# Manual of Petroleum Measurement Standards Chapter 12—Calculation of Petroleum Quantities

## Section 1—Calculation of Static Petroleum Quantities

## Part 1—Upright Cylindrical Tanks and Marine Vessels

SECOND EDITION, NOVEMBER 2001
REAFFIRMED, FEBRUARY 2008

# Manual of Petroleum Measurement Standards Chapter 12—Calculation of Petroleum Quantities

## Section 1—Calculation of Static Petroleum Quantities
## Part 1—Upright Cylindrical Tanks and Marine Vessels

**Measurement Coordination**

SECOND EDITION, NOVEMBER 2001

## SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

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 supplier of that material, or the material safety data sheet.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Upstream Segment [telephone (202) 682-8000]. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the general manager.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

# FOREWORD

This three-part publication presents standard calculation procedures for static petroleum liquids. The three parts consist of the following:

Part 1—"Upright Cylindrical Tanks and Marine Vessels"—8/96
Part 2—"Tank Cars"—3/00
Part 3—"LPG Static Tanks and Marine Vessels"—3/01

This standard has been developed through the cooperative efforts of many individuals from industry under the sponsorship of the American Petroleum Institute and the Gas Processors Association.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure accuracy and reliability of the data contained herein; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

Suggested revisions to this publication are invited and should be submitted to the Measurement Coordinator, Upstream Segment, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

# CONTENTS

Page



Figures



Tables

# Chapter 12—Calculation of Petroleum Quantities
# Section 1—Calculation of Static Petroleum Quantities
# Part 1—Upright Cylindrical Tanks and Marine Vessels

## 0 Introduction

The described procedures are intended to standardize static tank calculation procedures and support a uniform approach to the volumetric and mass calculations of crude oil, petroleum products, and petrochemicals when contained in tanks. This standard specifies the equations, calculation sequences, rules for rounding, and discrimination levels to be employed in these calculations, with the aim that different operators can arrive at identical results using the same standardized input data. No deviations from these specified equations are permitted, since the intent of this document is to establish a rigorous standard.

## 1 Scope

This standard is intended to guide the user through the steps necessary to calculate static liquid quantities, at atmospheric conditions, in upright, cylindrical tanks and marine tank vessels. The standard defines terms employed in the calculation of static petroleum quantities.

The standard also specifies equations that allow the values of some correction factors to be computed. Fundamental to this process is the understanding that in order for different parties to be able to reconcile volumes, they must start with the same basic information (tank capacity table, levels, temperatures, and so forth) regardless of whether the information is gathered automatically or manually.

This standard does not address the calculation of clingage, nonliquid material, small quantities (such as onboard quantities, quantities remaining on board, and Wedge Formula, where material is not touching all bulkheads on marine vessels), and vapor space calculations.

## 2 References

Several documents served as references for the revision of this standard. Other documents that were a resource for information were:

API

*Manual of Petroleum Measurement Standards*

Chapter 1, "Vocabulary"
Chapter 2, "Tank Calibration"
Chapter 3, "Tank Gauging"
Chapter 7, "Temperature Determination"
Chapter 8, "Sampling"
Chapter 9, "Density Determination"
Chapter 10, "Sediment and Water"
Chapter 11, "Physical Properties Data"
Chapter 15, "Guidelines for the Use of International System of Units (SI) in the Petroleum and Allied Industries"
Chapter 16, "Measurement of Hydrocarbon Fluids by Weight or Mass"
Chapter 17, "Marine Measurement"
Chapter 18, "Custody Transfer"

ACGIH[1]

*Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*

ASTM[2]

D-1250-80 *Petroleum Measurement Table*
D-4311 *Practice for Determining Asphalt Corrections to a Base Temperature*

ICS[3]

*International Safety Guide for Oil Tankers and Terminals*

IP[4]

200 *Petroleum Measurement Tables*

OSHA[5]

29 *Code of Federal Regulations* Part 1910

## 3 Definitions

### 3.1 GENERAL

The definition of those terms relative to this document can be found in other API or associated documents, as follows:

General Terms—API Chapter 1
Marine Terms—API Chapter 17.1 (17.1.3)
Units of Measure and Interrelation—ASTM D-1250 Table 1
International System (SI) Units—API Chapter 15

### 3.2 ABBREVIATIONS

The designation of corrections and correction factors by abbreviations rather than words is recommended to abbrevi-

[1]American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue, Building D-7, Cincinnati, Ohio 45211.
[2]American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428.
[3]International Chamber of Shipping, 30/32 Mary Axe Street, London, EC3A8ET, England.
[4]Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR, England.
[5]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.

ate the expression, facilitate algebraic manipulation, and reduce confusion. While a combination of upper case, lower case, subscripted, and superscripted notation is used, upper case notation may be used as appropriate. Additional letters may be added to symbolic notations for clarity and specificity. Definitions are listed in 3.2.1 – 3.2.15.

**3.2.1 CSW:** Correction for sediment and water.

**3.2.2 CTL:** Correction for temperature of the liquid. Compensates for the effect of temperature on a liquid. Corrects a volume at an observed temperature to a standard temperature. This is the same as VCF.

**3.2.3 CTSh:** Correction for temperature of the shell. The correction factor for the effect of the temperature, both ambient and liquid, on the shell of the tank.

**3.2.4 FRA:** Floating roof adjustment. The adjustment made to offset the effect of the displacement of the floating roof.

**3.2.5 FW:** Free water quantity deduction (may include bottom sediments). The water present in a container that is not suspended in the liquid hydrocarbon.

**3.2.6 GOV:** Gross observed volume. The total volume of all petroleum liquids and sediment and water, excluding free water, at observed temperature and pressure.

**3.2.7 GSV:** Gross standard volume. The total volume of all petroleum liquids and sediment and water, excluding free water, corrected by the appropriate volume correction factor (*CTL*) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C.

**3.2.8 GSW:** Gross standard weight. The weight (or mass) of the *GSV* quantity.

**3.2.9 NSV:** Net standard volume. The total volume of all petroleum liquids, excluding sediment and water and free water, corrected by the appropriate volume correction factor (*CTL*) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C.

**3.2.10 NSW:** Net Standard Weight. The weight (or mass) of the *NSV* quantity.

**3.2.11 TCV:** Total calculated volume. The total volume of all petroleum liquids and sediment and water corrected by the appropriate volume correction factor (*CTL*) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and all free water measured at observed temperature (gross standard volume plus free water).

**3.2.12 TOV:** Total observed volume. Total measurement volume of all petroleum liquids, sediment and water, free water, and bottom sediments at observed temperature. For the purposes of this standard, *TOV* is the volume taken from the tank capacity table prior to any corrections, such as those for floating roof and the temperature of the tank shell.

**3.2.13 TSh:** Temperature of the tank shell (see page 4).

**3.2.14 VCF:** Volume correction factor. This is the same as *CTL*. These two symbols are interchangeable. *CTL* is used in all equations in this standard.

**3.2.15 WCF:** Weight conversion factor. A factor that converts a volume, usually at standard temperature, to mass or apparent mass.

## 4 Calculation of Measurement Tickets or Reports

A measurement ticket is a written acknowledgement of a receipt or delivery of petroleum and petroleum products. If a change in ownership or custody occurs during the transfer, the measurement ticket or report serves as documentation between the parties involved as to the measured quantities and tested qualities of the liquids transferred. Measurement ticket is the generalized term used to embrace and supercede long-standing expressions such as "run ticket," "transfer ticket," "receipt and delivery ticket," etc.

Care must be taken to ensure that all copies of a measurement ticket are legible. Standard procedure forbids making corrections or erasures on a measurement ticket, unless the interested parties agree to do so and initial the ticket to that effect. Should a mistake or change be made, the ticket should be marked Void, a new ticket prepared, and the voided ticket attached to the new ticket. An alternate method commonly employed is to write an adjustment ticket that corrects the amount of the error or change.

## 5 Hierarchy of Accuracies

There is an inevitable or natural hierarchy of accuracies in petroleum measurement. At the top are the standards calibrated by the National Institute of Standards and Technology. From this level downwards, any uncertainty in a higher level must be reflected in all lower levels as a bias or systematic error. Whether such bias will be positive or negative is unknown, as uncertainty carries either possibility.

To expect equal or less uncertainty in a lower level of the hierarchy than exists in a higher level is unrealistic. The only way to decrease the random component of uncertainty in a given measurement system is to increase the number of determinations and then find their mean value. The number of digits in intermediate calculations of a value can be larger in the upper levels of the hierarchy than in the lower levels, but the temptation to move towards imaginary significance (more decimal places) must be tempered or resisted by a wholesome respect for realism.

Table 1—Significant Digits

| Units | No. of Decimals | Units | No. of Decimals |
|---|---|---|---|
| Liters | XXX.0 | Observed Density kg/m$^3$ | XXX.5 |
| Gallons | XXX.xx | Density kg/m$^3$ | XXX.x |
| Barrels | XXX.xx | Observed Relative Density | X.xxx5 |
| Cubic meters | XXX.xxx | Relative Density | X.xxxx |
| Pounds | XXX.0 | *S & W %* | XX.xxx |
| Kilograms | XXX.0 | *CSW* | X.xxxxx |
| Short tons | XXX.xxx | Ambient Temperature | XXX.0 |
| Metric tons | XXX.xxx | Temperature °F | XXX.x |
| Long tons | XXX.xxx | Temperature °C | XXX.x5 |
| *CTL* | X.xxxxx[a] | Tank Shell Temperature (*TSh*) | XXX.0 |
| API Gravity | XXX.x | *CTSh* | X.xxxxx |
| Density lbs/gal. | XXX.xxx | | |

[a]The current standard for determining *CTL* factors is the computer subroutine implementation procedures of API MPMS Chapter 11.1, Volume X (August 1980). When fully implemented, this generates a *CTL* factor of five significant digits. That is, five decimal digits at temperatures above standart temperature (60°F and 15°C) and four decimal digits at temperatures below standard temperature. Use of the printed table limits the user to four decimal digits above and below standard temperature in addition to limiting table entry discrimination to 0.5°F, 0.25°C, 0.5 API, and 2.0 kg/m$^3$. In the event of a dispute, the computer-generated *CTL* should take preference. Later versions of this standard should use the discrimination levels specified by that version.

# 6 Rounding and Discrimination

## 6.1 DATA LEVEL

In many cases the number of decimal places that are to be used is influenced by the source of the data itself. For example, if a vessel's capacity tables are calibrated to the nearest whole barrel, than all subsequent barrel values should be recorded accordingly; however, in those cases where there are no other limiting factors, the operator should be guided as follows by Table 1.

## 6.2 ROUNDING OF NUMBERS

When a number is to be rounded to a specific number of decimal digits, it shall always be rounded in one step to the number of digits that are to be recorded, and shall not be rounded in two or more steps of successive rounding. The rounding procedure shall be in accordance with the following:

### 6.2.1 Rounding Positive Numbers

When rounding positive numbers and the digit to the right of the last place to be retained is 5 or greater, the digit in the last place to be retained should be increased by 1. If the digit to the right of the last place to be retained is 4 or less, the digit in the last place to be retained does not change. For example, the range 54.55°F to 54.64°F should be rounded to 54.6°F, while the range 54.65°F to 54.74°F should be rounded to 54.7°F.

If the digits in the last place to be retained are themselves to be rounded to a multiple of 5 (e.g., xxx.00, xxx.05, xxx.10, xxx.15, etc.), the procedure is different. If the digit to be rounded is 0 through 2, it is rounded down to the next even multiple of 5; if it is 3 through 7, it is rounded to 5; and if it is 8 or 9, it is rounded up to the next even multiple of 5. For example, when rounding Celsius temperatures to the nearest 0.05°C (see Table 1), the range 12.48°C to12.52°C should be rounded to 12.50°C, the range 12.53°C to 12.57°C should be rounded to 12.55°C, and the range 12.58°C to 12.62°C should be rounded to 12.60°C.

### 6.2.2 Rounding Negative Numbers

When rounding negative numbers and the digit to the right of the last place to be retained is 5 or less, the digit in the last place to be retained should not change. If the digit to the right of the last place to be retained is 6 or greater, the digit in the last place to be retained should be increased numerically by 1. For example, the range –10.25°F to –10.16°F should be rounded to –10.2°F, while the range –10.15°F to –10.06°F should be rounded to –10.1°F.

If the digits in the last place to be retained are themselves to be rounded to a multiple of 5 (e.g., xxx.00, xxx.05, xxx.10, xxx.15, etc.), the procedure is different. If the digit to be rounded is 8 or 9, it is rounded down to the next even mulitple of 5; if it is 3 through 7, it is rounded to 5; and if it is 0 through 2, it is rounded up to the next even multiple of 5. For example, when rounding Celsius temperatures to the nearest 0.05°C (see Table 1), the range –14.62°C to –14.58°C should be rounded to –14.60°C, the range –14.57°C to –14.53°C should be rounded to –14.55°C, and the range –14.52°C to –14.48°C is rounded to –14.50°C. Remember, –14.60 is a smaller number than –14.50.

## 6.3 DISCRIMINATION

Where used to verify conformance to calculation procedures, the accounting hardware that displays or prints results from calculations shall have at least 32 bit binary word length or be capable of 10-digit display. In certain situations, such as with on-line real time calculations that are required by process measurement instrumentation, the available equipment may not have this capacity. In such cases, rounding and discrimination levels should be as close to the standard as the computing hardware will allow.

The rounding and discrimination requirements set forth in this section may be applied to verify compliance with the calculation procedures of this standard. The data in Table 1 neither construes or implies accuracy requirements or capabilities of instrumentation used to furnish the measurements.

In Table 1 that follows, the number of digits shown as (X) **in front of the decimal point** are for illustrative purposes only, and may have a value more or less than the number of (X)'s illustrated.

The number of digits shown as (x) **after the decimal point** are very specific, as they define the required discrimination level for each value described.

In cases where a value is shown with the number 5 in the last decimal place, such as XX.x5, this is intended to signify that the last decimal place in the value must be rounded to either 0 or 5, no other value is permitted.

## 7 Observed Data (Input, Direct, or Primary)

The input or observed data in Table 2 must be gathered as a first step in the calculation process. This document does not address how these data are obtained. That information is found in the referenced publications listed in Section 2, and it is assumed, for the purpose of this document, that all such data have been obtained in accordance with these referenced publications. It should be understood that the observed data must be gathered concurrently. In other words, the level gauge, water cut, temperature, and so forth should all be taken at the same time for inclusion on the same measurement ticket or ullage report.

## 8 Calculated Data (Indirect or Secondary)

The data points presented in Table 3 are necessary for the calculation process and are calculated or extracted using the input data from the previous section.

## 9 Calculation of Gross Observed Volume (*GOV*)

The calculation process for shore tanks and marine tank vessels only differs up to the point of calculating gross observed volume (*GOV*). From this point on, the calculations are the same.

Refer to Appendix A for examples of shore tank and marine vessel tank calculations.

### 9.1 SHORE TANKS

To calculate the *GOV* for shore tanks, deduct any free water (*FW*) from the total observed volume (*TOV*) and multiply the result by the tank shell temperature correction (*CTSh*); then, apply the floating roof adjustment (*FRA*), where applicable.

$$GOV = [(TOV - FW) \times CTSh] \pm FRA$$

#### 9.1.1 Total Observed Volume (*TOV*)

The *TOV* is obtained from the shore tank's capacity table and is entered with the observed innage or ullage.

Table 2—Observed Data

| Shore Tanks | Marine Vessel's Tanks |
|---|---|
| Recorded reference gauge height[a] | Recorded reference gauge height[a] |
| Observed reference gauge height[a] | Observed reference gauge height[a] |
| Innage or ullage or liquid level | Innage or ullage of liquid level |
| Innage or ullage of free water level | Innage or ullage of free water level |
| Average tank temperature °F or °C | Average tank temperature °F or °C |
| Observed density @ tank temperature | Observed density @ tank temperature |
| Percentage of sediment and water | Percentage of sediment and water |
| Ambient air temperature | Forward draft reading |
| | After draft reading |
| | Degrees of List |
| | Length between perpendiculars |

[a]These data points do not have any direct impact on the calculation process; however, they can impact the calculation process indirectly and are usually recorded at this time.

Table 3—Calculated Data

| Shore Tanks | Marine Vessel's Tanks |
|---|---|
| Density @ standard temperature | Trim of Vessel |
| Floating roof correction | Density @ standard temperature |
| Tank shell temperature correction | Trim correction and list correction |
| Total observed volume | Total observed volume |
| Free water volume | Free water volume |
| Gross observed volume | Gross observed volume |
| Correction for temperature of liquid (*CTL*) | Correction for temperature of liquid (*CTL*) |
| Gross standard volume | Gross standard volume |
| Sediment and water (volume or factor) | Sediment and water (volume or factor) |
| Net standard volume | Net standard volume |
| Weight conversion factor | Weight conversion factor |
| Apparent mass (weight in air) | Apparent mass (weight in air) |
| Mass (weight in vacuum) | Mass (weight in vacuum) |

### 9.1.2 Adjustment for the Presence of Free Water (*FW*) and Tank Bottom Sediments

It is necessary to determine the amount of *FW* and bottom sediments, if any, before and after each product movement into or out of a tank so that the appropriate corrections can be made.This adjustment (*FW*) will always be in the form of a volumetric deduction. The amount of the deduction can be determined by converting the *FW* level gauge to a volume through use of the tank's capacity table.

### 9.1.3 Correction for the Effect of Temperature on the Steel Shell of the Tank (*CTSh*)

Any tank, when subjected to a change in temperature, will change its volume accordingly. Assuming that they have been calibrated in accordance with *API MPMS* Chapter 2, upright cylindrical tanks have capacity tables based on a specific tank shell temperature. If the observed tank shell temperature differs from the capacity table tank shell temperature, the volumes extracted from that table will need to be corrected accordingly.

Storage tanks differ from test measures in size and wall thickness. Differences also occur because the tanks cannot readily be sheltered from the elements. Therefore, ambient temperatures as well as product temperatures must be considered when calculating an appropriate correction for the effect of temperature on the shell of the tank. The correction fact for the effect of temperature on the shell of the tank is called *CTSh* and may be calculated by the following:

$$CTSh = 1 + 2a\Delta T + a^2\Delta T^2 \quad (1)$$

where

$a$ = Linear coefficient of expansion of the tank shell material [see table 4],

$\Delta T$ = Tank Shell Temperature (*TSh*) – Base Temperature (*Tb*).

Notes:

1. Base Temperature (*Tb*) is the tank shell temperature for which the capacity table volumes were calculated to. In the US, this is usually 60°F.

2. The base temperature is usually stated on the capacity table. If this is not the case, contact the company that generated the table. Some capacity tables make reference to an operating product temperature; this should not be confused with the base temperature, which is a tank shell temperature.

3. When calculating $\Delta T$ it is important to maintain the arithmetic sign as this value can be positive or negative and must be applied as such in the *CTSh* formula.

Table 4—Linear Thermal Expansion Coefficients

| Type of Steel | Coefficient per °F | Coefficient per °C |
|---|---|---|
| Mild Carbon | 0.00000620 | 0.0000112 |
| 304 Stainless | 0.00000960 | 0.0000173 |
| 316 Stainless | 0.00000883 | 0.0000159 |
| 17-4PH Stainless | 0.00000600 | 0.0000108 |

**9.1.3.1** For noninsulated metal tanks, the temperature of the shell may be computed as follows (refer to Appendix B):

$$TSh = \frac{(7 \times Tl) + Ta}{8} \quad (2)$$

where

$TSh$ = tank shell temperature,

$Tl$ = liquid temperature,

$Ta$ = ambient temperature.

Note: Ambient air temperature surrounding a storage tank is always an arbitrary, and usually a widely varying quantity; specifically, where is the best place to measure it. For this reason alone, the uncertainty of this measurement can be within plus or minus five degrees Fahrenheit (2.5 degrees Celsius).

For practical operational purposes the recommended methods of taking this temperature are:

1. A temperature device carried by the gauger into the tank area when gauging tanks. Take at least one temperature reading in a shaded area. If more than one temperature is taken, average the readings.
2. Shaded external thermometers permanently mounted in the tank farm area.
3. Local on-site weather stations.

All on site temperature devices, used to record ambient air temperature for the calculation of tank shell correction factors during custody transfer shall have their accuracy of plus or minus two degrees Fahrenheit verified every three months.

Where the uncertainty of the ambient air temperature is plus or minus five degrees Fahrenheit, the effect on calculating the tank shell correction factor is 1 in 100,000.

Temperature readings are to be taken 3 ft (1 meter) from any obstructions or the ground. Additionally, allow sufficient time for temperature readings to stabilize.

**9.1.3.2** For insulated metal tanks, the temperature of the shell may be taken as closely approximating the adjacent liquid temperature, in which case, $TSh = Tl$.

**9.1.3.3** In applying these principles to upright cylindrical tanks, the horizontal cross-sectional area may be taken as a function of tank calibration. The coefficient determined from Equation 1 (see 9.1.3) is predicated on a thermal expansion for low-carbon steel per degree Fahrenheit.

Note: The cross-sectional correction (Equation 1) will have to be modified for stainless steel tanks based upon the coefficient of expansion for the type of stainless steel.

**9.1.3.4** The third dimension needed to generate volume—height—is a function of gauging and should be considered separately. The volumes reflected on tank tables are derived from area times incremental height. Therefore, K- factors for correction of areas have the same ratio as volume corrections and may be applied directly to tank table volumes. For an example calculation see Appendix B.

**9.1.3.5** The shell temperature correction factor is to be applied to volumes obtained from capacity tables that are at 60°F and are unrelated to the corrections designed to account for volume expansion and contraction of the product itself. Depending upon certain requirements, this shell temperature correction factor may be built into the capacity table for a specific operating temperature.

### 9.1.4 Floating Roof Adjustment (*FRA*)

The correction for the displacement of the floating roof can be addressed in one of two ways:

a. If the roof correction is calculated into the tank capacity table using a reference density, a secondary correction must be calculated for any difference between the reference density and the observed density at tank temperature. Such tables will contain a notation similar to the following:

Note: A total of____ barrels has been deducted from this table between ___ feet ____ inches; and ___ feet ___ inches for roof displacement based on a floating weight of ___ pounds and an observed liquid gravity of ___ API as observed under conditions of the liquid in which the roof is floating. (This may be at any observed temperature.) Gauged levels above ___ feet ___ inches reflect this deduction but should be corrected for observed API gravity of the liquid at prevailing temperatures as follows:

For ___ API as observed, no correction.

For each degree below ___ API observed, add ___ barrels.

For each degree above ___ API observed, subtract ___ barrels.

The observed gravity at tank temperature can be calculated by working backwards through *API MPMS* Chapter 11.1, Table 5A or 5B, "Correction of Observed API Gravity to API Gravity at 60°F." Locate the API gravity at 60°F on the horizontal line that corresponds to the observed tank temperature. The API gravity at observed temperature can be read at the top of the vertical column.

b. If the capacity table has been prepared as a table of gross or open-tank capacity, commonly referred to as a shell capacity table, the roof deduction is calculated by dividing the weight of the floating roof by the weight per unit volume at standard temperature multiplied by the *CTL* to bring this to observed conditions.

$$\text{Roof correction} = \frac{\text{Weight (apparent mass) of roof}}{\text{Density} \times \text{CTL}}$$

Notes:

1. The density units must be consistent to both the *CTL* and the units of the roof weight, in addition to being a density in air. For example, if the density is lbs/gal @ 60°F, then the roof weight must be in pounds and the *CTL* applicable to a standard temperature of 60°F. Additionally, this particular example will yield a roof correction in gallons. If the table units are in barrels, it will be necessary to divide the result by 42.
2. Floating roof correction will be less accurate if the liquid level falls inside the floating roof's critical zone regardless of table style.
3. If a significant amount of water, ice, or snow is present on a floating roof, it should either be removed or its weight estimated and calculated into the roof correction.
4. Roof corrections are not applicable for volumes below the critical zone.

For examples of both types of roof correction, see the examples below.

*Example 1*: Where roof calculation is calculated into the tank capacity table:

Calculation of the secondary correction for the difference between the reference density and the observed density when the primary roof correction is built into the capacity table using reference density.

Input Data:

| | |
|---|---|
| Product: | Crude Oil |
| API gravity @ 60°F: | 40.3 |
| Temperature of liquid: | 84.0°F |

Excerpt from a tank capacity table:

"A total of 4,088.2662 barrels was deducted from this table between 4 feet 00 inches and 5 feet 00 inches for floating roof displacement based on a weight of 1,215,000 pounds and a gravity of 35.0 API. Gauged quantities above 5 feet 00 inches reflect this deduction but shall be adjusted for varying API gravities at tank temperature according to the following."

| | |
|---|---|
| Referenced observed API gravity 35.0: | no adjustment |
| For each 1.0 API below 35.0 API: | add 24.59 barrels |
| For each 1.0 API above 35.0 API: | subtract 24.59 barrels |

*Step 1*: Calculate the observed API gravity for an API gravity at 60°F of 40.3 and an observed temperature of the liquid of 84.0°F. This is done by working backwards using ASTM 1250, Table 5A (or 5B if the tank content is a petroleum product) as shown in Table 5.

Note: When the API gravity @ 60°F does not fall on an exact gravity, the user must interpolate between gravities to arrive at the correct observed gravity. For example, the API @ 60°F to be corrected to observed, is 40.3. Looking up the gravity on Table 5 indicates the gravity falls between 40.0 and 40.4 or 3/4 of the difference between the observed gravities at the top of the table. The API of 40.3 falls between the observed gravities of 42.0 and 42.5, which have a difference of 0.5 gravity. To determine what 40.3 equates to as an observed gravity, calculate what 3/4 of 0.5 gravity. The calculation equates to 0.4 (rounded). Add this to the 42.0 and the observed gravity that equates to 40.3 @ 60 is 42.4 API.

## Table 5—Generalized Crude Oils API Correction to 60°F

API Gravity at Observed Temperature

| | Temp. °F | 40.0 | 40.5 | 41.0 | 41.5 | 42.0 | **42.4** ◊ | 42.5 | 43.0 |
|---|---|---|---|---|---|---|---|---|---|
| | Corresponding API Gravity at 60°F | | | | | | | | |
| | 75.0 | 38.8 | 39.2 | 39.7 | 40.2 | 40.7 | ↑ | 41.2 | 41.7 |
| | 75.5 | 38.7 | 39.2 | 39.7 | 40.2 | 40.7 | | 41.2 | 41.6 |
| | 76.0 | 38.7 | 39.2 | 39.7 | 40.1 | 40.6 | | 41.1 | 41.6 |
| | 76.5 | 38.6 | 39.1 | 39.6 | 40.1 | 40.6 | | 41.1 | 41.6 |
| | 77.0 | 38.6 | 39.1 | 39.6 | 40.1 | 40.5 | | 41.0 | 41.5 |
| | 77.5 | 38.6 | 39.0 | 39.5 | 40.0 | 40.5 | | 41.0 | 41.5 |
| | 78.0 | 38.5 | 39.0 | 39.5 | 40.0 | 40.5 | | 40.9 | 41.4 |
| | 78.5 | 38.5 | 39.0 | 39.4 | 39.9 | 40.4 | | 40.9 | 41.4 |
| | 79.0 | 38.4 | 38.9 | 39.4 | 39.9 | 40.4 | | 40.9 | 41.3 |
| | 79.5 | 38.4 | 38.9 | 39.4 | 39.8 | 40.3 | ↑ | 40.8 | 41.3 |
| | 80.0 | 38.3 | 38.8 | 39.3 | 39.8 | 40.3 | | 40.8 | 41.3 |
| | 80.5 | 38.3 | 38.8 | 39.3 | 39.8 | 40.2 | | 40.7 | 41.2 |
| | 81.0 | 38.3 | 38.8 | 39.2 | 39.7 | 40.2 | | 40.7 | 41.2 |
| | 81.5 | 38.2 | 38.7 | 39.2 | 39.7 | 40.2 | | 40.7 | 41.1 |
| | 82.0 | 38.2 | 38.7 | 39.2 | 39.6 | 40.1 | | 40.6 | 41.1 |
| S T | 82.5 | 38.1 | 38.6 | 39.1 | 39.6 | 40.1 | | 40.6 | 41.0 |
| A | 83.0 | 38.1 | 38.6 | 39.1 | 39.6 | 40.0 | | 40.5 | 41.0 |
| R T | 83.5 | 38.1 | 38.5 | 39.0 | 39.5 | 40.0 | | 40.5 | 41.0 |
| → | 84.0 | 38.0 | 38.5 | 39.0 | 39.5 | 40.0 | ↑ | 40.4 | 40.9 |
| | 84.5 | 38.0 | 38.5 | 39.0 | 39.4 | 39.9 | | 40.4 | 40.9 |
| | 85.0 | 37.9 | 38.4 | 38.9 | 39.4 | 39.9 | | 40.4 | 40.8 |

Note: Table 5 is from API Chapter 11.1, Table 5A (ASTM 1250, Table 5A).

*Step 2:* Calculate the difference between the observed API gravity and the referenced observed API gravity as follows:

| | |
|---|---|
| Referenced observed API gravity 35.0: | no adjustment |
| For each 1.0 API below 35.0 API: | add 24.59 barrels |
| For each 1.0 API above 35.0 API: | subtract 24.59 barrels |

| | |
|---|---|
| Referenced observed API gravity: | 35.0 |
| Observed API gravity @ 84°F: | 42.4 |
| Difference: | 7.4 |

For each 1.0 API above 35.0 API, subtract 24.95 barrels.
(7.4) × (–24.59) = –181.97 barrels
Floating roof adjustment = –181.97 barrels

*Example 2*: Where roof correction is not calculated in the tank capacity table—Shell Capacity Table:

Calculate a floating roof adjustment using a "shell capacity table." This is when no corrections have been made to the tank capacity table for the roof. (See note.)

| Gross observed volume corrected for *CTSh* = 242,362.15 barrels | |
|---|---|
| Product: | Crude Oil |
| API gravity @ 60°F: | 40.3 |
| Temperature of liquid: | 84.0°F |
| *CTL* (Table 6A): | 0.9879 |
| Weight of floating roof: | 1,215,000 pounds |
| Weight per unit volume of liquid: | 6.858 pounds/gallons (See note.) |

Note: From ASTM D-1250, Volume 11, Table 8 using the API gravity at 60°F.

$$\text{FRA} = \frac{\text{weight (apparent mass) of roof}}{\text{density} \times \text{CTL}}$$

$$\text{FRA} = \frac{1{,}215{,}000}{6.858 \times 0.9879}$$

$$\text{FRA } 179335.26 \text{ gallons} = -4269.89 \text{ barrels}$$

Gross observed volume corrected for *FRA* = 238,092.26 barrels

Note: When the floating roof adjustment (*FRA*) is calculated using a shell capacity table, the correction is always negative and must be subtracted from the tank volume.

## 9.2 MARINE VESSEL'S TANKS

To calculate the *GOV* for marine vessel's tanks, deduct the *FW* volume from the *TOV.*

$$GOV = TOV - FW$$

In the event of a volumetric trim or list correction as per 9.2.2 Item a, the calculation is as follows:

$$GOV = (TOV \pm \text{trim or list correction}) - FW \text{ (see note)}$$

Note: Refer to 9.2.5.

### 9.2.1 Total Observed Volume (*TOV*)

The *TOV* is obtained from the vessel's capacity tables, which are entered with one of the following:

a. The observed ullage or innage, if the trim and/or list corrections are a volumetric adjustment. The amount of trim and/or list correction will need to be applied to the *TOV* quantity to arrive at a trim and/or list corrected *TOV.*
b. The trim and/or list corrected ullage or innage.
c. The observed ullage or innage and the vessel's trim. Some capacity tables show varying *TOV* values for the same gauge under differing conditions of trim.

### 9.2.2 Trim Correction

The trim correction is applied to compensate for the change in liquid level due to the longitudinal plane of the vessel not being horizontal.

Subtract the forward draft reading from the after draft reading. If the trim is positive (that is, the after draft reading is larger), the vessel is said to be "trimmed by the stern." If the trim is negative (that is, the forward draft reading is larger), the vessel is said to be "trimmed by the head." Note the following:

a. The trim correction is found in the vessel's calibration tables and is usually a correction to the observed innage/ullage; however, it can be a volumetric adjustment to the *TOV.*
b. Trim corrections can be either positive or negative. The trim correction table will state how this correction is to be applied.
c. If trim corrections are not available, it may be possible to calculate this value. Refer to the equation and Figure 1.

Trim corrections are usually provided as part of the vessel's capacity tables and as such the following calculation is not normally carried out in the field; however, for those occasions where this may be required, the following formula can be used.

The trim correction is given by the following equation:

$$Sc = S \pm \left(\frac{(L \times T)}{LBP} - \frac{(\langle D - S \rangle \times T^2)}{(LBP)^2}\right)$$

Note: Units of measure for trim correction are generally in ft or meters, depending on the unit of measure describing the vessels dimensions.

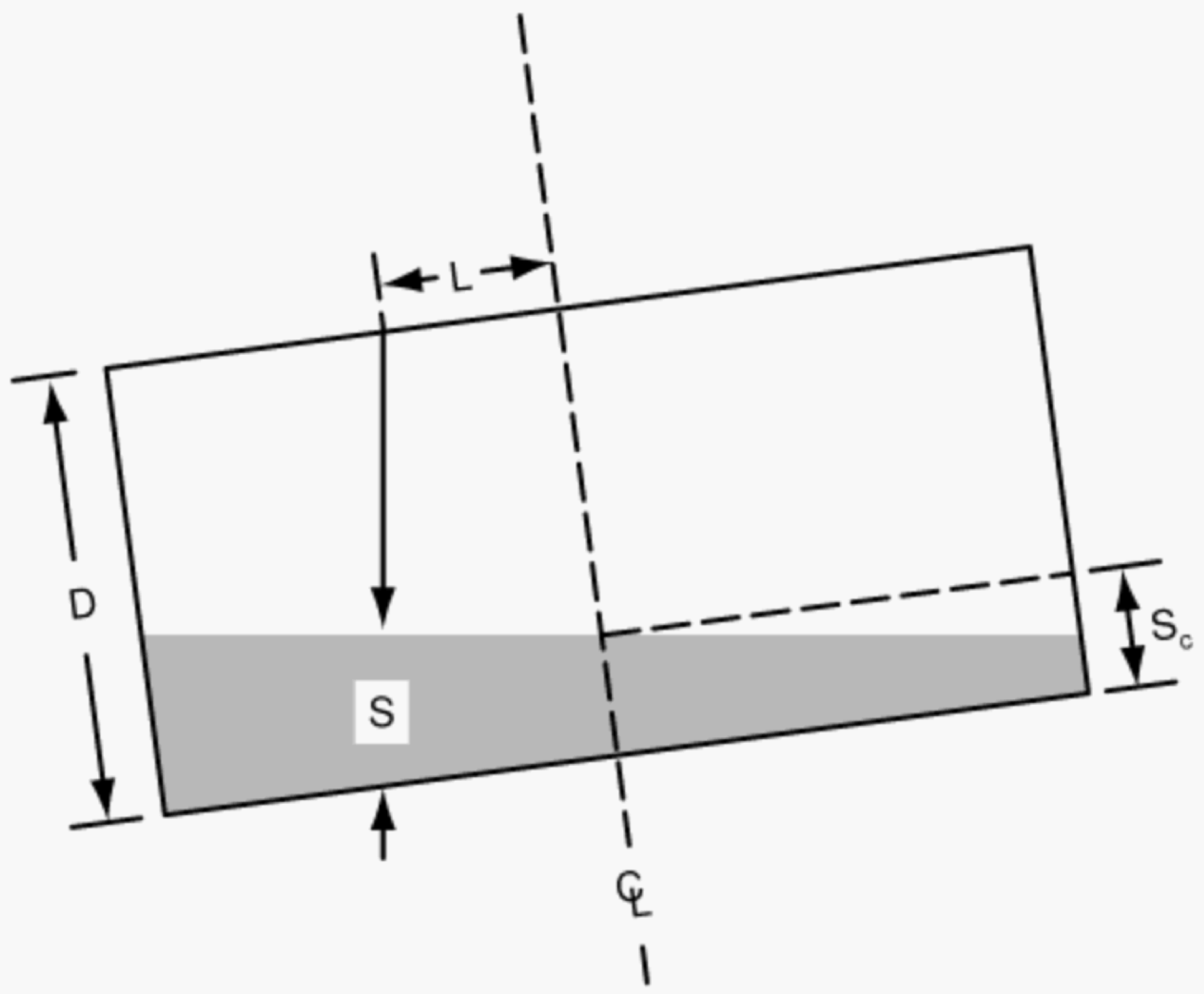



Figure 1—Calculating a Trim Correction

where

$D$ = Tank height, from the reference point,

$S$ = Observed gauge,

$L$ = Distance of the gauge hatch from the center of tank,

$Sc$ = Trim corrected gauge,

$LBP$ = Length of ship between perpendiculars,

$T$ = Trim of the ship.

All of the above must be expressed in the same units of length.

Note: The bracketed quantity is added when the observed gauge is forward and subtracted when aft of the center of the tank. When the liquid level in the tank is such that it no longer reaches the forward end, a wedge is formed and the application of the trim correction will no longer give the true gauge.

#### 9.2.3 List Correction

List correction is applied to compensate for the change in liquid level due to the vertical plane of the vessel not being perpendicular to the horizontal. A vessel's list is usually read from its inclinometer; however, if such an instrument is not available or there is doubt as to its accuracy, then the list can be calculated from the port and starboard midships draft readings. Refer to Figure 2 for this calculation. Note the following:

a. List corrections are applied in the same manner as are trim corrections.

b. List corrections can be either positive or negative. The list correction table will state how this correction is to be applied.

c. If list corrections are not available, it may be possible to calculate this value. Refer to *API MPMS* Chapter 2.8A, Section 10.4.

#### 9.2.4 Combining Trim and List Corrections

Caution must be exercised when applying trim and list corrections collectively. In many cases these corrections are only applicable when the other condition does not exist. When both conditions do exist, it is preferable (where possible) to eliminate one of them.

For information on the calculation procedure for combined trim and list corrections, refer to *API MPMS* Chapter 2.8A, Section 10.4.

#### 9.2.5 Free Water Volume (*FW*)

*FW* volume is obtained from the vessel's capacity tales, which are entered with the *FW* innage or ullage. As with any liquid in a marine vessel's tank, *FW* is subject to the effects of trim and list, and the previously referenced trim and list corrections are applicable to *FW*, provided that the *FW* is touching all bulkheads of the tank. If the *FW* does not touch all tank bulkheads, a wedge condition exists. The formula for calculating whether or not a wedge condition exists, the application of wedge tables/formulae, and the calculation of the wedge formula can be found in *API MPMS* Chapter 17.4.

## 10 Calculation of Gross Standard Volume (*GSV*) (Shore Tanks and Marine Vessel's Tanks)

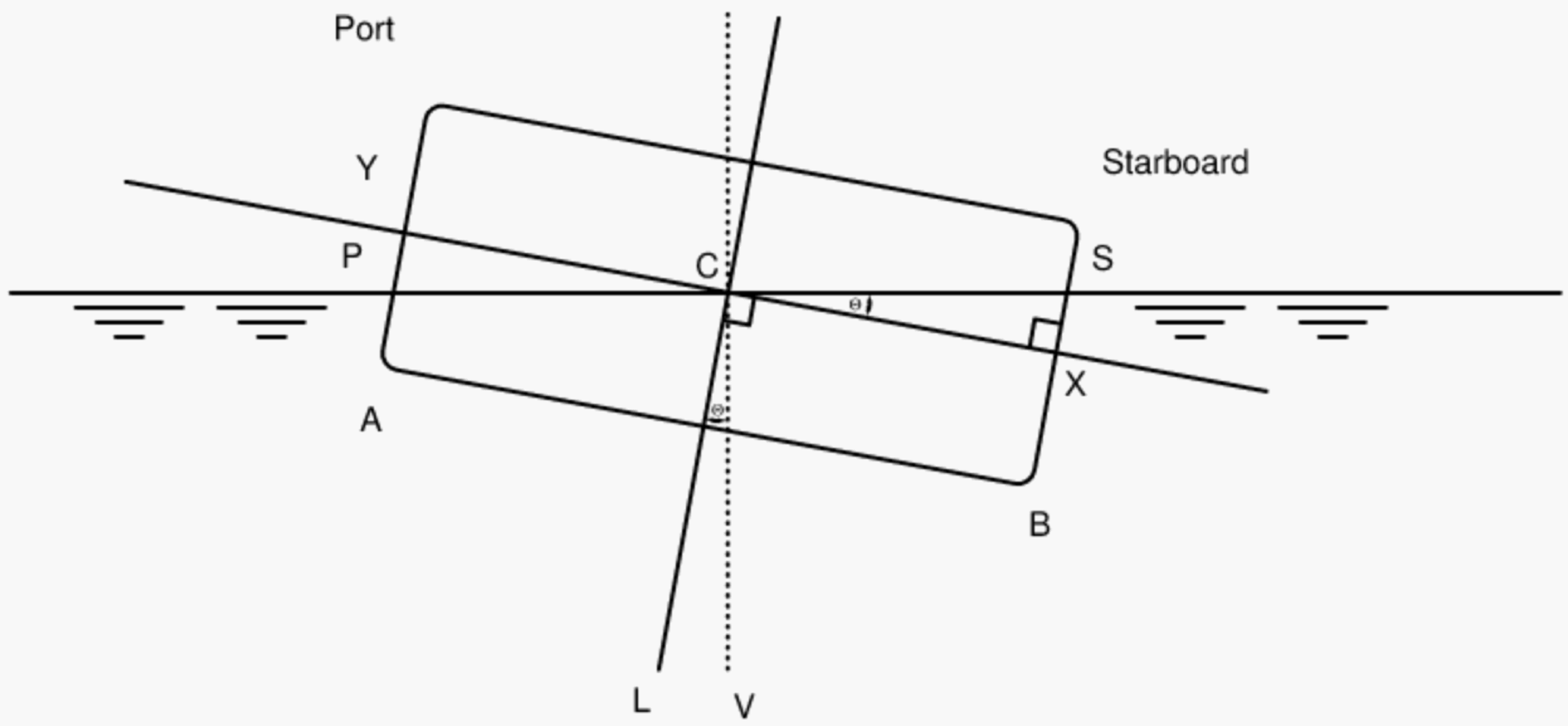
### 10.1 GROSS STANDARD VOLUME (*GSV*)

The *GSV* is calculated by multiplying the *GOV* by the correction for the effect of temperature on liquid (or volume correction factor).

$$GSV = GOV \times CTL$$

### 10.2 CORRECTION FOR THE EFFECT OF TEMPERATURE ON A LIQUID (*CTL*) OR VOLUME CORRECTION FACTOR (VCF)

If a volume of petroleum liquid is subjected to a change in temperature, its density will decrease as the temperature rises or increase as the temperature falls. This density change is proportional to the thermal coefficient of expansion of the liquid and temperature. The correction factor for the effect of the temperature on the density of a liquid is called *CTL* or VCF. The *CTL* factor is a function of the Base Density of the liquid and its temperature. The function of this correction factor is to adjust the volume of liquid at observed temperature to its volume at a standard temperature. The most common standard temperatures are 60°F, 15°C, and 20°C (68°F).




Legend: PA = Port Draft = 10.0 m
SB = Starboard Draft = 12.0 m
XY = Vessel Beam = 30.0 m

Theory: Angle LCV = Angle SCX = Angle of List = Θ

$$\text{Tangent } \Theta = \frac{SX}{CX} = \frac{(\text{Starboard Draft - Port Draft})/2}{(\text{Vessel's Beam})/2}$$

This reduces to

$$\text{Tangent } \Theta = \frac{\text{Starboard Draft - Port Draft}}{\text{Vessel's Beam}}$$

Calculation:

$$\text{Tangent } \Theta = \frac{(12.0 - 10.0)}{30} = 0.0667$$

From the chart of "Natural Functions of Angles," a tangent value of 0.0667 represents an angle of 4°, rounded to the nearest 0.5°.

Result: Vessel is listed 4° to starboard.

Figure 2—Method to Calculate Vessel's List Using Midships Draft Readings

These correction factors can be obtained from the petroleum measurement tables, which can be found in *API MPMS* Chapter 11.1, ASTM D-1250, or IP-200. These tables are entered with the observed average temperature and an API gravity at 60°F, a density at 15°C, a relative density at 60°F/60°F , or a coefficient of thermal expansion. To determine which table is applicable, refer to Table 6.

Many products, especially petrochemicals, may have specific volume correction factor tables, developed by the manufacturer. These individual tables have their own parameters and table entry requirements; however, their application is the same. The use of these tables should be by mutual agreement of all parties concerned.

## 11 Sediment and Water (S&W)

Crude oil and some liquid petroleum products contain sediment and water suspended or entrained throughout that fluid. The quantity of sediment and water is determined by laboratory analysis of a representative sample and is expressed as a percentage, usually volume percent. For information on how sediment and water analysis is performed, refer to *API MPMS* Chapter 10 or its ASTM equivalents.

When automatic sampling systems are employed for product transfer, tanks with varying densities (crude oil systems, for example) will need to accumulate base data differently than for transfers that do not include the use of an automatic sampler. While the volume calculation procedures for movements into a tank involving an automatic sampling system will be the same, the method of collecting the base information will be different. (Movements out of a tank are less affected as there is less blending of densities taking place). However, it may be necessary to report the density, as determined from the automatic sampling system, somewhere on the measurement ticket or report. Regardless, it will still be

Table 6—*CTL* Tables

| Table | Product | Temp | Table Entry |
|---|---|---|---|
| 6A | Generalized crude oil | °F | API gravity @ 60°F |
| 6B | Generalized products | °F | API gravity @ 60°F |
| 6C | Individual & special applications | °F | Thermal expansion coefficient |
| 6D | Generalized lubricating oils | °F | API gravity @ 60°F |
| 24A | Generalized crude oil | °F | Relative density @ 60/60°F |
| 24B | Generalized products | °F | Relative density @ 60/60°F |
| 24C | Individual & special applications | °F | Thermal expansion coefficient |
| 54A | Generalized crude oil | °C | Density @ 15°C |
| 54B | Generalized products | °C | Density @ 15°C |
| 54C | Individual & special applications | °C | Thermal expansion coefficient |
| 54D | Generalized lubricating oils | °C | Density @ 15°C |
| ASTM D-4311 | Asphalt to 60°F, Table 1 | °F | API gravity @ 60°F, Table A or B |
| ASTM D-4311 | Asphalt to 15°C, Table 2 | °C | Density @ 15°C, Table A or B |

necessary to sample the tank before and after a receipt because of the following:

a. At the beginning of the transfer, there is nothing in the sampler and therefore nothing on which to base opening measurements.

b. After the transfer, the incoming product has been blended with whatever was in the tank. In order for the *CTL* and *FRA* to be correct, they will have to be based on the density of the product as found in the tank.

c. The tank's *FW* level must be left the same on the closing report as on the opening report. All deducted water volumes should come from the sampler and be accounted for in the form of correction for S&W (*CSW*).

d. S&W are usually only deducted on crude oil cargoes. Petroleum products are not usually corrected for S&W unless required as a commercial condition or other specific requirement; therefore net standard volume = *GSV*.

## 12 Calculation of Net Standard Volume (*NSV*)

To calculate *NSV*, multiply the *GSV* by the *CSW*.

$$NSV = GSV \times CSW$$

which can be expanded to the following:

$$NSW = GSV \times [(100 - S\&W\%) \div 100]$$

### 12.1 CALCULATION OF THE CORRECTION FOR SEDIMENT AND WATER (*CSW*)

To calculate the *CSW* value, the percentage of S&W must be known. Deduct the S&W percentage value from 100, thus determining the *NSV* as a percentage of the *GSV*, divide this by 100, and multiply the *GSV* by it.

$$CSW = (100 - S\&W\%) \div 100$$

### 12.2 CALCULATION OF THE VOLUME OF SEDIMENT AND WATER (S&W)

It is frequently necessary to calculate the actual volumetric value of S&W. This can be achieved by subtracting the net standard volume (*NSV*) from the Gross Standard Volume (*GSV*).

$$S\&W(\text{vol}) = GSV - NSV$$

On multiple tank shipments, *NSV* can be calculated on a tank-by-tank basis if the individual S&W values are known; however, it can be calculated on a grade or parcel basis if the S&W was analyzed on an appropriate representative sample.

## 13 Calculation of Apparent Mass (Weight in Air)

### 13.1 GENERAL PROCEDURE

Usually, apparent mass is calculated by multiplying the *GSV* or *NSV* by the appropriate weight correction factor.

$$\text{Net standard weight (in air)} = NSV \times WCF$$

or

$$\text{Gross standard weight (in air)} = GSV \times WCF$$

### 13.2 WEIGHT CONVERSION FACTOR (*WCF*)

The *WCF* is found in the various tables that are contained in Volume XI and Volume XII of *API MPMS* Chapter 11.1. These volumes detail the "Intraconversion Between Volume Measures and Density Measures." These two volumes contain 26 different tables. Because of the diversity of these tables, it is possible to approach the calculation process from various directions using different tables. Where possible, the most direct conversion process (table) should be used to arrive at the answer. For example, a surveyor wishes to calculate the number of long tons and metric tons for *NSV* at a known API gravity at 60°F. It is preferable to use Table 11 to convert *NSV* to long tons and then Table 13 to convert *NSV* to metric tons rather than to use Table 11 to convert *NSV* to long tons and then Table 1 to convert the long tons to metric tons.

## 14 Calculation of Mass (Weight in Vacuum)

For crude oil and its products, it is generally preferred to calculate mass by multiplying the *GSV* or *NSV* by the appropriate density at the same standard temperature; however, mass can also be calculated directly from volume and density at the same observed temperature.

$$\text{mass} = \text{volume} \times \text{density}$$

The volume in this formula would be the *GOV.* The density used would typically be calculated from a density at a standard temperature (usually 15°C or 20°C) and adjusted to the observed temperature by use of a thermal expansion coefficient. This method is frequently used for the calculation of chemical cargoes. A table of observed densities for a range of temperatures can also be used if available, applicable, and acceptable to all parties involved.

## 15 Direct Mass Measurement

Some measurement methods, for example hydrostatic tank gauges, determine mass by measuring liquid head rather than liquid level. The calculation algorithms used by these methods may include corrections for the effect of temperature on the liquid (10.2), for the effect of liquid density on the floating roof (9.1.4), or the effect of temperature on the shell of the tank (9.1.3). In such cases, these corrections should not be duplicated. For calculation procedures, refer to *API MPMS* Chapter 16.2.

## 16 Calculation Sequence

### 16.1 GENERAL

It is outside the scope of this document to instruct the user in the procedures and techniques necessary to obtain all the observed information that will be needed in order to calculate a net volume. It is the user's responsibility to obtain that information from the standards referenced earlier. While there are some precautionary notes in the text of this document, it is assumed that the user will come to this standard with all the observed information necessary to begin to calculate net volumes. The information needed is liquid level, free water level, product temperature, ambient temperature, density, and the percentage of S&W present in the sample. It will also be necessary to have all the required capacity tables, all the applicable correction factor tables and any necessary computer subroutines.

Any deduction that is not applicable for a particular calculation will be a zero deduction,

Any correction that is not required in the calculation would be held as a factor of 1.00000.

The calculation routine will be the same.

### 16.2 VOLUME BASED CALCULATION PROCEDURE

The calculation sequence follows that of the preceding sections. The flow is as follows (see Figures A-1 and A-2):

$$TOV \rightarrow GOV \rightarrow GSV \rightarrow NSV \rightarrow NSW$$

a. With the liquid level or gauge, enter the capacity table and record the *TOV,* as recorded in the table.

b. Subtract any gauged *FW* volumes. The *FW* volume is obtained by entering the capacity table with the gauged *FW* level.

c. Apply the *CTSh* to arrive at the *GOV.*

d. Correct this quantity for any applicable *FRA*.

e. Correct the *GOV* to standard temperature. This is done by multiplying the *GOV* by the *CTL* to arrive at the *GSV.*

f. Adjust for any measured amount of S&W. This is done by multiplying *GSV* by the *CSW.*

g. If the net standard weight [NSW] is required, multiply the result from Item (f) by the appropriate *WCF.*

The mathematical formulae for the various required values can be expressed as follows:

$$GSV = [\{(TOV - FW) \times CTSh] \pm FRA\} \times CTL$$

$$NSV = \{[(TOV - FW) \times CTSh] \pm FRA\} \times CTL \times CSW$$

$$\text{NSW} = \{[(TOV - FW) \times CTSh] \pm FRA\} \times CTL \times CSW \times WCF$$

Chain calculations must be performed. Only the final result in the calculation is to be rounded. If it is necessary to report any intermediate values, the figure should be rounded as required in Section 6; however, the rounded figure is not to be inserted into the calculation sequence. See Appendix A for examples of shore tank and marine vessel tank calculations.

## 17 Calculation of Transferred Volumes From Small Lease Tanks

### 17.1 GENERAL

Lease tanks differ from storage tanks not only in size but in gauging procedure. Therefore, it is necessary to establish unique calculation procedures for lease tanks. This procedure is applicable to lease tanks of 5000 barrels and less and assumes that the clearance sample has verified merchantable oil at least 4 in. below the tank outlet. The *CTSh* is not significant to these situations and should not be applied.

## 17.2 TRANSFERRED VOLUME CALCULATION PROCEDURE FOR LEASE TANKS

The following are the procedures for calculating transferred volumes for lease tanks:

a. With the liquid level or gauge, enter the capacity table and record the *TOV* for the opening gauge.
b. Correct for the temperature of the oil. This is done by multiplying the answer from item a. by the *CTL*, arriving at the *GSV*, and rounding appropriately.
c. With the liquid level or gauge, enter the capacity table and record the *TOV* for the closing gauge.
d. Correct for the temperature of the product. This is done by multiplying the answer from item c. by the *CTL*, arriving at the *GSV*, and rounding appropriately.
e. Subtract the closing *GSV*(cl) from the opening *GSV*(op):

$$GSV = GSV(\text{cl}) - GSV(\text{op})$$

f. The last correction shall be to adjust for any measured amount of S&W. This is done by multiplying the *GSV* obtained from item e. by the *CSW* and rounding appropriately.

# APPENDIX A—EXAMPLES OF SHORE TANK AND MARINE VESSEL TANK CALCULATIONS

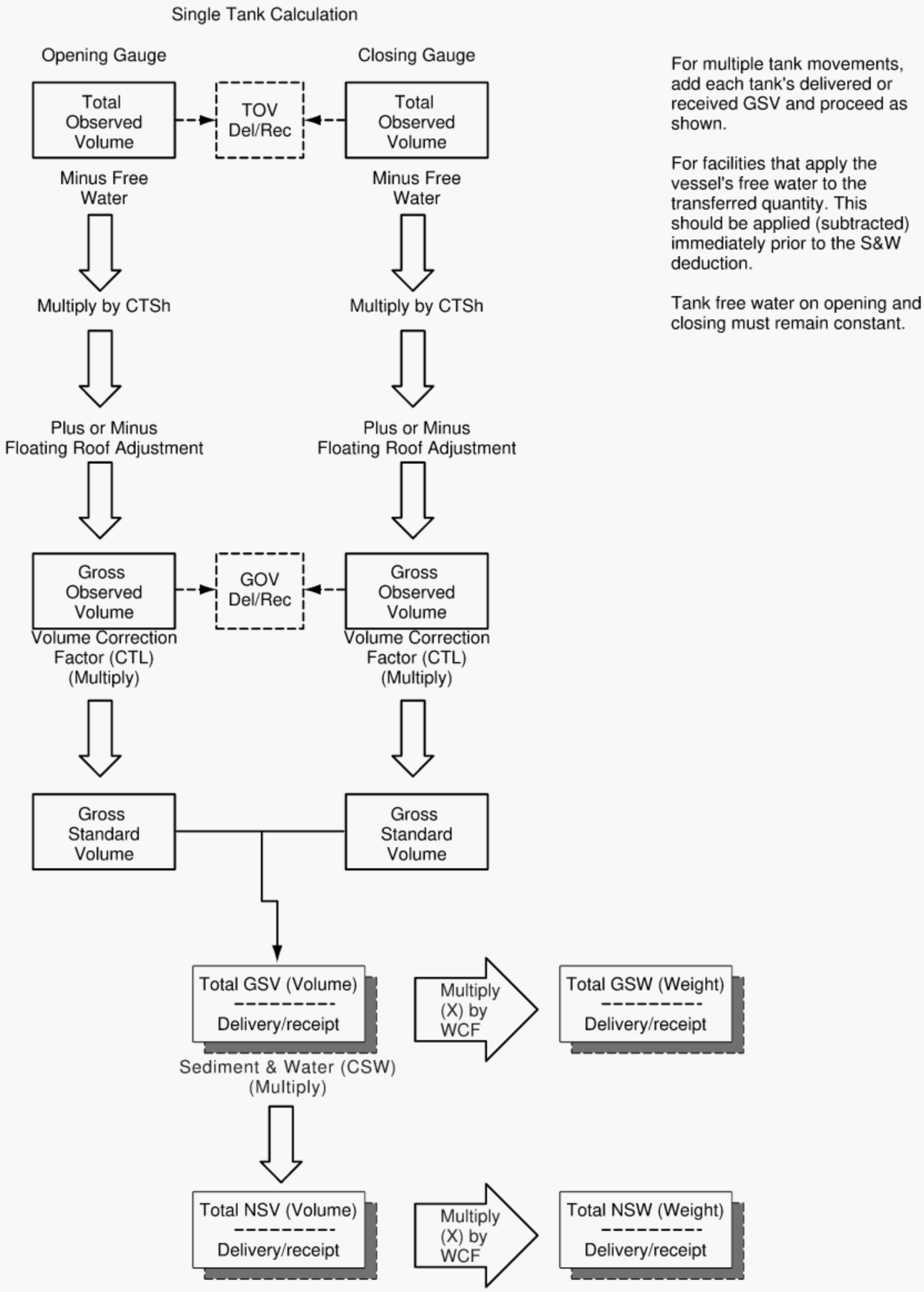



Figure A-1—Custody Transfer Flow Chart—Shore Tank(s) with Automatic Sampler

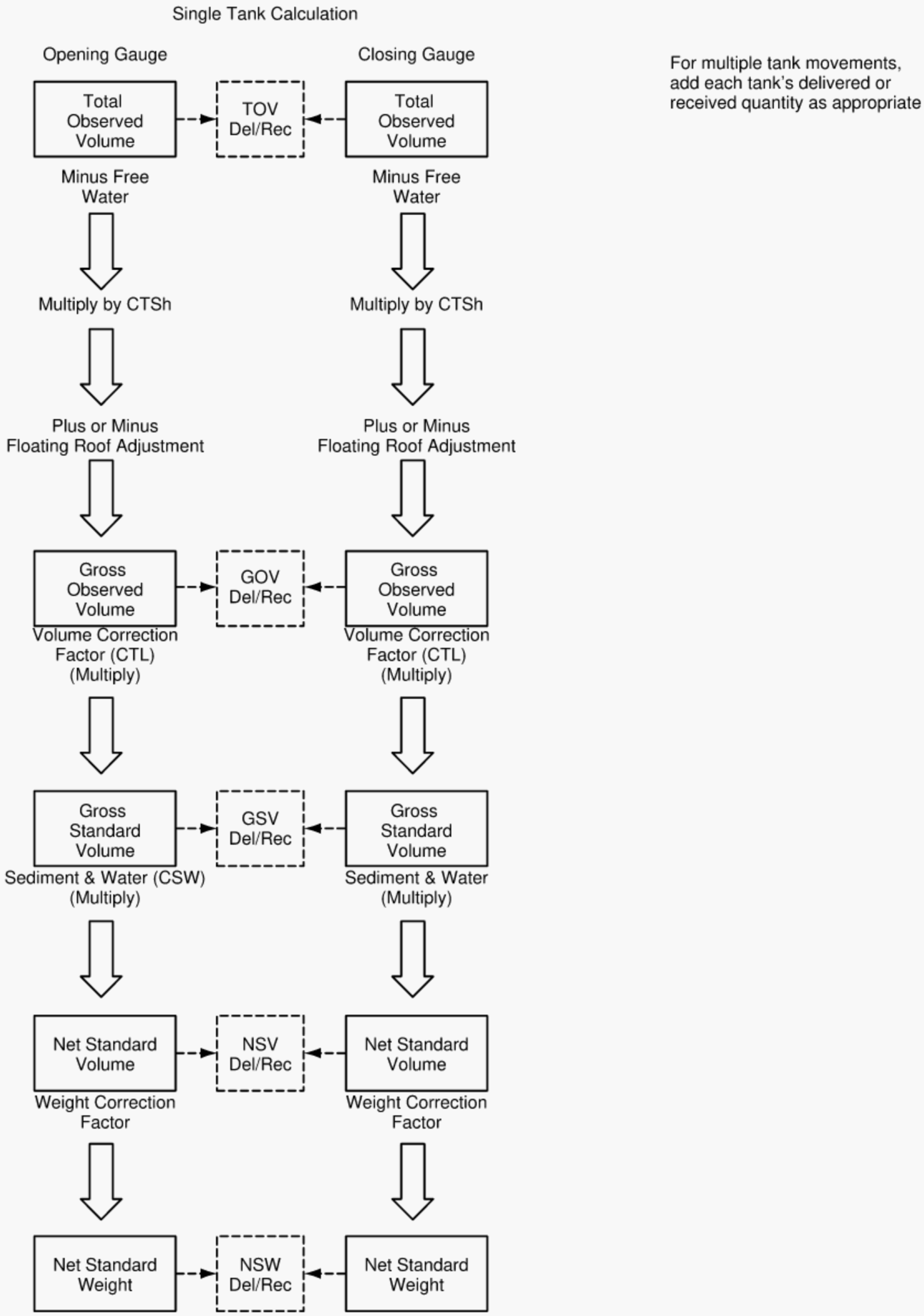



Figure A-2—Custody Transfer Flow Chart—Shore Tank(s) with Individual Tank Samples

## Table A-1—Example of a Shore Tank Calculation

| Analytical and Observed Data | | | | |
|---|---|---|---|---|
| Liquid level gauge[a] | N/A | | 46'06 1/4" | Observed data |
| Free water gauge | N/A | | 00'10 3/4" | Observed data |
| API gravity @ 60°F | N/A | 33.7 | | From analysis |
| Liquid temperature °F | N/A | 88.3 | | Observed data |
| Ambient temperature °F | N/A | 71.5 | | Observed data |
| Temperature of tank shell °F | *TSh* | 86.0 (rounded) | | By calculation |
| Sediment and water percent | N/A | 0.12% | | From analysis |
| Calculation | | | | |
| Calculated or Derived Data | Symbol | Reported Unit | | Running Calculation (Not Reported) |
| Total observed volume[a] | *TOV*[a] | | 435,218.32 | 435,218.32 |
| Free water | *FW* | | –154.37 | –154.37 |
| Gross observed volume[b] | *GOV*[b] | | 435,063.95 | 435,063.95 |
| Correction for temperature of shell | *CTSh* | 1.00032 | | |
| | | | 435,203.17 | 435,203.170464[c] |
| Floating roof adjustment | *FRA* | | +37.89 | +37.89 |
| | | | 435,241.06 | 435,241.060464[c] |
| Correction for temperature of Liquid (Table 6A) | *CTL* | 0.9868 | | |
| Gross standard volume | *GSV* | | 429,495.88 | 429,495.878465[c] |
| Correction for sediment and water[d] | *S&W* | 0.9988 | | |
| Net standard volume | *NSV* | | 428,980.48 | 428,980.48341[c] |
| Weight conversion factor (Table 11) | *WCF* | 0.13372 | | |
| Net standard weight (long tons) | *NSW* | | 57,363.270 | 57,363.2702415[c] |

Notes:

[a] Quantity from the tank capacity table using the liquid level gauge to enter the table. For this example, it is assumed that any correction to the gauge, due to expansion or contraction of the tape itself, has already been made. This issue is not addressed in this standard. The user should refer to the tape manufacturer's instructions for specific details.

[b] Gross observed volume, uncorrected for the temperature of the tank shell and floating roof adjustment.

[c] As displayed on a 12-digit calculator. Actual discrimination is determined by the calculating capacity of the calculation hardware.

[d] Refer to 12.2 to calculate the volumetric value for sediment and water.

## Table A-2—Examples of a Marine Vessel Tank Calculation

| Analytical and Observed Data | | | | |
|---|---|---|---|---|
| Liquid level gauge (ullage)[a] | | | 4'06 1/4" | Observed data |
| Free water gauge (ullage) | | | 55'10 3/4" | Observed data |
| API gravity @ 60°F | | 27.1 | | From analysis |
| Liquid temperature °F | | 91.1 | | Observed data |
| Sediment and water percent | | 0.17% | | From analysis |
| Forward draft | | | 36'06 | Observed data |
| After draft | | | 38'00 | Observed data |
| Trim | | (by the stern) | 1'06 | By calculation |
| List (vessel upright) | | | No list | Observed data |
| Calculation | | | | |
| Calculated or Derived Data | Symbol | Reported Unit | | Running Calculation (Not Reported) |
| Total observed volume[a] | *TOV*[a] | | 35,118.65 | 35,118.65 |
| Trim correction (volumetric)[b] | *Trim*[b] | | –135.72 | 34,982.93 |
| Total observed volume | *TOV* | | 34,982.93 | |
| Free water (by wedge) | *FW* | | –42.80 | 34,940.13 |
| Gross observed volume | *GOV* | | 34,940.13 | |
| Correction for temperature of liquid | | | | |
| | (Table 6A) | *CTL* | 0.9866 | |
| Gross standard volume | *GSV* | | 34,471.93 | 34,471.932258[c] |
| Correction for sediment and water[d] | *S&W* | 0.9983 | | |
| Net standard volume | *NSV* | | 34,413.33 | 34,413.3299731[c] |
| Weight conversion faction (Table 11) | *WCF* | 0.13930 | | |
| Net standard weight (long tons) | *NSW* | | 4,793.777 | 4,793.77686525 |

Notes:

[a] Quantity from the vessel's tank capacity table using the liquid level ullage gauge to enter the table.

[b] Not all trim (or list) corrections are volumetric. Many are linear adjustments that are made to the observed ullage. In this case, the adjustment would be made before entering the vessel's capacity table and a volumetric adjustment would not be necessary. If a volumetric list correction was applicable, it would be applied at this point in the calculation.

[c] As displayed on a 12-digit calculator. Actual discrimination is determined by the calculating capacity of the calculation hardware.

[d] The volumetric value for sediment and water is determined by subtracting the net standard volume from the gross standard volume.

# APPENDIX B—EXAMPLE OF SHELL TEMPERATURE CORRECTION FACTORS FOR EXPANSION AND CONTRACTION OF UPRIGHT CYLINDRICAL STEEL TANKS DUE TO TEMPERATURE

For mild steel tanks with a linear coefficient of expansion of 0.0000062/°, use Table B1. For temperatures outside the range of this table or for other coefficients of area expansion, use the formula in 9.1.3 .

This table is applicable to tanks whose capacity tables were calculated at a reference tank shell temperature of 60°F. For tanks with capacity tables calculated at a reference tank shell temperature other than 60°F, the table can still be used; however, it is necessary to subtract the reference temperature from the shell temperature and then add 60 to arrive at the temperature used to enter the table. It is important to pay attention to the algebraic signs (positive or negative) when performing this calculation.

## B.1 Shell Temperature Correction Factors for Expansion and Contraction of Upright Cylindrical Steel Tanks Due to Temperature

**B.1.1** Tanks undergo expansion or contraction due to variations in ambient and product temperatures. Such expansion or contraction in tank volume may be computed once the tank shell temperature is determined.

**B.1.2** For tanks that are insulated, the tank shell temperature (*TSh*) is assumed to be the same as the temperature of the product (*TL*) stored within the tank (that is, *TSh* = *Tl* ). For tanks that are not insulated, the shell temperature is a weighted average of the ambient and the product temperature based the following equation:

$$TSh = \frac{(7 \times Tl) + Ta}{8}$$

where

*Tl* = liquid product temperature

*Ta* = ambient air temperature

**B.1.3** Once the shell temperature is determined, the shell temperature correction factor (*CTSh*) is computed using the following equation:

$$CTSh = 1 + 2\alpha\Delta T + \alpha^2\Delta T^2$$

where

$\alpha$ = Linear coefficient of expansion of the tank shell material [see Table B2]

$\Delta T$ = Tank Shell Temperature (*TSh*) – Base Temperature (*Tb*)

## B.2 Application of Shell Temperature Correction

*Case 1*: Capacity table at base tank shell temperature of 60°F, of mild steel, non-insulated construction with a linear coefficient of expansion of 0.000062/°F.

—Volume at a given level (base tank shell temperature 60°F) = 100,000 bbls.

—Ambient Temperature = 70°F.

—Product Temperature = 155°F.

—Compute capacity table volume reflecting above conditions.

Solution:

a. Calculate shell temperature (*TSh*) at 155°F product temperature:

$$TSh = \frac{(7 \times Tl) + Ta}{8}$$

$$TSh = \frac{(7 \times 155) + 70}{8}$$

*TSh* = 144°F (rounded to nearest 1°F)

b. Compute $\Delta T$

$\Delta T$ = Tank Shell Temperature (*TSh*) – Base Temperature (*Tb*)

$\Delta T$ = 144 – 60

$\Delta T$ = 84

c. Compute the shell temperature correction factor (*CTSh*) for 144°F

$$CTSh = 1 + 2\alpha\Delta T + \alpha^2\Delta T^2$$

$\Delta T$ = Tank Shell Temperature (*TSh*) – Base Temperature (*Tb*)

$CTSh = 1 + (2 \times 0.0000062 \times \Delta T) + (0.0000062 \times 0.0000062 \times \Delta T \times \Delta T)$

$CTSh = 1 + (0.0000124 \times 84) + (0.00000000003844 \times 7056)$

$CTSh = 1 + 0.0010416 + .00000027123264$

$CTSh$ = 1.00104 (rounded to five decimal places)

d. Compute the correct volume:

$V$ = Volume at $TSh$ 60°F × $CTSh$ FOR 144°F

$V$ = 100,000 bbls × 1.00104

$V$ = 100,104 bbls.

*Case 2*: Capacity table already corrected for a tank shell temperature of 185°F, on a mild steel non-insulated tank [see note below].

—Volume at a given level (base tank shell temperature 185°F) = 100,000 bbls.

—Ambient Temperature = 70°F.

—Product Temperature = 155°F.

—Compute capacity table volume reflecting above conditions.

Solution:

a. Calculate shell temperature ($TSh$) at 155°F product temperature:

$TSh$ = 144°F (rounded to nearest 1°F)

b. Compute ΔT

ΔT = Tank Shell Temperature ($TSh$) – Base Temperature ($Tb$)

ΔT = 144 – 185

ΔT = –41

c. Compute the shell temperature correction factor ($CTSh$) for 144°F

$CTSh = 1 + 2a\Delta T + a^2\Delta T^2$

ΔT = Tank Shell Temperature ($TSh$) – Base Temperature ($Tb$)

$CTSh = 1 + (2 \times 0.0000062 \times \Delta T) + (0.0000062 \times 0.0000062 \times \Delta T \times \Delta T)$

$CTSh = 1 + (0.0000124 \times -41) + (0.00000000003844 \times 1681)$

$CTSh = 1 - 0.0005084 + .00000006461764$

$CTSh$ = 0.99949 (rounded to five decimal places)

d. Compute the correct volume:

$V$ = Volume at $TSh$ 185°F × $CTSh$ FOR 144°F

$V$ = 100,000 bbls × 0.99949

$V$ = 99,949 bbls.

Note: For tanks that specify a product operating temperature, it will be necessary to obtain the actual base tank shell temperature that was used to compute the capacity table volumes. If the tank is insulated, it can be assumed that the base tank shell temperature is the same as the product operating temperature. If the tank is not insulated, the user should contact the company that generated the capacity table to determine what base tank shell temperature was used.

## Table B-1—Correction Factors for Effect of Temperature on the Tank Shell

For mild steel tanks with a linear coefficient of expansion of 0.0000062/°F, whose capacity tables were calculated at a base tank shell temperature ($T_b$) of 60°F. For temperatures outside the range of this table use the formula in 9.1.3.1.

| Shell Temp (°F) | Shell Correction Factor | Shell Temp (°F) | Shell Correction Factor | Shell Temp (°F) | Shell Correction Factor | Shell Temp (°F) | Shell Correction Factor | Shell Temp (°F) | Shell Correction Factor | Shell Temp (°F) | Shell Correction Factor | Shell Temp (°F) | Shell Correction Factor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.99926 | 45 | 0.99981 | 90 | 1.00037 | 135 | 1.00093 | 180 | 1.00149 | 225 | 1.00205 | 270 | 1.00261 |
| 1 | 0.99927 | 46 | 0.99983 | 91 | 1.00038 | 136 | 1.00094 | 181 | 1.00150 | 226 | 1.00206 | 271 | 1.00262 |
| 2 | 0.99928 | 47 | 0.99984 | 92 | 1.00040 | 137 | 1.00096 | 182 | 1.00151 | 227 | 1.00207 | 272 | 1.00263 |
| 3 | 0.99929 | 48 | 0.99985 | 93 | 1.00041 | 138 | 1.00097 | 183 | 1.00153 | 228 | 1.00208 | 273 | 1.00264 |
| 4 | 0.99931 | 49 | 0.99986 | 94 | 1.00042 | 139 | 1.00098 | 184 | 1.00154 | 229 | 1.00210 | 274 | 1.00266 |
| 5 | 0.99932 | 50 | 0.99988 | 95 | 1.00043 | 140 | 1.00099 | 185 | 1.00155 | 230 | 1.00211 | 275 | 1.00267 |
| 6 | 0.99933 | 51 | 0.99989 | 96 | 1.00045 | 141 | 1.00100 | 186 | 1.00156 | 231 | 1.00212 | 276 | 1.00268 |
| 7 | 0.99934 | 52 | 0.99990 | 97 | 1.00046 | 142 | 1.00102 | 187 | 1.00158 | 232 | 1.00213 | 277 | 1.00269 |
| 8 | 0.99936 | 53 | 0.99991 | 98 | 1.00047 | 143 | 1.00103 | 188 | 1.00159 | 233 | 1.00215 | 278 | 1.00271 |
| 9 | 0.99937 | 54 | 0.99993 | 99 | 1.00048 | 144 | 1.00104 | 189 | 1.00160 | 234 | 1.00216 | 279 | 1.00272 |
| 10 | 0.99938 | 55 | 0.99994 | 100 | 1.00050 | 145 | 1.00105 | 190 | 1.00161 | 235 | 1.00217 | 280 | 1.00273 |
| 11 | 0.99939 | 56 | 0.99995 | 101 | 1.00051 | 146 | 1.00107 | 191 | 1.00163 | 236 | 1.00218 | 281 | 1.00274 |
| 12 | 0.99940 | 57 | 0.99996 | 102 | 1.00052 | 147 | 1.00108 | 192 | 1.00164 | 237 | 1.00220 | 282 | 1.00275 |
| 13 | 0.99942 | 58 | 0.99998 | 103 | 1.00053 | 148 | 1.00109 | 193 | 1.00165 | 238 | 1.00221 | 283 | 1.00277 |
| 14 | 0.99943 | 59 | 0.99999 | 104 | 1.00055 | 149 | 1.00110 | 194 | 1.00166 | 239 | 1.00222 | 284 | 1.00278 |
| 15 | 0.99944 | 60 | 1.00000 | 105 | 1.00056 | 150 | 1.00112 | 195 | 1.00167 | 240 | 1.00223 | 285 | 1.00279 |
| 16 | 0.99945 | 61 | 1.00001 | 106 | 1.00057 | 151 | 1.00113 | 196 | 1.00169 | 241 | 1.00225 | 286 | 1.00280 |
| 17 | 0.99947 | 62 | 1.00002 | 107 | 1.00058 | 152 | 1.00114 | 197 | 1.00170 | 242 | 1.00226 | 287 | 1.00282 |
| 18 | 0.99948 | 63 | 1.00004 | 108 | 1.00060 | 153 | 1.00115 | 198 | 1.00171 | 243 | 1.00227 | 288 | 1.00283 |
| 19 | 0.99949 | 64 | 1.00005 | 109 | 1.00061 | 154 | 1.00117 | 199 | 1.00172 | 244 | 1.00228 | 289 | 1.00284 |
| 20 | 0.99950 | 65 | 1.00006 | 110 | 1.00062 | 155 | 1.00118 | 200 | 1.00174 | 245 | 1.00230 | 290 | 1.00285 |
| 21 | 0.99952 | 66 | 1.00007 | 111 | 1.00063 | 156 | 1.00119 | 201 | 1.00175 | 246 | 1.00231 | 291 | 1.00287 |
| 22 | 0.99953 | 67 | 1.00009 | 112 | 1.00064 | 157 | 1.00120 | 202 | 1.00176 | 247 | 1.00232 | 292 | 1.00288 |
| 23 | 0.99954 | 68 | 1.00010 | 113 | 1.00066 | 158 | 1.00122 | 203 | 1.00177 | 248 | 1.00233 | 293 | 1.00289 |
| 24 | 0.99955 | 69 | 1.00011 | 114 | 1.00067 | 159 | 1.00123 | 204 | 1.00179 | 249 | 1.00234 | 294 | 1.00290 |
| 25 | 0.99957 | 70 | 1.00012 | 115 | 1.00068 | 160 | 1.00124 | 205 | 1.00180 | 250 | 1.00236 | 295 | 1.00292 |
| 26 | 0.99958 | 71 | 1.00014 | 116 | 1.00069 | 161 | 1.00125 | 206 | 1.00181 | 251 | 1.00237 | 296 | 1.00293 |
| 27 | 0.99959 | 72 | 1.00015 | 117 | 1.00071 | 162 | 1.00127 | 207 | 1.00182 | 252 | 1.00238 | 297 | 1.00294 |
| 28 | 0.99960 | 73 | 1.00016 | 118 | 1.00072 | 163 | 1.00128 | 208 | 1.00184 | 253 | 1.00239 | 298 | 1.00295 |
| 29 | 0.99962 | 74 | 1.00017 | 119 | 1.00073 | 164 | 1.00129 | 209 | 1.00185 | 254 | 1.00241 | 299 | 1.00297 |
| 30 | 0.99963 | 75 | 1.00019 | 120 | 1.00074 | 165 | 1.00130 | 210 | 1.00186 | 255 | 1.00242 | 300 | 1.00298 |
| 31 | 0.99964 | 76 | 1.00020 | 121 | 1.00076 | 166 | 1.00131 | 211 | 1.00187 | 256 | 1.00243 | 301 | 1.00299 |
| 32 | 0.99965 | 77 | 1.00021 | 122 | 1.00077 | 167 | 1.00133 | 212 | 1.00189 | 257 | 1.00244 | 302 | 1.00300 |
| 33 | 0.99967 | 78 | 1.00022 | 123 | 1.00078 | 168 | 1.00134 | 213 | 1.00190 | 258 | 1.00246 | 303 | 1.00302 |
| 34 | 0.99968 | 79 | 1.00024 | 124 | 1.00079 | 169 | 1.00135 | 214 | 1.00191 | 259 | 1.00247 | 304 | 1.00303 |
| 35 | 0.99969 | 80 | 1.00025 | 125 | 1.00081 | 170 | 1.00136 | 215 | 1.00192 | 260 | 1.00248 | 305 | 1.00304 |
| 36 | 0.99970 | 81 | 1.00026 | 126 | 1.00082 | 171 | 1.00138 | 216 | 1.00194 | 261 | 1.00249 | 306 | 1.00305 |
| 37 | 0.99971 | 82 | 1.00027 | 127 | 1.00083 | 172 | 1.00139 | 217 | 1.00195 | 262 | 1.00251 | 307 | 1.00307 |
| 38 | 0.99973 | 83 | 1.00029 | 128 | 1.00084 | 173 | 1.00140 | 218 | 1.00196 | 263 | 1.00252 | 308 | 1.00308 |
| 39 | 0.99974 | 84 | 1.00030 | 129 | 1.00086 | 174 | 1.00141 | 219 | 1.00197 | 264 | 1.00253 | 309 | 1.00309 |
| 40 | 0.99975 | 85 | 1.00031 | 130 | 1.00087 | 175 | 1.00143 | 220 | 1.00198 | 265 | 1.00254 | 310 | 1.00310 |
| 41 | 0.99976 | 86 | 1.00032 | 131 | 1.00088 | 176 | 1.00144 | 221 | 1.00200 | 266 | 1.00256 | 311 | 1.00311 |
| 42 | 0.99978 | 87 | 1.00033 | 132 | 1.00089 | 177 | 1.00145 | 222 | 1.00201 | 267 | 1.00257 | 312 | 1.00313 |
| 43 | 0.99979 | 88 | 1.00035 | 133 | 1.00091 | 178 | 1.00146 | 223 | 1.00202 | 268 | 1.00258 | 313 | 1.00314 |
| 44 | 0.99980 | 89 | 1.00036 | 134 | 1.00092 | 179 | 1.00148 | 224 | 1.00203 | 269 | 1.00259 | 314 | 1.00315 |

## American Petroleum Institute — Related Publications Order Form - 2001

Available through Global Engineering Documents — Effective August 1, 2001

**Phone Orders: 1-800-854-7179** (Toll-free in the U.S. and Canada) • **303-397-7956** (Local and International) • **Fax Orders: 303-397-2740**

**Online Orders: www.global.ihs.com**

**Date:** ________________ ❑ **API Member** *(Check if Yes)*

**Invoice To** (❑ Check here if same as "Ship To")

Name:

Title:

Company:

Department:

Address:

City: State/Province:

Zip/Postal Code: Country:

Telephone:

Fax:

E-Mail:

**Ship To** (UPS will not deliver to a P.O. Box)

Name:

Title:

Company:

Department:

Address:

City: State/Province:

Zip/Postal Code: Country:

Telephone:

Fax:

E-Mail:

| Quantity | Product Number | Title | SO★ | Unit Price | Total |
|---|---|---|---|---|---|
| | H30302 | MPMS 12.2, *Calculation of Petroleum Quantities Measured by Turbine or Displacement Meters* | | $ 61.00 | |
| | H12021 | MPMS 12.2.1, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volume Correction Factors—Part 1—Introduction* | | $ 72.00 | |
| | H12022 | MPMS 12.2.2, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors—Part 2—Measurement Tickets* | | $ 66.00 | |
| | H12023 | MPMS 12.2.3, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors—Part 3—Proving Reports* | | $ 83.00 | |
| | H12024 | MPMS 12.2.4, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods—Part 4—Calculation of Base Prover Volumes by Waterdraw Method* | | $ 83.00 | |
| | H12031 | MPMS 12.3, *Calculation of Volumetric Shrinkage from Blending Light Hydrocarbons with Crude Oil* | | $ 61.00 | |
| | H17014 | MPMS 17.1, *Guidelines for Marine Cargo Measurement* | | $ 94.00 | |
| | H17022 | MPMS 17.2, *Measurement of Cargoes on Board Tank Vessels* | | $ 94.00 | |

❑ **Payment Enclosed** ❑ **P.O. No.** (Enclose Copy)

❑ **Charge My Global Account No.**

❑ **VISA** ❑ **MasterCard** ❑ **American Express** ❑ **Diners Club** ❑ **Discover**

Credit Card No.:

Print Name (As It Appears on Card):

Expiration Date:

Signature:

**Subtotal**

**Applicable Sales Tax** *(see below)*

**Rush Shipping Fee** *(see below)*

**Shipping and Handling** *(see below)*

**Total** *(in U.S. Dollars)*

★ ***To be placed on Standing Order for future editions of this publication, place a check mark in the SO column and sign here:***

***Pricing and availability subject to change without notice.***

**Mail Orders** – Payment by check or money order in U.S. dollars is required except for established accounts. State and local taxes, $10 processing fee*, and 5% shipping must be added. Send mail orders to: **API Publications, Global Engineering Documents, 15 Inverness Way East, M/S C303B, Englewood, CO 80112-5776, USA.**

**Purchase Orders** – Purchase orders are accepted from established accounts. Invoice will include actual freight cost, a $10 processing fee*, plus state and local taxes.

**Telephone Orders** – If ordering by telephone, a $10 processing fee* and actual freight costs will be added to the order.

**Sales Tax** – All U.S. purchases must include applicable state and local sales tax. Customers claiming tax-exempt status must provide Global with a copy of their exemption certificate.

**Shipping (U.S. Orders)** – Orders shipped within the U.S. are sent via traceable means. Most orders are shipped the same day. Subscription updates are sent by First-Class Mail. Other options, including next-day service, air service, and fax transmission are available at additional cost. Call 1-800-854-7179 for more information.

**Shipping (International Orders)** – Standard international shipping is by air express courier service. Subscription updates are sent by World Mail. Normal delivery is 3-4 days from shipping date.

**Rush Shipping Fee** – Next Day Delivery orders charge is $20 in addition to the carrier charges. Next Day Delivery orders must be placed by 2:00 p.m. MST to ensure overnight delivery.

**Returns** – All returns must be pre-approved by calling Global's Customer Service Department at 1-800-624-3974 for information and assistance. There may be a 15% restocking fee. Special order items, electronic documents, and age-dated materials are non-returnable.

***Minimum Order** – There is a $50 minimum for all orders containing hardcopy documents. The $50 minimum applies to the order subtotal including the $10 processing fee, excluding any applicable taxes and freight charges. If the total cost of the documents on the order plus the $10 processing fee is less than $50, the processing fee will be increased to bring the order amount up to the $50 minimum. This processing fee will be applied before any applicable deposit account, quantity or member discounts have been applied. There is no minimum for orders containing only electronically delivered documents.

# There's more where this came from.

The American Petroleum Institute provides additional resources and programs to the oil and natural gas industry which are based on API Standards. For more information, contact:

| | | |
|---|---|---|
| • Monogram Licensing Program | Phone:<br>Fax: | 202-962-4791<br>202-682-8070 |
| • American Petroleum Institute Quality Registrar (APIQR) | Phone:<br>Fax: | 202-962-4791<br>202-682-8070 |
| • API Spec Q1 Registration | Phone:<br>Fax: | 202-962-4791<br>202-682-8070 |
| • Perforator System Registration | Phone:<br>Fax: | 202-962-4791<br>202-682-8070 |
| • Inspector Certification Programs | Phone:<br>Fax: | 202-682-8161<br>202-962-4739 |
| • Engine Oil Licensing and Certification System (EOLCS) | Phone:<br>Fax: | 202-682-8233<br>202-962-4739 |
| • Training/Workshops | Phone:<br>Fax: | 202-682-8490<br>202-962-4797 |

Check out the API Publications, Programs, and Services Catalog online at www.api.org/cat.

Additional copies are available through Global Engineering Documents at (800) 854-7179 or (303) 397-7956

Information about API Publications, Programs and Services is available on the World Wide Web at: http://www.api.org

American
Petroleum
Institute

1220 L Street, Northwest
Washington, D.C. 20005-4070
202-682-8000

Product No. H12112