Manual of Petroleum Measurement Standards Chapter 17—Marine Measurement

Section 4—Method for Quantification of Small Volumes on Marine Vessels (OBQ/ROB)

FIRST EDITION, OCTOBER 1994

American Petroleum Institute

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FOREWORD

This publication covers standard practice for quantification by manual gauging of small volumes on marine vessels and supersedes all applicable sections of API Standard 2545, *Method of Gaging Petroleum and Petroleum Products* (October 1965).

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

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Chapter 17—Marine Measurement

SECTION 4—METHOD FOR QUANTIFICATION OF SMALL VOLUMES ON MARINE VESSELS (OBQ/ROB)

17.4.0 Introduction

The purpose of this standard is to provide a method for determining the small volumes of on-board quantity (OBQ) prior to loading a vessel or material remaining on board (ROB) a vessel upon completion of discharge.

17.4.1 Scope and Field of Application

This standard applies only to quantification by manual gauging of small volumes on marine vessels prior to loading or upon completion of discharge. It does not address clingage, hydrocarbon vapors, cargoes in transit, or cargo pumpability (refer to API MPMS Chapter 3).

17.4.2 Referenced Publications

The following publications are cited in this standard:

ACGIH[1]

Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment

API

Publ 2026 *Safe Descent Onto Floating Roofs of Tanks in Petroleum Service*

Publ 2217 *Guidelines for Confined Space Work in the Petroleum Industry*

Manual of Petroleum Measurement Standards

Chapter 1, "Vocabulary"

Chapter 3, "Tank Gauging," Section 1A, "Standard Practice for the Manual Gauging of Petroleum and Petroleum Products"

Chapter 7, "Temperature Determination," Section 1, "Static Temperature Determination Using Mercury-in-Glass Tank Thermometers"; Section 3, "Static Temperature Determination Using Portable Electronic Thermometers"

Chapter 8, "Sampling," Section 1, "Manual Sampling of Petroleum and Petroleum Products"

Chapter 17, "Marine Measurement," Section 1, "Guidelines for Marine Cargo Inspection"; Section 2, "Measurement of Cargoes On Board Tank Vessels"

ICS[2]/OCIMF[3]/IAPH[4]

International Safety Guide for Oil Tankers and Terminals (ISGOTT)[5]

OSHA[6]

Occupational Safety and Health Standards, 29 *Code of Federal Regulations* Section 1910.1000 and following

17.4.3 Definitions

For the purposes of this standard, the following definitions apply.

17.4.3.1 clingage: cargo that adheres to all surfaces of the emptied portion of the tank other than bottom surfaces.

17.4.3.2 liquid volume: the measurable amount of material that is free flowing at the time of measurement.

17.4.3.3 multipoint gauging: the activity of measuring cargo in a vessel tank through two or more openings in the top of the tank.

17.4.3.4 nonliquid volume: the measurable amount of material that is not free flowing at the time of measurement. Nonliquid material may include any one or a combination of hydrocarbon waxes, water/oil emulsions, sediment, or solidified cargo.

17.4.3.5 on-board quantity (OBQ): the material present in a vessel's cargo tanks, void spaces, and pipelines before the vessel is loaded. On-board quantity may include any combination of water, oil, slops, oil residue, oil/water emulsion, and sediment.

17.4.3.6 remaining on board (ROB): the material remaining in a vessel's cargo tanks, void spaces, and pipelines after the cargo is discharged. Remaining on board quantity

[1]American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue, Building D-7, Cincinnati, Ohio 45211.

[2]International Chamber of Shipping, 30/32 Mary Axe Street, London EC3A 8ET, England.

[3]Oil Companies International Marine Forum, Portland House, 6th Floor, Stag Place, London SW1E 5BH, England.

[4]International Association of Ports and Harbors, Kotohira-Kaikan Building, 2-8, Toranomon 1-Chome Minato-Ku, Tokyo 105, Japan.

[5]*ISGOTT* is available from Witherby & Co., Ltd. (Marine Publishing), 32/36 Aylesbury Street, London EC1R 0ET, England.

[6]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.

may include any combination of water, oil, slops, oil residue, oil/water emulsion, and sediment.

17.4.3.7 sediment: solid materials including, but not limited to, sand, rust, and scale.

17.4.3.8 sludge: that element of the material in a ship's cargo tank that is essentially not free flowing. Sludge consists of hydrocarbon waxes and may contain water/oil emulsions and sediment. The use of this term is not recommended.

17.4.3.9 wedge formula: a mathematical means to approximate small quantities of measurable liquid and/or nonliquid material on board that is in a wedge configuration and does not touch all bulkheads of the vessel's tank. The formula is based on cargo compartment characteristics, vessel trim, and the depth of the material.

17.4.3.10 wedge table: a vessel's cargo tank volume table calculated on the wedge formula for use when cargo does not touch all bulkheads of the tanks. Wedge tables preclude the need for calculation by wedge formula at times of cargo transfer.

17.4.3.11 Other terms used in this standard are defined in API MPMS Chapter 1 or other API petroleum-measurement standards.

17.4.4 Safety and Health Considerations

Due consideration should be given to applicable safety procedures. Safety considerations should 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 among others. The physical characteristics of the cargo and existing operational conditions should be evaluated, and applicable international, federal, state, and local regulations should be observed. 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 appropriate Oil Companies International Marine Forum (OCIMF) and API publications provide additional safety information and should be consulted. See Appendix A.

17.4.5 Quantification Procedures

Appendix B provides examples of small volume calculations and configurations. Appendix C provides an example of an OBQ/ROB report form. Appendix D provides an explanation and example of the wedge formula; Appendix D also provides a wedge calculation worksheet.

17.4.5.1 GAUGING

Before taking any OBQ/ROB measurements, record the trim and list of the vessel. The vessel should be requested to eliminate or minimize any list.

17.4.5.1.1 All spaces on board the vessel that could contain OBQ/ROB shall be gauged and quantified prior to loading and after discharge. Gauging shall be performed in accordance with procedures outlined in API MPMS Chapter 3 and Chapter 17, Sections 1 and 2.

17.4.5.1.2 Gauging OBQ/ROB at several points in a vessel compartment is very useful to establish whether material is or is not evenly distributed across a tank bottom. When multiple gauging points in a compartment are available, manual gauges from each gauge point should be taken and recorded.

17.4.5.2 TEMPERATURES

Temperatures shall be obtained, recorded, and used for cargo volume correction whenever depth of material is sufficient and the nature of the material permits. If temperature cannot be measured, the gross observed volume shall be reported as gross standard volume (GSV).

Temperature measurements shall be obtained in accordance with API MPMS Chapter 17, Section 2, and Chapter 7, Sections 1 and 3.

Note: Volume correction factors are not applicable to nonliquid volumes (see API MPMS Chapter 3, Section 1A).

17.4.5.3 SAMPLING

When OBQ/ROB is accessible, samples shall be obtained from all compartments containing liquid volume. An attempt should also be made to sample nonliquid volumes. Samples taken should be in sufficient quantity to permit any required analysis. Samples shall be taken in accordance with API MPMS Chapter 8, Section 1.

17.4.5.4 VESSEL CARGO LINES AND PUMPS

It is the vessel's responsibility to drain and strip all cargo lines and pumps prior to final OBQ/ROB measurement. If possible, one vessel tank, preferably the smallest, should be designated to receive material drained from all lines and pumps. The designated tank must be gauged both before and after line and pump draining.

17.4.5.5 SLOPS

Slops must be measured, quantified, and reported on the OBQ/ROB form at loading and discharge ports in accordance with procedures for slop tanks outlined in API MPMS Chapter 17, Section 2.

17.4.6 OBQ/ROB Characteristics

Care must be taken to determine the liquid or nonliquid nature of OBQ/ROB. Both liquid and nonliquid material may co-exist in the same vessel compartment.

17.4.6.1 LIQUID MATERIAL

Liquid material may include any one or a combination of liquid petroleum, suspended sediment and water, or free water. The free water interface can often be measured with water-finding paste or an electronic interface detector. To accurately determine the composition of liquid material, samples must be taken and examined or tested.

17.4.6.1.1 When a vessel is not on an even keel, liquid volumes must be quantified by trim/list correction, wedge table, or wedge formula. When liquid contacts all bulkheads, a trim correction must be applied to the vessel tank calibration tables, or a trim table must be used. If liquid does not contact all bulkheads, a wedge table or the wedge formula must be used. See Appendix D.

17.4.6.1.2 Liquid may lie on top of nonliquid in the same compartment. When gauging indicates the presence of both liquid and nonliquid material, the liquid volume is calculated by subtracting the nonliquid volume from the total observed volume of OBQ/ROB in the compartment.

17.4.6.2 NONLIQUID MATERIAL

17.4.6.2.1 To accurately determine the composition of nonliquid material, samples must be taken and examined or tested.

17.4.6.2.2 Nonliquid material may be in a wedge condition. Multipoint gauging is recommended to determine if a wedge condition exists.

17.4.6.2.2.1 Since the wedge formula uses a trim factor to determine the quantity, an accurate calculation will not be possible without knowing the trim of the vessel at the time the material solidified.

17.4.6.2.2.2 If the material measured is not a wedge, the average of the multiple readings should be used for volume determination. However, if only one gauge point is available, the material shall be assumed to be evenly distributed over the tank bottom.

17.4.7 Calculating Quantities

After carefully assessing the configuration of the material in the tank, calculate the material's volume according to the illustrative examples, formulae, and forms given in Appendixes B through D.

APPENDIX A—PRECAUTIONARY INFORMATION

A.1 Physical Characteristics and Fire Considerations

A.1.1 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. Personnel 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.

A.1.2 API Publications 2217 and 2026 and any applicable regulations should be consulted when sampling requires entry into confined spaces.

A.1.3 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.

A.2 Safety and Health Considerations

A.2.1 Potential health effects can result from exposure to any chemical and are dependent on the toxicity of the chemical, concentration, and length of the exposure. Everyone should minimize his or her exposure to workplace chemicals. The following general precautions are suggested:

a. Minimize skin and eye contact and breathing of vapors.
b. Keep chemicals away from the mouth; they can be harmful or fatal if swallowed or aspirated.
c. Keep containers closed when not in use.
d. Keep work areas as clean as possible and well ventilated.
e. Clean up spills promptly and in accordance with pertinent safety, health, and environmental regulations.
f. Observe established exposure limits and use proper protective clothing and equipment.

Information on exposure limits can be found by consulting the most recent editions of the *Occupational Safety and Health Standards*, 29 *Code of Federal Regulations*, Sections 1910.1000 and following, and the ACGIH publication *Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment*.

A.2.2 INFORMATION CONCERNING SAFETY AND HEALTH RISKS AND PROPER PRECAUTIONS WITH RESPECT TO PARTICULAR MATERIALS AND CONDITIONS SHOULD BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER, OR THE MATERIAL SAFETY DATA SHEET.

APPENDIX B—CONFIGURATION EXAMPLES AND CALCULATIONS

B.1 Nonliquid Only (See Figure B-1)

No trim correction or wedge formula applicable. Volume to be obtained directly from vessel's calibration tables.

EXAMPLE (all units in meters)

S = observed sounding
$S_1 = 0.15$
$S_2 = 0.12$
$S_3 = 0.15$

If more than one sounding is taken, calculate the mathematical average (see below) and then go to the vessel's calibration tables. In this example there are three soundings. If it is only possible to take one sounding, then the one is used to enter the tables.

$$S = \frac{S_1 + S_2 + S_3}{3}$$

$$= \frac{0.15 + 0.12 + 0.15}{3}$$

$$= \frac{0.42}{3}$$

$$= 0.14$$

B.2 Single Liquid in Contact with All Four Bulkheads (See Figure B-2)

Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables.

S = observed sounding

The trim correction is typically applied to the observed sounding to arrive at a trim corrected sounding. The trim corrected sounding is used to enter the vessel's calibration tables to obtain the liquid volume.

Caution must be exercised when applying trim corrections to soundings. If the trim corrections are applicable to ullages, then the sign "+" or "–" must be reversed when applying the corrections to soundings.

It is also acceptable in this situation to enter the vessel's calibration tables with a trim corrected ullage.

Alternate 1: On some vessels, the calibration tables are entered with the observed sounding and the trim. The trim adjusted volume is then read directly from the table.

Alternate 2: Some trim correction tables provide a volumetric adjustment that is applied to the volume obtained from the vessel's calibration tables using the observed sounding.

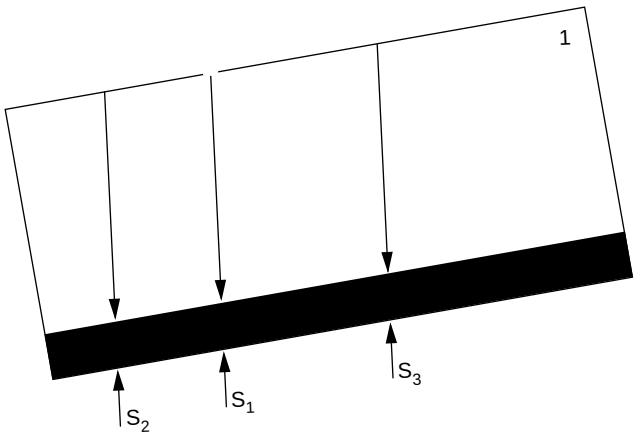

Figure B-1—Nonliquid Only

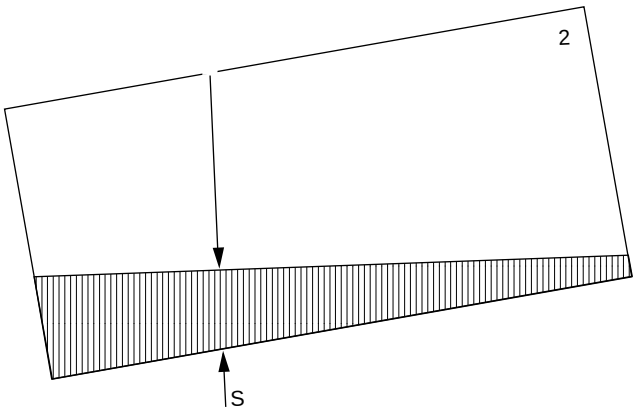

Figure B-2—Single Liquid in Contact with All Four Bulkheads

B.3 Single Liquid in Contact with Three Bulkheads Only (See Figure B-3)

Wedge table or formula to be used for volume calculation. If wedge tables are available, they should be used.

Wedge tables are usually entered with the observed sounding and the trim. Wedge volume is read directly from the table.

In the wedge formula, there are four basic steps to follow:

Step 1: Calculate the adjusted sounding "A".
Step 2: Verify the existence of the wedge condition.
Step 3: Divide "A" by two and extract the table volume (for this sounding) from the vessel's calibration tables.
Step 4: Calculate the wedge volume, which is a function of the table volume obtained in Step 3.

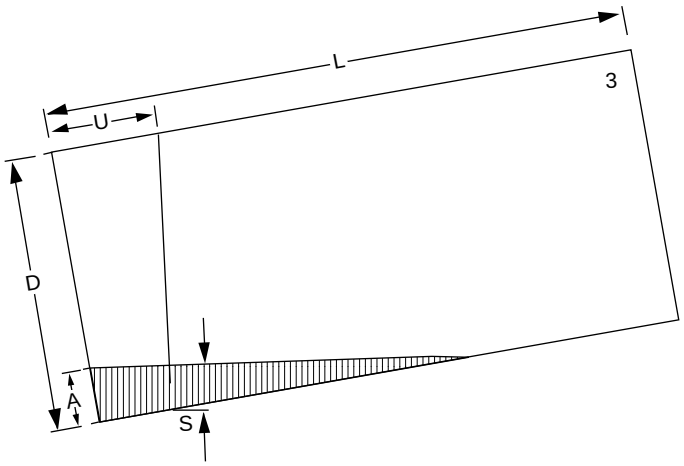

Figure B-3—Single Liquid in Contact with Three Bulkheads Only

EXAMPLE (all units in meters)

Required Field Information	Legend	Field Data
Forward Draft	N/A	3.20
After Draft	N/A	8.50
Trim	N/A	5.30
Length Between Perpendiculars (LBP)	N/A	220.00
Length of Tank	L	35.35
Width of Tank	W	12.82
Reference Gauge Height	D	20.18
Distance from Aft Bulkhead to Gauge Point	U	4.90
Observed Sounding	S	0.19
Trim Factor (trim divided by LBP)	F	0.02409

Step 1: Calculate the adjusted sounding "A" as follows:

$$A = \left\{\left[U - \left(D \times F\right)\right] \times F\right\} + S$$

$$= \left\{\left[4.90 - \left(20.18 \times 0.02409\right)\right] \times 0.02409\right\} + 0.19$$

$$= \left[\left(4.90 - 0.486\right) \times 0.02409\right] + 0.19$$

$$= \left(4.414 \times 0.02409\right) + 0.19$$

$$= 0.106 + 0.19$$

$$= 0.296$$

Step 2: Verify the existence of the wedge condition. Determine the validity of the wedge condition as follows:

$$\text{length of wedge} = \frac{A}{F}$$

If the calculated length is greater than the actual compartment length, a wedge condition DOES NOT EXIST.

Vessel's trim correction is applicable in this situation; refer to B.2.

Step 3: Divide "A" by 2.

$$\frac{0.296}{2} = 0.148$$

Extract from the tank table the volume corresponding to a sounding of 0.148 meter, with the vessel on an even keel and upright. (For the purposes of this example, this volume is quoted as 379.68 barrels.)

Step 4: Calculate the wedge volume as follows:

$$\text{wedge volume} = \frac{\text{table volume} \times A}{L \times F}$$

$$= \frac{379.68 \times 0.296}{35.35 \times 0.02409}$$

$$= \frac{112.39}{0.85158}$$

$$= 131.98 \text{ Bbls}$$

Note: If the table volume is in barrels, the answer will be in barrels. [All units of measurement must be of the same denomination (that is, decimal feet or meters)].

The use of the table volume provides a volumetric factor that, when applied to the total expression of the formula, partially accounts for the internal tank framing (if included in the vessel's capacity tables), volume below tank datum, and width of the tank at the lower extremities of the tank.

B.3.1 VESSELS TRIMMED BY THE HEAD

For vessels that are trimmed by the head, the value for "U" is the distance from the gauge point to the forward bulkhead as opposed to the after bulkhead as shown in Figure B-3. The calculation for vessels trimmed by the head is termed a reverse wedge.

B.3.2 COMPARTMENTS WITH EXTREME SHAPE DUE TO HULL CURVATURE

Refer to Appendix D.

B.4 Single Liquid Above Nonliquid (See Figure B-4)

Liquid in contact with all four bulkheads.

For Total Volume: Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. (Refer to B.2; the sounding represented by "XZ" is the applicable observed sounding.)

For Nonliquid Volume: No trim correction or wedge formula applicable. Volume to be obtained directly from vessel's calibration tables. (Refer to B.1; the sounding represented by "YZ" is the applicable observed sounding.)

For Liquid Volume: Deduct the nonliquid volume from the total volume.

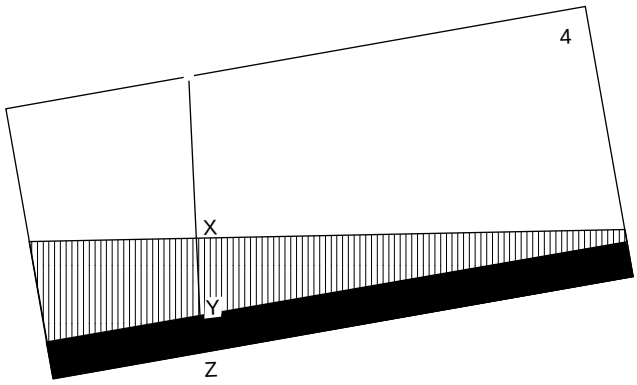

Figure B-4—Single Liquid Above Nonliquid (Liquid in Contact with All Four Bulkheads)

B.5 Single Liquid Above Nonliquid (See Figure B-5)

Liquid in contact with three bulkheads only.

For Total Volume: Sum of nonliquid volume and wedge volume. Nonliquid volume to be obtained directly from vessel's calibration tables. [Refer to B.1; the sounding represented by "YZ" is the applicable observed sounding (S = YZ).]

For Wedge Volume: Wedge formula to be used to calculate liquid volume. [Refer to B.3; the sounding represented by "XY" is the applicable observed sounding (S = XY). The reference gauge height should be reduced by the amount of the nonliquid sounding.]

B.6 Two Liquids (Oil and Water) (See Figure B-6)

Both liquids in contact with all four bulkheads.

For Total Liquid: Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. (Refer to B.2; the sounding represented by "XZ" is the applicable observed sounding.)

For Lower Liquid: Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. (Refer to B.2; the sounding represented by "YZ" is the applicable observed sounding.)

For Upper Liquid: Subtract the lower liquid volume from the total liquid volume.

It is also acceptable in this situation to enter the vessel's calibration tables with trim corrected ullages for the total liquid and the lower liquid respectively.

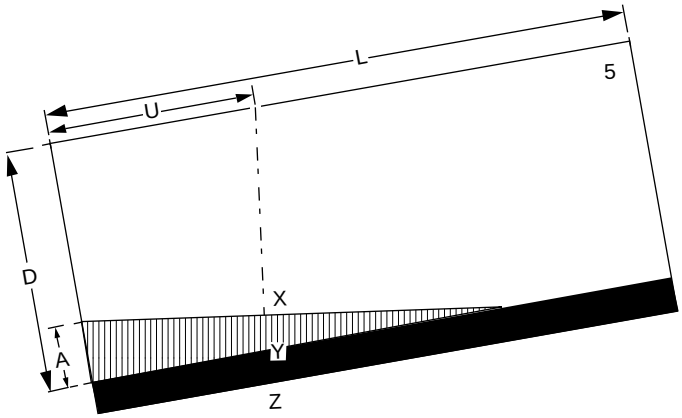

Figure B-5—Single Liquid Above Nonliquid (Liquid in Contact with Three Bulkheads Only)

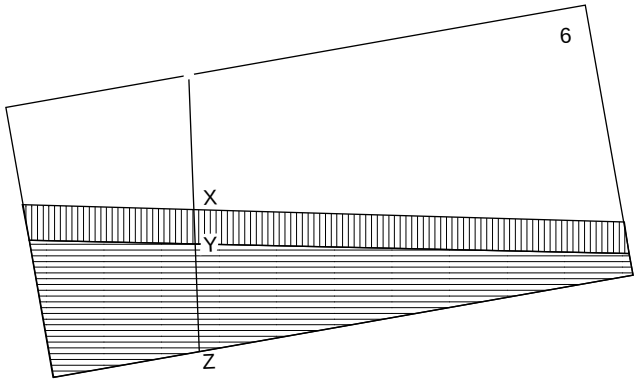

Figure B-6—Two Liquids (Both Liquids in Contact with All Four Bulkheads)

B.7 Two Liquids (Oil and Water) (See Figure B-7)

Lower liquid in contact with three bulkheads only.

For Total Liquid: Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. [Refer to B.2; the sounding represented by "XZ" is the applicable observed sounding (S = XZ).]

For Lower Liquid: Wedge table or formula to be used for volume calculation. [Refer to B.3; the sounding represented by "YZ" is the applicable observed sounding (S = YZ).]

For Upper Liquid: Subtract the lower liquid wedge volume from the total liquid volume.

B.8 Two Liquids (Oil and Water) (See Figure B-8)

Both liquids in contact with three bulkheads only.

For Total Liquid: Wedge table or formula to be used for volume calculation. [Refer to B.3; the sounding represented by "XZ" is the applicable observed sounding (S = XZ).]

For Lower Liquid: Wedge table or formula to be used for volume calculation. [Refer to B.3; the sounding represented by "YZ" is the applicable observed sounding (S = YZ). The adjusted sounding at the after bulkhead is represented by the lowercase "a."]

For Upper Liquid: Subtract the lower wedge volume from the total wedge volume.

B.9 Two Liquids (Oil and Water) with a Nonliquid Lower Layer (See Figure B-9)

Lower layer liquid in contact with three bulkheads only.

For Total Volume: Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. (Refer to B.2; the sounding represented by "VZ" is the applicable observed sounding.)

For Lower (Nonliquid) Volume: No trim correction or wedge formula applicable. Volume to be obtained directly from vessel's calibration tables. (Refer to B.1; the sounding represented by "YZ" is the applicable observed sounding.)

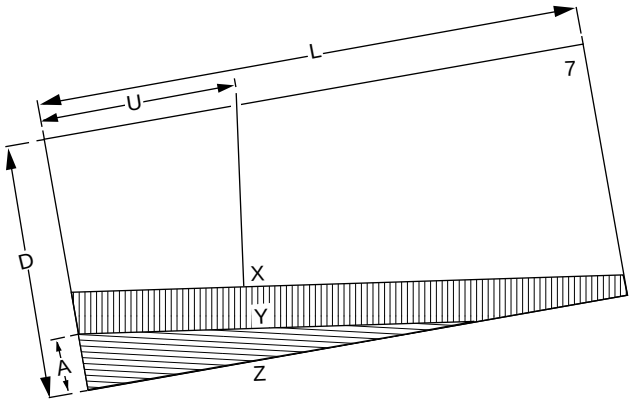

Figure B-7—Two Liquids (Lower Liquid in Contact with Three Bulkheads Only)

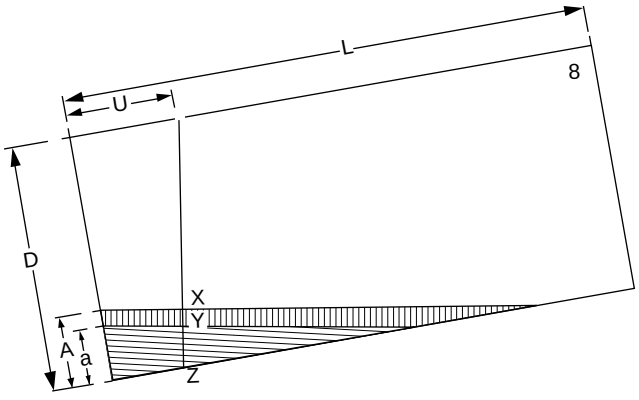

Figure B-8—Two Liquids (Both Liquids in Contact with Three Bulkheads Only)

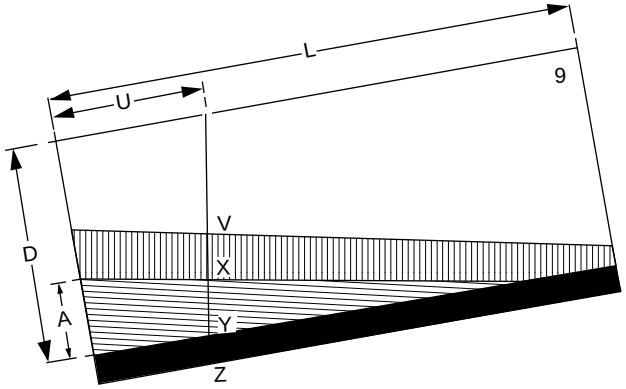

Figure B-9—Two Liquids with a Nonliquid Lower Layer (Lower Layer Liquid in Contact with Three Bulkheads Only)

For Central Wedge Volume: Wedge formula to be used for volume calculation. [Refer to B.3; the sounding represented by "XY" is the applicable observed sounding (S = XY). The reference gauge height should be reduced by the amount of the nonliquid sounding.]

For Upper Volume: Deduct the lower and central volumes from the total volume.

B.10 Two Liquids (Oil and Water) with a Nonliquid Lower Layer (See Figure B-10)

Lower layer liquid in contact with all four bulkheads.

For Total Volume: Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. (Refer to B.2; the sounding represented by "VZ" is the applicable observed sounding.)

For Two Lower Volumes (Combined): Trim correction to be applied. Corrected volume to be obtained directly from vessel's calibration tables. (Refer to B.2; the sounding represented by "XZ" is the applicable observed sounding.)

For Lower (Nonliquid) Volume: No trim correction or wedge formula applicable. Volume to be obtained directly from vessel's calibration tables. (Refer to B.1; the sounding represented by "YZ" is the applicable observed sounding.)

For Upper Liquid Volume: Deduct the two lower volumes from the total volume.

For Central Liquid Volume: Deduct the lower nonliquid volume from the lower volumes.

B.11 Two Liquids (Oil and Water) with a Nonliquid Lower Layer (See Figure B-11)

Both liquids in contact with three bulkheads only.

For Lower (Nonliquid) Volume: No trim correction or wedge formula applicable. Volume to be obtained directly from vessel's calibration tables. (Refer to B.1; the sounding represented by "YZ" is the applicable observed sounding.)

For Total Wedge Volume (Upper and Central Volumes): Wedge formula to be used for volume calculation. [Refer to B.3; the sounding represented by "VY" is the applicable observed sounding (S = VY). The reference gauge height should be reduced by the amount of the nonliquid sounding.]

For Central Wedge Volume: Wedge formula to be used for volume calculation. [Refer to B.3; the sounding represented by "XY" is the applicable observed sounding (S = XY). The reference gauge height should be reduced by the amount of the nonliquid sounding. The adjusted sounding at the after bulkhead is represented by the lowercase "a."]

For Upper Liquid Volume: Deduct the central wedge volume from the total volume.

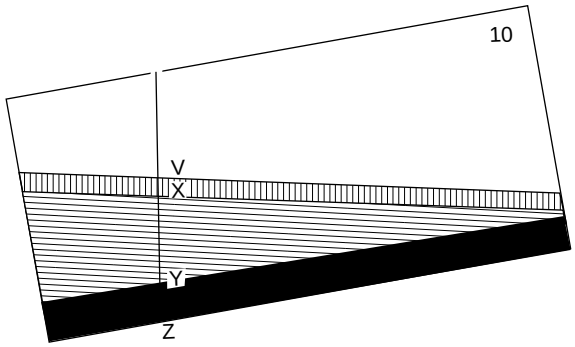

Figure B-10—Two Liquids with a Nonliquid Lower Layer (Lower Layer Liquid in Contact with All Four Bulkheads)

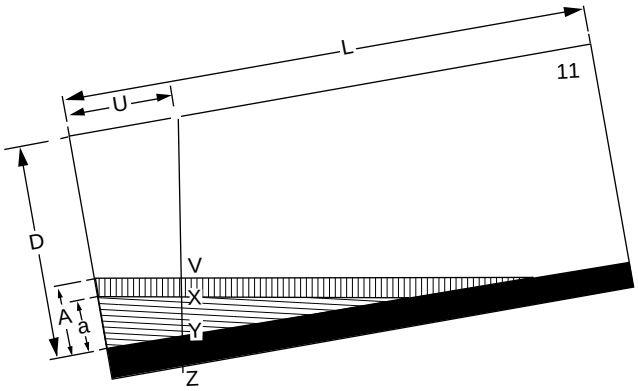

Figure B-11—Two Liquids with a Nonliquid Lower Layer (Both Liquids in Contact with Three Bulkheads Only)

Appendix C—On–Board Quantity/Remaining On Board Report

INDICATE ➧ ☐ ROB ☐ OBQ

ON-BOARD QUANTITY/REMAINING ON BOARD REPORT

VESSEL	PORT/TERMINAL	CARGO	DATE/TIME MEASUREMENT TAKEN	API/DENSITY

TANK NUMBER	GAUGE HT LOCATION (NOTE 1) FCAO	INNAGE/ULLAGE (NOTE 2)		MATERIAL DESCRIPTION		TOTAL OBSERVED VOLUME ( )	FREE WATER			GROSS OBSERVED VOLUME ( )	TEMP °F/°C	VCF (TABLE)	GROSS STANDARD VOLUME ( )
							INNAGE/ULLAGE		VOLUME ( )				
		UNCORRECTED	CORRECTED (W IF WEDGED)	LIQUID	NON-LIQUID		UNCORRECTED	CORRECTED (W IF WEDGED)					

ADDITIONAL SPACE PROVIDED ON REVERSE SIDE OF FORM **( ) IDENTIFY UNIT OF VOLUME AND/OR MEASUREMENT**

NOTES:

1. F = Forward
   C = Center
   A = Aft
   O = Other
2. If wedged, attach wedge calculation
3. Liquid indicated is free flowing (in the opinion of the measurement representative)

GSV ( )							
FREE WATER ( )						FORWARD DRAFT ( )	
TCV ( )						AFT DRAFT ( )	
LIQUID ( ) (NOTE 3)						LIST (DEGREES) P/S	
NONLIQUID ( ) (NOTES 2 AND 3)						BALLAST TANKS USED THIS VOYAGE	
	STRIPPED		DROPPED		TANK NO.	OTHER (EXPLAIN)	
	YES	NO	YES	NO			
TOP LINES						SAMPLES TAKEN YES NO	
BOTTOM LINES						SEA VALVE SEAL NUMBERS	
HOSES/ARM						PORT _____	
						STARBOARD _____	
						OVERBOARD _____	

SIGNATURES
VESSEL REPRESENTATIVE
TERMINAL REPRESENTATIVE
MEASUREMENT REPRESENTATIVE

ON-BOARD QUANTITY/REMAINING ON BOARD REPORT

TANK NUMBER	GAUGE HT LOCATION (NOTE 1) FCAO	INNAGE/ULLAGE (NOTE 2)		MATERIAL DESCRIPTION		TOTAL OBSERVED VOLUME ( )	FREE WATER			GROSS OBSERVED VOLUME ( )	TEMP °F/°C	VCF (TABLE)	GROSS STANDARD VOLUME ( )
							INNAGE/ULLAGE		VOLUME ( )				
		UNCORRECTED	CORRECTED (W IF WEDGED)	LIQUID	NON-LIQUID		UNCORRECTED	CORRECTED (W IF WEDGED)					

( ) IDENTIFY UNIT OF VOLUME AND/OR MEASUREMENT

NOTES:

1. F = Forward
   C = Center
   A = Aft
   O = Other
2. If wedged, attach wedge calculation
3. Liquid indicated is free flowing (in the opinion of the measurement representative)

APPENDIX D—WEDGE CALCULATION

D.1 The Method of Calculating Wedge Volumes on Marine Vessels

The method described below details the formula and calculations necessary to determine the volume remaining in a marine vessel's cargo compartment when the marine vessel is trimmed by the stern and the vessel's trim correction is not applicable [that is, the material in the compartment does not extend the full length of the tank/compartment (i.e., not touching the forward bulkhead)].

The method should only be applied after certain factors have been established:

a. The material is lying in a wedge configuration on the compartment bottom (see D.2.2).
b. The material is not touching the forward bulkhead of the compartment.
c. The observed innage (gauge) represents part of the wedge surface area that extends from the aftermost compartment bulkhead to the foremost leading edge of the material surface (that is, the gauge is not a pool or puddle of liquid or part of a small wedge lying directly forward of a transverse frame). It is recommended that additional innages (gaugings) be obtained forward and/or aft of the primary innage to verify the validity and use of the wedge calculation.

D.2 Formula/Method of Application

D.2.1 CALCULATION OF ADJUSTED INNAGE/GAUGE (A)

The first step in the formula is to calculate the adjusted innage/gauge (A) at the aftmost compartment bulkhead, using the observed innage as follows:

$$\left[\left(U - DF\right) \times F\right] + S = A$$

Where:

A = adjusted innage at aft bulkhead.
U = distance from aft bulkhead to ullage position.
DF = reference gauge height (D) × trim factor (F).
F = trim factor [trim divided by length between perpendiculars (LBP)].
S = observed innage (gauge).

D.2.2 TEST FOR WEDGE

The second step is to determine that the material is lying in a wedge configuration.

$$\frac{A}{F} = \text{length of wedge}$$

If the result is greater than the compartment length, a wedge condition does not exist. Do not proceed with the calculation; apply the vessel's trim correction.

If "A" is less than the compartment length, continue with the second part of the formula expression (shown below).

If a wedge condition does exist, the third step is to extract the mean table volume for use in the formula. The adjusted innage (A) is divided by two, and the table volume for this depth is extracted from the vessel's calibration tables.

In the fourth step, this mean table volume is used in the second expression of the formula to calculate the wedge volume:

$$\frac{Tv \times A}{L \times F} = \text{wedge volume (in table units)}$$

Where:

Tv = table volume (vessel ullage tables).
A = adjusted innage at aft bulkhead.
L = length of compartment (tank).
F = trim factor (trim divided by LBP).

Note: All units of measurement must be of the same denomination (that is, decimal feet or meters).

The use of the table volume provides a volumetric ratio that, when applied to the total expression of the formula, partially compensates for the internal tank framing (if included in the vessel's ullage/capacity tables), volume below tank datum, and width of the tank at the lower extremities of the compartment.

The total formula expression therefore is as follows:

$$\frac{\left\{\left[\left(U - DF\right) \times F\right] + S\right\} \times Tv}{L \times F} = \text{wedge volume (in table units)}$$

Note: For vessels that are trimmed down by the head, the distance from the ullage hatch to the forward bulkhead must be used in the calculation (L – U), as opposed to using the distance from the aft bulkhead. The calculation for vessels trimmed by the head is termed a "reverse wedge."

D.3 Compartments with Extreme Shape Due to Hull Curvature

Care must be exercised on compartments where the vessel's hull curvature is extreme, such as on the forward- and after-most wing tanks where significant variation in longitudinal width and/or depth is evident. For such tanks the mean width at the liquid surface should be ascertained.

An example of this is where the width at the aft end of a tank, say Number 1 starboard, is 10 meters; whereas the width at the forward end is only 5 meters. A small liquid volume at the aft end of the tank would have a width close to that of 10 meters. In this case, it would be more appropriate to use the actual width at the bottom of the tank in the simplified formula thus:

$$\frac{A^2 \times W}{2 \times F} = \text{wedge volume (in measured units)}$$

Where:

A = adjusted innage at the aft bulkhead (squared).
W = width at the tank bottom (usually aft end).
F = trim factor (trim divided by LBP).

EXAMPLE (Number 1 Starboard)

Trim = 4.00 meters
LBP = 230.00 meters
Trim Factor = 0.01739 (to five places)
A = 0.05 (adjusted innage)
Width = 8.00 meters (at bottom aft section of tank, as taken from the vessel's drawings)

$$\text{wedge volume} = \frac{A^2 \times W}{2 \times F}$$

$$= \frac{0.05^2 \times 8.00}{2 \times 0.01739}$$

$$= \frac{0.02}{0.03478}$$

$$= 0.575 \text{ cubic meters}$$

$$= 3.62 \text{ barrels (cubic meters} \times 6.28981)$$

In aft-most wing compartments, the effect of hull curvature is reversed: the width is much smaller at the aft end. Additionally, in such tanks, it is quite common for the gauge tape not to reach the very bottom of the tank because the tape comes into contact with the shell (curving in toward the tank bottom). As the vessel's ullage tables give the volume below the datum, using the table volume in the formula will most often result in a more accurate ratio than using the simplified formula. Hull curvature and tank configuration vary significantly from vessel to vessel. Where possible, a vessel's drawings should be consulted to help qualify the choice of appropriate wedge formula application.

WEDGE CALCULATION WORKSHEET

VESSEL: ____________________ PRODUCT/CARGO: ____________________ PORT/TERMINAL: ____________________ DATE: ________________

TANK NO.	U (SEE NOTE 3)	– DF	¥ F	+ S	= A	WEDGE LENGTH (SEE NOTE 1)	DIVIDE A BY 2	TABLE VOLUME (SEE NOTE 2)	MULTIPLY BY A	DIVIDE BY F	DIVIDE BY L	VOLUME (BARRELS/ CUBIC METERS)
											TOTAL VOLUME (SAME UNITS AS TABLE VOLUME)	

Key (all values to be in same units)	
A	Adjusted innage at aft bulkhead
D	Reference height (depth)
S	Sounding (observed innage)
U	Ullage distance (from aft bulkhead) (See Note 3)
L	Length of tank
F	Trim factor (trim + LBP)

FIELD INFORMATION	
Draft Aft	
Draft Forward –	
Trim =	
LBP ÷	
Trim Factor (F) =	
Mean Height (D) ¥	

NOTES:

1. Wedge length = A ÷ F. If the length of the wedge is greater than the tank length, do not proceed with the calculation; use applicable trim correction.
2. Extract the table volume for a vessel on an even keel and upright.
3. Reverse wedge: If the vessel (barge) is trimmed down by the head (bow), then use the distance from the ullage hatch to the forward bulkhead.
4. On tanks with extreme shape (e.g., 1 wings), calculate the adjusted innage (A) and use the compartments' bottom width (W) in substitute formula A^2 ¥ W ÷ F and multiply by 0.089055 (customary

INSPECTOR: ________________ FOR VESSEL: ________________

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