subdivide the interior of a vessel into compartments or rooms.

Camber is the arching or rounding up transversely of the vessel's deck.

Deadrise is the transverse rise of the vessel's bottom from the keel to the bilge.

Deadwood is any internal tank structural member, fitting, or appurtenance, expressed as a volume, that affects the total or incremental liquid capacity of the tank.

The *depth, molded,* is the vertical distance from the baseline to the underside of the deck plating at the side measured at the mid-length of the vessel.

The *draft, extreme,* is the depth of the vessel below the waterline measured vertically from the waterline to the lowest projecting portion of the vessel.

The *draft, molded,* is the depth of the vessel below the waterline, measured vertically from the baseline to the waterline.

The *draft marks* are the vertical column of numbers on each side of the vessel at each end and sometimes amidships to indicate the distance from the lower edge of the number to the bottom of the keel.

An *expansion trunk (dome)* is a trunk extending above a space used for the storage of liquid cargo that provides space for the thermal expansion of the liquid without overflowing.

Garboard is the strake of shell plating adjacent to the keel plate.

Guards are heavy half-round pipes running longitudinally and welded to the outside of the side shell plating to act as fenders.

A *hatch* is an opening in the top of a tank for access or other purposes such as gauging or cleaning.

The *headlog* (in river craft of a rectangular shape) is the structural member at the extreme end between the rake shell plating and the deck.

Hog is the distortion of a barge's form because of stresses in which the bow and stern drop below their normal positions relative to the midship portion of the vessel.

An *independent tank* is a tank whose boundaries are not part of the hull structure of the barge.

An *integral hull tank* is a tank whose boundaries are the bottom, side, deck, or bulkhead of the barge hull.

The *keel, flat plate,* is the horizontal centerline bottom shell strake or plating.

The *length* of a tank barge is the distance measured on the centerline between the headlog plates at each end.

List is the transverse deviation of a vessel from the upright position, expressed in degrees.

Molded dimensions are the dimensions of a vessel to the molded lines.

The *molded lines* are the lines defining the geometry of a hull as a surface without thickness.

The *molded volume* is the volume of a compartment without deduction for internal structure or fittings.

Rake is applied to the fore and aft inclination from the vertical of the mast, smokestack, stem, and so on. On barges, it is the end portion of the hull that rises from the bottom at an inclination from the vertical to meet the deck at the headlog.

Sag is the distortion of a barge's form due to stresses in which the midship portion of the vessel drops below its normal position relative to the bow and stern.

Sheer is the longitudinal curve of a vessel's deck in a vertical plane. As a result of sheer, a vessel's deck height above the baseline is higher (or lower) at the ends than amidships.

The *shell* is the plating forming the outer side and bottom skin of the hull.

Stern notch is the recess in the stern of a barge in which the bow of the tug is inserted and secured so that the two vessels may be maneuvered as a single integrated unit.

A *strake* is a course or row of shell, deck, bulkhead, or other plating.

Trim is the difference between the draft forward and the draft aft.

B.2 References

The preceding vocabulary definitions were obtained from the following sources:

Shipbuilding Cyclopedia, Simmons-Boardman Publishing Company, April 1920.

Ship Design and Construction, Society of Naval Architects and Marine Engineers, 1980.

American Bureau of Shipping, *Rules for Building and Classing Steel Vessels for Service on Rivers and Intercoastal Waterways*, 1971.

APPENDIX C—PHYSICAL CHARACTERISTICS AND FIRE CONSIDERATIONS

Personnel involved with the handling of petroleum-related substances (and other chemical materials) should be familiar with their physical and chemical characteristics, including potential for fire, explosion and reactivity, and appropriate emergency procedures. They should comply with individual company safe operating practices and local, state, and federal regulations, including use of proper protective clothing and equipment. Personnel should be alert to avoid potential sources of ignition and should keep containers of materials closed when not in use.

API publications 2217 *(Guidelines for Confined Space Work in the Petroleum Industry)* and 2026 *(Guide for Safe Descent Onto Floating Roofs of Tanks in Petroleum Service)* and any applicable regulations should be consulted when sampling requires entry into confined spaces.

INFORMATION REGARDING PARTICULAR MATERIALS AND CONDITIONS SHOULD BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT MATERIAL, OR THE MATERIAL SAFETY DATA SHEET.

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