API Manual of Petroleum Measurement Standards
Chapter 17.5

EI Hydrocarbon Management HM 64

Guidelines for Cargo Analysis and Reconciliation of Cargo Quantities

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Introduction

The shipment of petroleum or petroleum products by marine vessels may result in a difference between the load port (Bill of Lading) and discharge port (Outturn) quantities. This difference, gain or loss, will be caused by one or more of the following:

a. **Physical Loss/Gain** is an actual loss or gain of cargo (sometimes referred to as "Real Loss or Gain").

   Physical losses can be the result of evaporation, unmeasured ROB, line fill, volumetric shrinkage, cargo diversion, spillage or theft.

   Evaporative loss may occur during load/discharge operations and during transit. Daily temperature variations and movement of the cargo during the voyage (sloshing) will increase evaporative losses. Cargos with higher vapour pressure are likely to suffer greater evaporative losses.

   The ROB (quantity remaining on board) is the liquid and non-liquid cargo left on board the vessel after discharge. The ROB measurement can only include the cargo which is on the tank floor. That cargo which remains as clingage on the tank sides or other internal structure is not included in the ROB measurement and will result in a real loss when the outturn is considered. The amount of clingage will be dependent upon cargo viscosity and temperature.

   Line fill losses result from transfer lines which contain more cargo after the movement than before, leading to reduced quantities being measured in the receiving tanks. This can occur during loading or discharge.

   Volumetric shrinkage may occur when two or more hydrocarbons with different densities are mixed. The combined volume will be less than the sum of the components. This shrinkage results from the smaller molecules of the light material filling the voids between the heavier molecules.

   Cargo diversion can occur inadvertently as a result of incorrectly set or leaking valves, or intentionally as theft.

   While physical gains are not common, some cargos with the ability to absorb water or to blend with other components or additives may show physical gain. In addition, gains may be caused by physical operations and equipment errors or failures such as cargo diversion, Crude Oil Washing (COW) recovering clingage from previous cargo, etc.

b. **Apparent Loss/Gain** is a difference in quantity which is not related to a physical loss. Apparent losses include errors which can possibly be corrected and also differences due to uncertainties in the measurement systems which generally cannot be removed. The majority of individual losses and gains are apparent rather than real and fall into the following categories.

   Measurement error includes all the errors associated with measurement procedures, equipment and operator performance. These errors can be in liquid level or meter measurements, determining temperature, sampling, tank calibration, and laboratory testing methods.

   Procedural error occurs when operations deviate from the industry measurement standards and good practice. An example would be the failure to ensure pipeline fullness at the start of the cargo transfer.

   Calibration error relates to accuracy (calibration) of the measurement equipment. Only the base international standards are deemed to be exact. The possibility of introducing a fixed error or bias increases with every step in the calibration chain, moving from the base standard to the field device. Random error or uncertainty increases with each step.
Further, all measuring equipment is affected by use and handling, so regular field checks and calibrations are necessary to ensure that equipment continues to provide accurate measurements.

Paper Loss/Gain is a term frequently used to include all Apparent Losses/Gains. It is the result of calculation errors which may occur when converting basic measurement data into cargo quantities. Computer programmes and calculators have reduced the risk of mathematical errors but the cargo calculations should always be checked when a large discrepancy occurs.

1 Scope

This standard covers guidelines for the reconciliation of marine cargo quantities. These guidelines are intended to provide a basis for analyzing and reconciling the quantity differences (gains/losses) resulting from marine custody transfer movement(s) of petroleum and petroleum product cargoes. As such, the guidelines are complementary to, but do not replace, normal inspection procedures.

2 Referenced Publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

The following documents may be referenced to supplement the information presented in this chapter:

2.1 API/EI Joint Documents

API MPMS 12.1/EI HM1 Part 1 Calculation of Static Petroleum Quantities - Upright Cylindrical Tanks and Marine Vessels

API MPMS 17.6/EI HM66 “Guidelines for Determining the Fullness of Pipelines between Vessels and Shore Tanks”

API MPMS 17.9/EI HM49 “Vessel Experience Factor”

API MPMS 17.11/EI HM52 “Measurement and Sampling of Cargoes On Board Tank Vessels Using Closed/Restricted Equipment”

API MPMS 17.12/EI HM51 “Procedures for Bulk Liquid Chemical Cargo Inspection by Cargo Inspectors”

API MPMS 19.5/EI HM65 “Atmospheric Hydrocarbon Emissions from Marine Vessel Transfer Operations” was Pub 2514A

2.2 API Documents

Manual of Petroleum Measurement Standards

Chapter 1, “Vocabulary”

Chapter 3, “Tank Gauging” (Applicable Sub-Chapters)

Chapter 4, “Proving Systems” (Applicable Sub-Chapters)

Chapter 5, “Metering Suite”

Chapter 6, “Metering Systems” (Applicable Sub-Chapters)
Chapter 7, “Temperature Determination”

Chapter 8, “Sampling” (Applicable Sub-Chapters)

Chapter 9, “Density Determination” (Applicable Sub-Chapters)

Chapter 10, “Sediment and Water” (Applicable Sub-Chapters)

Chapter 11.1, “Volume Correction Factors”

Chapter 12, “Calculation of Petroleum Quantities” (Applicable Sub-Chapters)

Chapter 17.1, “Guidelines for Marine Cargo Inspection”

Chapter 17.2, “Measurement of Cargoes on Board Tank Vessels”

Chapter 17.3, “Guidelines for Identification of the Source of Free Waters Associated with Marine Petroleum Cargo Movements”

Chapter 17.4, “Method for Quantification of Small Volumes on Marine Vessels (OBO/ROB)”

Chapter 17.8, “Marine Measurement—Guidelines for Pre-Loading Inspection of Marine Vessel Cargo Tank”

2.3 EI Documents

HM28, Procedures for oil cargo measurements by cargo surveyors. Section 1: Crude oil

HM29, Procedures for petroleum product cargo measurements by cargo inspectors

HM68, Procedures for Bulk Liquid Fatty Acid Esters and Bio Diesel Cargo Inspections

HM40, Guidelines for the crude oil washing of ships’ tanks and the heating of crude oil being transported by sea

HM50, Guidelines for the cleaning of tanks and lines for marine tank vessels carrying petroleum and refined products

IP200, Guidelines for the use of the Petroleum Measurement Tables

2.4 Other Documents

Marpol 73/78 The International Convention for the Prevention of Pollution from Ships

ISO 91-1:1992, Petroleum measurement tables -- Part 1: Tables based on reference temperatures of 15 degrees C and 60 degrees F.


ISO 3170, Petroleum liquids – Manual sampling

ISO 3171, Petroleum liquids – Automatic pipeline sampling
3 Definitions

3.1 apparent loss
A difference in quantity which is not related to a physical loss.

3.2 complex voyage
A shipment of one or more grades of cargo at one or more load and/or discharge ports. (i.e. Anything other than a simple voyage)

3.3 physical loss or gain
An actual loss/gain of cargo (sometimes referred to as “Real Loss/Gain”).

3.4 simple voyage
A single grade cargo movement from one load port to one discharge port.

3.5 theoretical differences
The theoretical shore quantity is the vessel quantity adjusted by the VEF at either the load or the discharge port. The theoretical shore quantity minus the actual measured shore quantity is the theoretical difference.

3.6 theoretical discharge Port shore volume
The vessel delivered volume (TCV – ROB) divided by the vessel’s experience factor (VEF).

3.7 theoretical load port shore volume
The vessel received volume (TCV – OBQ) divided by vessel’s experience factor (VEF).

3.8 vessel experience factor for discharge
VEFD
Calculated in accordance with API Ch 17.9/EI HM49.

3.9 vessel experience factor for load
VEFL
Calculated in accordance with API Ch 17.9/EI HM49.

3.10 vessel-to-vessel transfer
The movement of cargo from one vessel to one or more other vessels.

3.11 volume correction factor
VCF
The ratio of the density of a liquid at a given temperature to its density at reference temperature (normally
60°F). Multiplying a liquid’s measured volume by this value gives its volume at reference temperature (Gross Standard Volume). Also known as CTL (correction, temperature, liquid).

3.12 **voyage analysis report**
**VAR**
A report allowing for consistent organization and calculation of basic marine cargo data.

3.13 **voyage summary and reconciliation report**
**VSRR**
A report allowing for consistent summarizing of the various components affecting gains/losses of marine cargo transfers.

4 **Cargo Reconciliation**

If a marine petroleum shipment results in an unusual gain or loss a detailed cargo reconciliation is made to determine, and if possible, to identify the reason(s) for volume differences. The full reconciliation process may be complex and should only be performed when circumstances warrant or when it is specifically requested.

The primary steps for marine cargo reconciliation are:

a. collecting data;
b. completing the Voyage Analysis Report (VAR); and, when required
c. completing a Voyage Summary and Reconciliation Report (VSRR);
d. investigating the reason(s) for the loss or gain;
e. taking action where appropriate.

4.1 **Collecting Information and Data**

This first step consists of gathering all relevant vessel and shore measurement data for analysis and reconciliation. This will include the official custody transfer data together with reports from the independent inspection companies which are usually the main source for measurement and volumetric calculation data.

Typical marine transfer inspection reports are; shore gauging, metering, vessel gauging, time log, line fill verification, laboratory analysis, and Vessel Experience Factor (VEF). (See relevant API MPMS Ch. 17.1 and MPMS Ch. 17.2 for a complete list of information that should be included in inspection reports.)

Important information may need to be collected from other sources. This may include weather, sea conditions, and cargo stowage changes during the voyage that may impact accurate measurement.

4.2 **The Voyage Analysis Report (VAR)**

The VAR provides a useful format for the organization of basic cargo data and also provides calculations recommended in this procedure. Any shore-to-shore variances are broken down according to Total Calculated Volume (TCV), Free Water (FW), Gross Standard Volumes (GSV), Sediment and Water (S&W), and Net Standard Volumes (NSV) during each stage of the voyage.
A blank example of the VAR form is provided in Annex A. (Examples of completed VARs can be found in Appendix B.) It is recognized that other forms may be used for this purpose.

Note: If more than one port or cargo is involved, complete a separate VAR form for each parcel, for each movement, and for the total shore/vessel figures (including slops and all previously loaded parcels).

There are three types of VAR.

1. A simple voyage VAR is a single grade cargo movement from one load port to one discharge port.
2. A complex voyage VAR involves the shipment of one or more grades of cargo at one or more load or discharge ports.
3. Vessel-to-vessel Transfer VAR involves the movement of cargo from one vessel to one or more other vessels.

The VAR is divided into six sections.

1. Header—General Information (vessel and cargo identification, VCF tables used, etc.).
2. Section I—Comparison of Shore Quantities in Custody Transfer (Load vs. Discharge Port).
3. Section II—Vessel/Shore Quantities at Load Port(s).
4. Section III—Vessel/Shore Quantities at Discharge Port(s).
5. Section IV—Vessel’s Comparison of Loading and Discharge Port(s).
6. Footer—Comments and Signatures.

4.2.1 Header General Information

The header section of the VAR includes identifying information such as vessel name and related vessel information, cargo description and quantity units, port names and dates, and the source of Volume Correction Factors (VCFs) used to calculate quantities.

Compare the VCF sources used, and, if they are not the same, recalculate volumes using the discharge port VCF throughout.

4.2.2 Section I—Comparison of Shore Quantities in Custody Transfer

Section 1 of the VAR records the loaded cargo quantity (Bill of Lading) and the discharged quantity (Outturn).

Compare the reported Outturn quantities from the discharge port(s) with the reported Bill of Lading (B/L) quantities from the load port(s). Also compare the B/L API gravity or density against the Outturn API gravity or density.

Any volume difference is referred to as the shore-to-shore gain or loss for the shipment and is used as the primary indicator of whether a more in-depth analysis is required. The user’s gain or loss experience with a particular cargo and/or trade route may determine if the particular shipment gain or loss is considered to be acceptable or excessive. A summary of the calculations for these shore-to-shore comparisons is shown in Table 1.
Table 1—B/L to Outturn Comparison

<table>
<thead>
<tr>
<th>TCV</th>
<th>Outturn TCV</th>
<th>Outturn FW</th>
<th>Outturn GSV</th>
<th>Outturn S &amp; W</th>
<th>Outturn NSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B/L TCV</td>
<td>Outturn TCV</td>
<td>Outturn FW</td>
<td>Outturn GSV</td>
<td>Outturn S &amp; W</td>
<td>Outturn NSV</td>
</tr>
<tr>
<td>TCV Difference</td>
<td>FW Difference</td>
<td>GSV Difference</td>
<td>S &amp; W Difference</td>
<td>NSV Difference</td>
<td></td>
</tr>
</tbody>
</table>

Note: Differences should be noted in both volumes and percentages.

4.2.3 Section II—Vessel/Shore Quantities at Load Port(s)

Section II records the vessel and shore quantities at the load port. This section will show any difference between vessel and shore quantities at the load port and will also allow the calculation of a theoretical load port shore volume, if needed.

Compare these values by subtracting the Bill of Lading quantities from the corresponding vessel quantities to obtain the difference in each as shown in Table 2. For this comparison, the vessel loaded volume is the volume gauged (TCV) on board after loading minus any OBQ measured on board before loading.

Table 2—Shore to Vessel Comparison—Load Port(s)

<table>
<thead>
<tr>
<th>TCV</th>
<th>FW</th>
<th>GSV</th>
<th>TCV: VEF Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Loaded TCV</td>
<td>Vessel Loaded FW</td>
<td>Vessel Loaded GSV</td>
<td>Theoretical Shore TCV</td>
</tr>
<tr>
<td>B/L TCV</td>
<td>B/L FW</td>
<td>B/L GSV</td>
<td>B/L TCV</td>
</tr>
<tr>
<td>TCV Difference</td>
<td>FW Difference</td>
<td>GSV Difference</td>
<td>Theoretical Shore TCV Diff.</td>
</tr>
</tbody>
</table>

Note: Differences should be recorded on the VAR form in volumes and percentages. It should be recognized that a total water comparison (FW + S & W) may be necessary to validate the FW difference. (See 6.1.2 and 6.1.3 of this document.)

4.2.4 Section III—Vessel/Shore Quantities at Discharge Port(s)

Section III records vessel and shore quantities at the discharge port. This section will show any difference between vessel and shore quantities at the discharge port and will also allow the calculation of a theoretical discharge port shore volume if needed.

Compare these values by subtracting the Outturn quantities from the corresponding vessel quantities to obtain the difference in each as shown in Table 3. For this comparison, the vessel discharge volume is the volume gauged (TCV) on board before discharge minus any ROB measured on board after discharge.

Table 3—Vessel to Shore Comparison—Discharge Port(s)

<table>
<thead>
<tr>
<th>TCV</th>
<th>FW</th>
<th>GSV</th>
<th>TCV: VEF Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Discharged TCV</td>
<td>Vessel Discharged FW</td>
<td>Vessel Discharged GSV</td>
<td>Theoretical Outturn TCV</td>
</tr>
<tr>
<td>B/L TCV</td>
<td>B/L FW</td>
<td>B/L GSV</td>
<td>B/L TCV</td>
</tr>
<tr>
<td>TCV Difference</td>
<td>FW Difference</td>
<td>GSV Difference</td>
<td>Theoretical Shore TCV Diff.</td>
</tr>
</tbody>
</table>

Note: Differences should be recorded on the VAR form in volumes and percentages. It should be recognized that a total water comparison (FW + S & W) may be necessary to validate the FW difference. (See 6.1.2 and 6.1.3 of this document.)

4.2.5 Section IV—Comparison of Vessel Quantities at Load and Discharge Port(s)

Section IV records the reported vessel’s volume on departure and on arrival at the discharge port and will show any change in cargo volume during transit.
Calculate the vessel’s transit quantity difference by subtracting vessel volumes at sailing port from arrival port volumes. Compare quantities as shown in Table 4 for each parcel and for the total vessel.

<table>
<thead>
<tr>
<th>TCV</th>
<th>FW</th>
<th>GSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Arrival TCV</td>
<td>Vessel Arrival FW</td>
<td>Vessel Arrival GSV</td>
</tr>
<tr>
<td>Vessel Sailing TCV</td>
<td>Vessel Sailing FW</td>
<td>Vessel Sailing GSV</td>
</tr>
<tr>
<td>TCV Difference</td>
<td>FW Difference</td>
<td>GSV Difference</td>
</tr>
</tbody>
</table>

Note: Differences should be noted in volumes and percentages. For this comparison, no adjustments are to be made to vessel volumes for OBQ or ROB.

Calculate the OBQ and ROB difference, including totally segregated slops if applicable, by subtracting the components of the ROB from the components of the OBQ as shown in Table 5.

<table>
<thead>
<tr>
<th>Total OBQ (Liquid + Non-liquid)</th>
<th>Total ROB (Liquid + Non-liquid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW + GSV</td>
<td>FW + GSV</td>
</tr>
</tbody>
</table>

4.2.6 Footer: Comments and Preparer’s Identification

In the footer, summarize any appropriate comments that pertain to the movement, especially Letters of Protest (LOP) or Notices of Apparent Discrepancy (NOAD). Enter the name, title, and company of the person preparing the VAR, and the date of preparation.

4.3 The Voyage Summary and Reconciliation Report (VSRR)

The VSRR is designed to consolidate the reported facts of the voyage, together with any relevant background information, in an effort to explain the reason(s) for the voyage gain or loss. An example of a completed voyage reconciliation can be found in Annex B, Figure B.7.

If a gain or loss is not satisfactorily explained from the voyage analysis process (VAR), proceed with the voyage summary and reconciliation process, in which specific relevant factors are reviewed to evaluate each gain or loss difference identified. Whenever possible, the differences should be quantified by volume. The total of the reconciliation volumes should approximately equal the total NSV gain or loss for the movement.

All quantity calculations, measurements, or testing methods used in this reconciliation that are not based on recognized standards should be fully explained, referenced, or documented.

The VSRR is divided into five general areas.
1. General Information (vessel and cargo identification, port names, dates, etc.).
2. Comparison of NSV Quantities in Custody Transfer (load vs. discharge port).
3. A Summary of Reported Differences (based on researching the possible causes of differences).
4. Vessel Quantities (1) reported and (2) adjusted for VEFs at load and discharge ports.
5. Comments and Signatures.

CAUTION: VEFs should not be calculated using volumes from vessel-to-vessel transfers.

Note 1: Confirm and record the Load Vessel Experience Factor Load (VEFL). Determine the theoretical shore volume by dividing the vessel loaded volume by the VEFL and compare it to the Bill of Lading TCV. (See VEF, API MPMS Ch. 17.9) Differences should be noted in both volumes and percentages.

Note 2: Confirm and record the Vessel Experience Factor Discharge (VEFD). Determine the theoretical shore volume by dividing the vessel delivered volume by the VEFD and compare it to the Shore Receipt TCV. (See VEF, API MPMS Ch. 17.9) Differences should be noted in volumes and percentages.

5 Possible Causes of Losses or Gains

5.1 General

The factors which may contribute to cargo measurement differences during a marine custody transfer movement are discussed below. When any of these factors are used and/or quantified in performing a voyage analysis, reasons for doing so should be supported. Their impact on the entire movement should be considered.

Note: Marine transportation product loss/gain is defined as the difference between the net cargo quantity measured at the loading terminal and the net cargo quantity measured at the receiving terminal. This can be in volume or in weight. A loss will have a negative sign:

Net Loss/Gain (%) = \frac{(\text{Net received quantity}) - (\text{Net loaded Quantity})}{(\text{Net loaded Quantity})} \times 100

Note: The formula is often turned around to allow a loss to be represented by a minus sign and a gain as a plus.

Due to the uncertainties which apply to the measurements which are used to determine the net standard volume at each stage in the voyage there will almost always be differences between the quantity loaded and the quantity received, and between the on board measurements, sometimes positive and sometimes negative. The task of loss control is to determine if a particular difference is unusual or simply to be expected under the circumstances which apply and then, when an unusual difference is identified, to determine where any loss has occurred.

5.1.2 Cargo Transfer Measurement Points

In a typical marine movement there are four points at which the cargo is measured. One of these points will normally be defined in the contract as the point where the custody transfer measurement will be made.
Figure 1—Four Point Reconciliation

The diagram shows the losses or differences that occur at each stage of the movement:

1 = Load Loss
2 = In transit Loss
3 = Discharge Loss
4 = Shore to Shore Difference

When a loss/gain has occurred a comparison of all four measurements will often show a discrepancy at one point, which will indicate where to begin further investigation.

A simple example might be as follows:

1. Shore Tanks at Load (BOL), 1 000 000 Bbls (net)
2. Vessel at Load (adjusted by VEFL), 1 000 050 Bbls (net)
3. Vessel at Disport (adjusted by VEFD), 995 000 Bbls (net)
4. Shore Tanks at Disport (Outturn), 994 950 Bbls (net)

Overall loss is 5050 Bbls (0.51%) and the loss appears to have occurred during the voyage. However, it is not possible to assume that this is the case and all points of measurement must be investigated. In this case, although the loss appears to be on board, there could be a number of reasons/causes as to why and where the loss occurred (e.g. the vessel quantity could have been mis-measured at load and which would then indicate that the BOL was overstated, this would then lead to further investigation of the shore measurements) The following sections addresses items which should be considered as part of an investigation.

5.2 Shore Measurements
5.2.1 Meters

Custody transfer measurement may be carried out using meters. Some knowledge of how the various meter types operate, potential errors and the generation of final figures will allow pertinent questions to be asked when investigating a gain or loss.

Meters may be incorrectly installed, maintained, operated or have errors due to wear and tear of components. Points for consideration include the following.

a. Meter proving frequency (This should be in accordance with manufacturer’s recommendations, company or national legislation).

b. Maintenance records.

c. Control charts.

d. Meter K factor on the custody transfer document compared to the most recent prover report.

e. Prover calibration records.

The terminal should be able to provide meter factor control charts and the last prover calibration report with traceability to national/international standards. If possible compare the metered volumes with shore tank volumes.

Note: Custody transfer meters shall be properly proven, certified and operated to a recognized industry standard. If any of the meter data cannot be obtained, the metered volume may be questionable.

Refer to Figure A.3 in Annex A for information on documentation that should be provided by the terminal, vessel or inspector.

5.2.2 Shore Tank Measurements

Tank calibration tables should comply with recognized industry standards. In particular note and confirm the date of the most recent calibration. This information should be requested from the facility but also may be available through the independent inspector.

When addressing suspected problems with shore tank measurements the following issues should be considered.

a. Differences between manual and automatic tank gauge (ATG) measurements.

b. Tanks may move and deform over time causing reference points to distort and capacity tables may become less accurate.

c. Inadequate settling time before gauging may result in inaccurate liquid measurements, particularly with regard to water determination.

d. Tank bottom flexing may affect measurements especially if tank level has changed considerably from open to close.

e. Temperature or density stratification may have an effect on floating roof correction calculation.

f. Valve leakage.
g. Product density may be incorrect. A comparison should be made with density at other measurement points.

h. The observed reference height should have been measured and may not be the same as stated on the tank capacity table (or information plate). However, the difference between the two measurements should be minimal. Any significant differences should be investigated and may be due to distortion or a buildup of sediment.

i. The datum plate height above the tank bottom may not allow for identification and quantification of material below the datum plate.

j. Unslotted standpipes may have been used for measurements.

k. Sediment build up in the tank or stand pipe may affect free water determination, measurement accuracy, and/or tank critical zone positions (see 5.2.2.1). Also the presence of sediment on the tank bottom may complicate free water determination as the horizontal water/oil interface may not extend across the whole tank.

l. Tank shell thermal expansion corrections may not have been correctly applied.

Terminal balances and stock reconciliation may be needed to investigate any potential cargo diversions.
5.2.2.1 Floating Roof Tanks

If the shore tanks have floating roofs it is important to verify that the roofs were not in the critical zone at the start or finish of the movement. Measurements taken in the critical zone are not acceptable for custody transfer (refer API MPMS Ch. 3). Sediment build up can change the critical zone. Tank capacity tables should show the levels at which the roof is fully grounded or floating. Verify that any changes in these levels have been recorded. In some locations tanks may be strapped for both high and low leg positions. Verify that correct strapping tables were used to obtain volumes.

Issues with gauging a floating roof tank could be as follows.

a. When a measurement is made and the roof is thought to be floating but is not then an incorrect quantity will be measured.

b. In older tanks sediment build up can extend the critical zone.

c. Movement of the floating roof or gauging tape due to wind.

d. Change in tank roof orientation i.e. tilting or canting, sinking etc.

e. A change in the weight of the floating roof, i.e. water, snow load, product on roof.

f. Absence of a fixed reference height (i.e. gauging on the floating roof).

5.2.3 Line Verification

The fill condition of shore lines before and after loading and discharge should be correctly determined and documented. Slack lines can result in a discrepancy in the BOL or the outturn. The preference would be for lines to be either full or empty, and to be in the same condition before and after the movement. This should be verified. The fill condition of vessel lines after loading and discharge should also be documented to verify that there is no unmeasured cargo on the vessel. The effect of any reported differences in line fill can usually be calculated. Refer to API MPMS Ch. 17.6 “Guidelines for Determining the Fullness of Pipelines Between Vessels and Shore Tanks” for more detailed information regarding the procedure.

In the event of a discrepancy then shoreline configuration should be verified to ensure that pipelines were correctly aligned.

5.3 Vessel measurements

Vessel measurements are a vital part of the transport chain and need to be reviewed as part of any loss or gain investigation. A difference between shore quantity and vessel quantity, adjusted by the VEF, can indicate an inaccurate shore or vessel measurement.

Automatic gauging equipment may drift (or partly fail) over time and regular manual checks need to be made using calibrated equipment, particularly as closed and restricted operations are leading to increased reliance on these systems.

Where there is a concern that specific tank readings appear to be incorrect records of regular verification of vessel automatic gauges against manual readings can be requested from vessel owners or operators.

When addressing suspected problems with vessel measurements the following issues should be considered:

a. Use of non-calibrated measurement equipment.
b. Weather and sea conditions.

c. Capacity tables may have been incorrect (i.e. for a different gauge point).

d. Differences between manual and automatic tank gauge (ATG) measurements.

e. Trim, list and wedge corrections may not have been correctly applied.

f. Gauge height adjustments to allow for retrofitted equipment such as vapor control valves and closed system fittings may not have been correctly applied.

g. Different gauge points may have been used at load and discharge.

h. Unslotted standpipes may have been used for measurements.

i. Vessel line fill condition may have been different at load and discharge port.

j. Clingage, unmeasured ROB and OBQ.

5.3.1 Vessel Tank Capacity Tables

Vessel capacity tables should be specific to the vessel/tank and carry the date together with notes and corrections for any structural changes, particularly modifications to stand pipes and vapor control valve fittings.

Calculations should be checked to verify that trim and list corrections have been applied correctly, as this can have a significant impact on the measured quantities. Ideally a vessel should complete loading as close to even keel and upright as possible to reduce errors in gauging.

5.3.2 Vessel Experience Factor

Where a VEF has been applied to the vessel’s figures, refer to API Ch17.9/EI HM49.

5.3.3 Transit Differences

Transit differences are normal to most marine movements and result from either a physical gain or loss during the voyage or discrepancies in measurement.

A comparison of the vessel’s departure TCV and its arrival TCV will give an indication of transit cargo variation. The measurements which make up the TCV (GSV and FW) should be reviewed individually.

A transit gain may be due to:

a. Material pumped from engine room bilges into slop tanks.

b. Heating coils leaking into cargo tanks.

c. Displacement into cargo tanks of other materials, which were received/discharged between the time when cargo load and discharge measurements are made, e.g., bunkers, slops, and other parcels.

d. Introduction of water to cargo tanks.

e. Measurement inaccuracy due to vessel motion and/or equipment limitations.
A transit loss may be due to:

a. Vapor losses.

b. Leaks:
   1. External: cargo that escapes from vessel tanks to the sea.
   2. Internal: cargo that escapes to other cargo tanks or into voids, cofferdams, slop tanks, ballast tanks, or other non-designated areas but is not discovered.

c. Unreported cargo diversion, or cargo burned as fuel.

d. Transfer or decanting of free water from slop or dirty ballast tanks during voyage.

e. Volumetric Shrinkage

f. Measurement inaccuracy due to vessel motion and/or equipment limitations.

If a vessel shows more cargo on arrival at the discharge port than was reported on departure from the load port, the cargo volumes and measurements should be carefully reviewed and analyzed. If the departure quantity is considered to have been understated, this apparent transit gain may be entered on the VSRR form under “Transit Difference.” Caution should be exercised when recording transit variations since such variances may or may not have any bearing on the overall gain or loss.

Examples:
   g. A large transit loss, with no corresponding difference between VEF-adjusted vessel volume versus outturn at discharge, might indicate a physical loss during the voyage.
   h. A large transit gain, with a large vessel/shore difference at the load port and minimal differences noted at discharge, might indicate vessel measurement errors caused by gauging in rolling seas, the use of different calibration tables at each port, or a change in the reference gauge point.
   i. Evaporative losses.

5.3.5 Change in Cargo Stowage

Stowage refers to the arrangement of cargo in the vessel. Changes in stowage should be investigated some examples are:

a. Request from Charterers for blending of cargo en-route or heating and/or circulation of cargoes between two or more tanks.

b. Need to alter the vessel’s trim for stability/performance or to facilitate load/discharge.

5.3.6 Cargo Diversion

Any unauthorized diversion of cargo must be fully investigated and reported.

Bunker survey reports and receipts should be obtained where appropriate.

5.3.7 OBQ and ROB
A difference in OBQ and ROB quantities may be expected as a result of unmeasured ROB or clingage which may later settle to the bottom of the tanks and then become measureable as OBQ. ROB clingage which does not settle can result in cargo gains at next loadport. The practice of loading on top of retained oily residues (slops) and the implementation of enhanced cargo recovery techniques, such as Crude Oil Washing (COW), have a marked effect on the differences in these volumes.

Typical ROB quantities have been considerably reduced since the introduction of double hulled vessels. Large quantities of cargo remaining in the tanks may suggest poor procedures or problems with vessel's equipment.

Liquid calculations should be checked to ensure that the wedge formula has been applied correctly where appropriate.

While measured ROB does not represent a measurement loss it may be a real loss to the receiving terminal. High ROB (measured and unmeasured) can be due to inadequate heating on the vessel, possibly coupled with low temperatures at discharge. If cargo heating has been specified and a problem is suspected, heating records should be obtained from the vessel. These should indicate whether charter party requirements have been followed.

If the cargo has not been correctly heated wax may be deposited on the tank floor and sides, increasing measured and unmeasured ROB. Heated cargos can suffer from high ROB if the cargo has not been discharged quickly once below the level of heating coils. Excess ROB in one tank may indicate that stripping was too slow or that stoppages have occurred, allowing heavy cargo to begin to solidify. Time logs and any Letters of Protest should be reviewed.

The physical characteristics of the product and the ability of the vessel to pump it are also factors affecting ROB. Problems can result from cargo vaporizing in the pumps (air lock) and loss of suction during final stripping. Trim and/or list may prevent the free flow of product to the suction point.

A difference in OBQ and ROB quantities may be expected as a result of unmeasured ROB or clingage which settles to the bottom of the tanks and then becomes measureable as OBQ. The practice of loading on top of retained oily residues (slops) and the implementation of enhanced cargo recovery techniques, such as Crude Oil Washing (COW), have a marked effect on the differences in these volumes.

5.3.8 Undetected ROB

Undetected ROB is the result of cargo that remains clinging to the bulk head (clingage) or in unmeasurable areas of vessel compartments.

Clingage varies depending on the physical characteristics of the cargo and the conditions under which the discharge is performed. It also can vary depending upon the type of vessel, the number of tanks, and tank construction. Any quantification of loss due to clingage can only be a subjective determination, but it is an identifiable reason for cargo loss.

While clingage cannot be precisely measured for the voyage in question, it may be estimated for similar cargo type and voyage conditions by using one of two methods:

a. ROB versus subsequent voyage OBQ (excluding water introduced in cargo/slop tanks for tank washing on ballast voyage).

b. Load On Top Monitoring Record Calculation (see API MPMS Ch. 17.1).

Note: Clingage may be recoverable through COW or tank cleaning on a subsequent voyage.
5.3.8 Crude Oil Washing

Crude Oil Washing (COW) operations can reduce the cargo volumes retained on board after discharge (ROB). Although COW is a useful technique to improve cargo discharge, its effectiveness is dependent on many factors including the nature of the cargo, the efficiency of equipment, the number of tanks being washed, and the ambient air and sea temperatures during discharge.

A thorough COW may reduce ROB to less than the OBO. However, COW may cause additional cargo losses with volatile cargoes due to the vapor generated. In cold weather improper handling of high pour or viscous cargoes may increase rather than decrease clingage.

A flushing medium may be employed to COW a vessel’s tanks or to displace a previously discharged cargo in the shore line. The medium, typically a light oil, is loaded aboard the vessel and stowed in a suitable tank for the intended purpose.

The vessel should be gauged before and after the flushing medium is transferred to the vessel. The quantity received by the vessel (TCV) should be compared to the volume from the shore tank or meter and must be correctly accounted for to properly reconcile cargo quantities. Any flushing medium remaining on the vessel after discharge should be accounted for as ROB.

Note: Refer to Marpol 73/78 (the International Convention for the Prevention of Pollution from Ships) and HM40 ‘Guidelines for the crude oil washing of ships’ tanks and the heating of crude oil being transported by sea’

5.3.9 Slops

Slops are a readily identifiable source of gain/losses in cargo outturns when compared with BOL volumes and should be taken into consideration in the reconciliation. Slops discharged with the cargo may have been either commingled with the cargo (loaded on top) or segregated from the cargo in a separate tank.

5.4 Water Determination

5.4.1 Free Water

Sales are based on GSV or NSV and therefore accurate water measurements are critical.

When investigating possible losses, a water balance should be carried out between each measurement point. In cases where large amounts of water are found, analysis may determine the source of the water (Estuary, formation water, sea water, etc.). Care should be taken that all aspects are checked as there is often confusion between fresh ballast water and formation water. Now that segregated ballast is almost universal, ballast water should not normally be found in cargo tanks.

If the additional water is reflected in a larger gross measurement on the vessel after loading and at discharge then there may not have been any apparent net product loss.

Differences in the free water quantity could be due to the following.

a. Introduction of water into the cargo from vessel pipelines, loading/discharge lines (particularly under sea lines or floating hoses), or shore lines during the loading or discharge operations. Water in the shore line between an automatic sampler and the vessel on loading may not be accounted for.

b. Mixing of FW with cargo as it is pumped. This will reduce the FW volume while increasing the S&W volume. However, total water should remain the same.

c. Settling out of S&W which will increase the FW content at the discharge port, compared to the load port.
d. Insufficient time allowed for water to settle.

e. Different measurement methods, e.g., separate S&W and FW measurements versus total S&W of homogenized samples from an in-line sampler.

f. Different methods of detecting FW, e.g., water paste versus electronic interface detector, especially for crude oils containing emulsified water.

g. FW volumes on the vessel not properly corrected for wedge or trim conditions.

h. Different sea conditions when measuring the FW on the vessel at the load port and discharge port, e.g., rough seas versus calm seas.

i. Changes in trim and/or list from loading port to discharge port. Depending on gauge point locations a wedge of FW may not be detected under certain conditions.

j. Tank bottom deformation or sediment in tanks affecting FW measurement.

k. The datum plate height above the tank bottom preventing quantification of water below the datum plate. This is a particular problem with cone bottom tanks where gauging points are typically offset to one side of the tank.

l. Shut down or malfunction of the automatic sampler during a part of the loading or discharge or improper cleaning and operation.

m. Ballast water entering the vessel’s cargo tanks or lines.

Refer to API MPMS Ch. 17.3 “Guidelines for Identification of the Source of Free Waters Associated with Marine Petroleum Cargo Movements,” for a possible explanation of the origin of excessive FW.

5.4.2 Sediment and Water (S&W)

A difference between reported S&W at load port and discharge port will give a shore-to-shore NSV gain or loss, unless this is associated with a similar change in FW.

Inconsistent S&W results can occur for any of the following reasons.

a. The non-homogeneity of product may result in samples that contain more or less water than the whole cargo.

b. Different methods of sampling, e.g. manual sampling versus automatic inline sampling.

c. The use of incorrect sampling method or procedure.

d. Inability to obtain a representative samples with closed or restricted equipment. (see MPMS Chapter 17.11)

e. Different methods of laboratory analysis, e.g. Karl Fischer titration; water by distillation; centrifuge, etc.

f. Settling of S&W can decrease the entrained S&W content of the vessel composite at a discharge port as compared to a load port. Likewise, mixing resulting from turbulence during pumping may increase S&W as FW becomes entrained and thus part of S&W.
Failure to follow standard test methods, e.g., use of uncalibrated centrifuge tubes, or non-standard or exhausted reagents.

Improper sample handling and/or mixing.

Auto sampler records may be available so that performance throughout the movement can be verified against relevant standards (API MPMS Ch. 8.2 or ISO 3171). Manual samples obtained from shore tanks and vessel may be used for reference comparison purposes.

An automatic flow proportional sampler is the preferred method for collecting a representative sample from a cargo at loading and discharge. Manual samples, especially when taken through restricted or closed gauging systems, are less likely to be representative.

Various types of auto sampler are in use (portable, fixed in-line probe, fast loop, fast loop with pumped mixer). Where an automatic sampler has been used it should be confirmed that the sampler and sample probe are installed in a suitable position.

Also verify that if the product was susceptible to layering (vertical separation of lighter/heavier components or settling of water in layers, or even horizontal stratification in very viscous products) spot or zone samples were taken.

Density and water content measurements on the individual zone or spot samples may confirm layering such that running samples or upper/middle lower samples may not be sufficient to determining correct parameters to apply to the full cargo.

5.4.3 Water Balance

Typically, an increase in free water volumes on the vessel during a voyage may indicate that water has settled out. However this could indicate incorrect measurement, sampling or the possible introduction of water into the cargo.

Free water may be from internal or external sources such as shore tanks, pipelines, sea water, steam lines or vessel compartments. Analysis of samples, if available, will help to determine its source. Free water quantities in the first vessel tanks loaded may indicate the presence of water in either the shore or vessel lines.

5.5 Additional Factors

5.5.1 Temperature

Temperature measurements are critical in standard volume calculations and a careful review of temperature measurements is recommended as part of any reconciliation.

Temperature changes in a short period of time may indicate a measurement problem unless the oil is being aggressively heated. Temperatures can be examined volumetrically and the resulting theoretical values compared to the actual temperatures reported. Small differences in temperatures can result in significant volume changes.

Sensitivity varies and is greater with lighter products but can be of the order of 0.15% by volume for a 1C temperature change or 0.08% by volume for a 1F temperature change.
Example: Volumetric theoretical temperature calculation vessel discharge

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shore Volume</td>
<td>50,000</td>
</tr>
<tr>
<td>Shore Temperature</td>
<td>70</td>
</tr>
<tr>
<td>Shore Volume x Temp</td>
<td>3,500,000</td>
</tr>
<tr>
<td>Vessel Volume</td>
<td>100,000</td>
</tr>
<tr>
<td>Vessel Temperature</td>
<td>100</td>
</tr>
<tr>
<td>Vessel Volume x Temp</td>
<td>10,000,000</td>
</tr>
<tr>
<td>Shore VT ratio</td>
<td>13,500,000</td>
</tr>
<tr>
<td>Vessel VT ratio</td>
<td></td>
</tr>
<tr>
<td>Shore Volume + Vessel Volume</td>
<td>150,000</td>
</tr>
<tr>
<td>Shore VT + Vessel VT / Shore V + Vessel V</td>
<td>90</td>
</tr>
</tbody>
</table>

5.5.1 Evaporative Losses

Evaporation is the loss of the relatively low boiling point hydrocarbon components ("light ends") of cargoes to the atmosphere and occurs during loading, in transit and at discharge. The extent of this loss is influenced by the volatility of the cargo, the temperature of the cargo, and agitation of the cargo, COW, the condition of the vessel, and the design and operation of the inert gas system and P/V valves.

Vapor pressure can be used as an indication of the relative volatility of the cargo at a given temperature. The evaporation portion of a loss is difficult to measure.

Factors that can contribute to evaporation loss include the following.

1. High vapor pressure of the cargo.
2. The increase in temperature of the cargo caused by ambient conditions or heating of the cargo.
3. The improper operation of the vessel’s inert gas system and the incorrect setting of pressure relief valves on the vessel.
4. Gauge hatches left open.
5. Excessive agitation of cargo during loading or passage, e.g., heavy weather conditions.
6. Integrity of the cargo compartment—worn packing on tank lids.
7. The performing of a COW operation at discharge.
8. The amount of free surface area of the cargo.

5.5.2 Density

A significant difference between shore and vessel density measurements may lead to a quantity difference. For example in the case of long shore line’s a large proportion of the loaded quantity may not have been sampled. Although losses due to density differences are quite small when considering standard volume, many product cargoes are traded in weight and in these situations density differences can lead to more significant losses.
Density stratification may occur with some products. This can result in composite shore tank samples showing differences from the product loaded if only part of a tank is drawn from and may also lead to problems in determining a density for the cargo when blending on-board.

5.5.3 Volume Correction Factors (VCF)

VCF tables should be consistent at all measurement points throughout the voyage. If the loaded quantities were calculated using VCF tables other than the VCF tables used at the discharge port, then the loaded quantities should be recalculated based on the VCF tables used at the discharge port, for the purposes of comparison. Any quantity difference resulting from the use of different VCF tables should be recorded on the VSRR in the “Table Difference—Reported Quantity.”

When investigating measurement differences the VCF Table difference should be reviewed to confirm that it is within parameters for the tables involved and the cargo temperature.

Note: Not all countries apply current ISO or API/EI/ASTM standards, some continue to use the 1952 ASTM tables and many Former Soviet Union (FSU) countries use GOST tables which calculate cargo quantities as weight in vacuum.

5.5.4 Volumetric Shrinkage

Volumetric shrinkage can occur when mixing two hydrocarbons with different molecular structures. The amount of shrinkage depends on the density difference and percentage of the components. The shrinkage is greatest when the percent of light or heavy component increases toward a 50% mixture. For additional details and the calculation procedures, see API MPMS Ch. 12.3 “Calculation of Volumetric Shrinkage Resulting from Blending Light Hydrocarbons with Crude Oil.”

5.5.5 Letter of Protest - Notice of Apparent Discrepancy

Any unusual event which occurred during a loading or discharge should have been reflected in the terminal or vessel time log and possibly in a Letter of Protest or Notice of Apparent Discrepancy. This documentation should be reviewed as part of any loss investigation.

5.5.6 Lightering

When cargo is transferred in a lightering operation, the quantity transferred may be better quantified by using the shuttle receipt quantity, adjusted by the VEF, than the quantity based on the delivering vessel. If weather or sea conditions during lightering were not conducive to accurate measurement, or measurements could not be obtained, the transferred quantity may be better quantified using the shuttle vessel’s arrival quantity (minus OBQ) at the discharge port, adjusted by the VEF.

5.6 Measurement Uncertainties and Errors

Examples of possible errors that are not specific to vessel or shore tank include the following.
a. Failure to follow proper operating practices.
b. The use of defective or non-standard measurement equipment.
c. The environment at the time the measurements are taken.
d. Observed tank height differences between opening and closing measurements.
e. The use of incorrect tank tables or the improper use of tank tables.
f. The use of incorrect quantity correction factors (i.e., VCF or WCF).
g. Temperature and density stratification (may also have an effect on floating roof correction calculations).
h. The use of incorrect conversion factors when converting between systems of measurement.
i. Random errors in measurement.

j. Failure to use properly calibrated equipment.
k. Failure to perform cargo measurement operations in accordance with API standards.
Annex A
(informative or normative?)

Instructions for Completion of voyage analysis forms

A.1 Voyage Analysis Forms

2. Summary of Vessel-to-vessel Transfers.
3. Field Facts.

Note: The forms in this appendix may be copied for use by anyone, however they are included only as examples. When all parties agree, other forms may be used for this purpose.

A.1.1 The Voyage Analysis Report (VAR)

The VAR form is where the essential information regarding any marine custody transfer is recorded. A separate VAR form should be completed for each shore-to-shore or Vessel-to-vessel Transfer. On complex voyages and lighterings, a Summary VAR should also be completed. Refer to 5.2 for complete instructions regarding entries on the VAR form.

Note: All volumes on VARs must be based on consistent Volume Correction Factors (VCFs). If the VCFs used at the load port are different from the discharge port VCFs, Section I of the VAR form provides a box on line 5 to enter the recalculated load port quantity based on the discharge port VCF.

The four possible applications of the VAR form are listed below. A single VAR form may cover more than one application, and each application is indicated by checking one (or more) of the blocks at the top left corner of the form:

a. A Loading VAR where the following are filled in:
   1. the top section (vessel name, cargo, port, etc.) records general information about the cargo transfer;
   2. Line 1 of Section I (Bill of Lading quantity);
   3. all of Section II (lines A – J).

b. A Discharge VAR where the following are filled in:
   1. Since the discharge port is where shore-to-shore quantity discrepancies would be found, the entire VAR form should be completed.

c. A Vessel-to-vessel Transfer VAR where the following are filled in:
   1. the top section (vessel name, cargo, port, etc.) records general information about the cargo transfer;
   2. Section II (Lines A – J).
d. A Summary VAR where the entire form is filled in (as applicable).

Note: The Summary VAR should not be confused with the Summary of Vessel-to-vessel Transfers form.

A.1.2 The Summary of Vessel-to-vessel Transfers Form

The Summary of Vessel-to-vessel Transfers form is designed to recapitulate all quantities transferred during a lightering operation:

1. the top section is for general information (mother vessel name, number of transfers, lightering position, etc.);
2. a Summary of Transfers section to indicate the total quantity of cargo discharged from the mother vessel and the total received by all shuttle vessels during a lightering operation;
3. a Detail of Transfers section to indicate the name of each shuttle vessel, the quantity lightered based on mother vessel gauging, and the quantity lightered based on shuttle vessel gauging.

A.1.3 Field Facts Form

The Field Facts form is designed to verify that specific operational items were either performed or checked as recommended by the appropriate standards. Items that cannot be verified may warrant later consideration as measurement or operational uncertainties. To be most effective, the form should include facts from both the loading port(s) and discharge port(s).

A.1.4 The Voyage Summary and Reconciliation Report Form (VSSR)

The VSRR information is divided into four vertical groupings:

1. the heading, showing the vessel’s name, load and discharge ports, dates of arrival and sailing, etc.;
2. a listing and reconciliation of the quantity differences taken from the VAR report (Transit difference, OBO/ROB difference, etc.);
3. a calculation of the difference between the vessel loaded volume (VAR, line C) adjusted first by the DVEF and then by the LVEF;
4. comments that apply to the reconciliation.

A.2 Simple Voyages

A simple voyage is a single grade cargo movement from one load port to one discharge port.

For a simple voyage, only one VAR form is needed and it will cover the loading, the discharge, and a summary of the voyage. Therefore, the Loading, Discharge and Summary boxes at the top left corner of the form should all be marked.

If the reason for any gain or loss cannot be readily detected from the VAR form alone, completing the VSRR form should be considered.

A.3 Complex Voyages

A complex voyage involves the shipment of one or more grades of cargo and one or more load or discharge ports. Complex voyages may require the use of all three analysis forms. Following is an example of the
forms that would be used for a typical complex cargo analysis. See A.1 for instructions to complete each style of VAR mentioned below.

**Complex Cargo Example:**

One vessel loads and discharges three cargoes and a VAR form should be completed for each loading, discharge and summary (five VARs in all):


<table>
<thead>
<tr>
<th>Cargo</th>
<th>Load Port</th>
<th>Discharge Port</th>
<th>VAR Application (Mark Box on Form)</th>
<th>VSRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>A</td>
<td>D</td>
<td>Loading, Discharge, Summary</td>
<td>If needed</td>
</tr>
<tr>
<td>Y</td>
<td>B</td>
<td>E</td>
<td>Loading, Discharge</td>
<td>If needed</td>
</tr>
<tr>
<td>Z</td>
<td>B</td>
<td>D</td>
<td>Loading, Discharge</td>
<td>If needed</td>
</tr>
<tr>
<td>Z</td>
<td>B</td>
<td>E</td>
<td>Loading, Discharge</td>
<td>If needed</td>
</tr>
<tr>
<td>Z</td>
<td>B</td>
<td>D, E</td>
<td>Summary</td>
<td>If needed</td>
</tr>
</tbody>
</table>

**A.4 Vessel-To-Vessel Voyages (Lighterings)**

A Vessel-to-vessel voyage occurs when a cargo is moved from one vessel to another. Typically, this is ship-to-ship or ship-to-barge. The most common lighterings involve cargoes of crude oil where a large tanker discharges parcels of the crude oil to smaller tankers that can meet draft restrictions at the intended discharge terminal.

**Vessel-to-vessel Transfer Example:**

Supertanker “C” loads

- 200,000 tons of Crude Oil at Load port “A”

Supertanker “C” discharges

- 60,000 tons to Shuttle Vessel “A”
- 70,000 tons to Shuttle Vessel “B”
- 70,000 tons to Shore Terminal “C”

**Forms needed:**

1. Loading VAR for Supertanker “C” at Load port “A”
2. **Vessel-to-vessel Transfer VAR** for Shuttle “A”
1 *Vessel-to-vessel Transfer VAR* for Shuttle “B”

1 *Summary of Vessel-to-vessel Transfers* to recap the two shuttles from Supertanker “C”

1 *Discharge VAR* for Supertanker “C” (for the discharge at Shore Terminal “C”)

1 *Summary VAR* summarizing:

   1. the loading of Supertanker “C;”
   2. the quantities discharged to shore from the two shuttles;
   3. the balance from Supertanker “C” discharged directly to shore.

1 *VSRR* form may be required to research variances indicated on each VAR above.

Blank VAR Form (Figure A.1) is inserted here.
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Figure A-1—Voyage Analysis Report (VAR)

<table>
<thead>
<tr>
<th>Loading</th>
<th>Discharge</th>
<th>Var/Transfer</th>
<th>Summary</th>
<th>Reference No.</th>
<th>Voyage No.</th>
<th>CP</th>
<th>PUE (O/F)</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Quay Unit | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|
| Loading Port/Terminal | Arrived (M/T) | Sailed (M/T) | Discharge Port/Terminal | Arrived (M/T) | Sailed (M/T) |
|             |             |             |             |             |             |

| Description | | | | | | |
|-------------|------------|------------|------------|------------|------------|
| API Duty | TCV | PV | BDU | SWY | NSY | Calculation Reference |
|-------------|------------|------------|------------|------------|------------|

**1. Vessel/Quay Quantities (Q) (Cargo Port(s))**

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Shipment</th>
<th>V</th>
<th>LIQUID</th>
<th>NSY</th>
<th>SUM</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>

**2. Vessel/Quay Quantities (Q) (Discharge Port(s))**

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Shipment</th>
<th>V</th>
<th>LIQUID</th>
<th>NSY</th>
<th>SUM</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
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</tbody>
</table>

**3. Vessel Conversion of Liquid and Discharge Port(s) (Voyage Must Be Constant)**

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Difference</th>
<th>V</th>
<th>LIQUID</th>
<th>NSY</th>
<th>SUM</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**Comments**

Prepared by | The Company | Data Completed (M/T) | |
|-------------|-------------|---------------------| |
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Blank “Summary of Vessel-to-Vessel Transfers” (Figure A.2) form inserted here.

### Blank “Summary of Vessel-to-Vessel Transfers” (Figure A.2) form inserted here.

<table>
<thead>
<tr>
<th>Reference No.</th>
<th>Vessel ID No.</th>
<th>Owner</th>
<th>Port No.</th>
<th>Date of Transfers</th>
<th>Quantity Unit</th>
<th>Supplier</th>
<th>Port of Loading</th>
<th>Port of Discharging</th>
<th>Port of Loading</th>
<th>Port of Discharging</th>
<th>Reference No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page No.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
Blank “Field Facts” (Figure A.3) form inserted here.

### Figure A.3—Field Facts

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Cargo</th>
<th>Reference No.</th>
<th>Voyage Trip No.</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading Point/Information</td>
<td>Product/Location</td>
<td>Unit</td>
<td>Quantity</td>
<td>Unit</td>
</tr>
<tr>
<td>Discharge Point/Information</td>
<td>Product/Location</td>
<td>Unit</td>
<td>Quantity</td>
<td>Unit</td>
</tr>
</tbody>
</table>

**Legend**:
- (Used/Checked)
- (Used/Checked)

1. **Measurements Used in Quantity Transfer (Static/Value or Vessel)**

2. **Other Operations**

3. **Vessel Operations**

4. **Calculation and Reporting**

   - 4.1 L/D of Product Issued
   - 4.2 Notice of Apparent Discrepancy Issued
   - 4.3 Volume Correction Factor Table Used on Trip
   - 4.4 Volume Correction Factor Table Used on Trip
   - 4.5 WPD in Vessel/Group
   - 4.6 WPD in Vessel/Group

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Blank VSRR form (Figure A.4) inserted here.

Figure A.4—Voyage Summary and Reconciliation Report (VSRR)

<table>
<thead>
<tr>
<th>Item</th>
<th>Charge</th>
<th>Type of Voyage</th>
<th>Reference Number</th>
<th>Voyage No.</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leading Port/terminal/Port</td>
<td>Arrelo (c/ft)</td>
<td>Discharge Port/terminal/Port</td>
<td>Actual (c/ft)</td>
<td>(c/ft)</td>
<td>(c/ft)</td>
</tr>
</tbody>
</table>

Information may be filled from a completed VSRR form (Figure A.4) inserted here.

<table>
<thead>
<tr>
<th>DIFFERENCES</th>
<th>QUANTITIES</th>
<th>REPORTED QUANTITY</th>
<th>EXHAUSTED QUANTITY</th>
<th>VOLATILE QUANTITY</th>
<th>UNEXPLAINED FRESH</th>
<th>LINE FULL</th>
<th>MEASUREMENTS</th>
<th>ADJUSTED QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE DIFFERENCE:**

* TABLE DIFFERENCE IS THE DIFFERENCE BETWEEN THE BILL OF LADING FIGURE AND THE RECALCULATED QUANTITY BASED ON APPLICABLE HOPPABLE (C.D. F.B.)

**LOAD/DISCHARGE VESSEL DIFFERENCES:**

| Difference | | | | | | | | | | | | | |

*LOAD/DISCHARGE VESSEL DIFFERENCES:*

**LOAD/DISCHARGE VESSEL DIFFERENCES:**

| Difference | | | | | | | | | | | | | |

*LOAD/DISCHARGE VESSEL DIFFERENCES:*
Annex B
(informative or normative?)

Examples of Cargo Analysis and Reconciliation

B.1 Example of a Complex Voyage Analysis and Reconciliation

In this example (Figure B.1 through Figure B.5), a vessel is loaded with fuel oil. The vessel first ties up at anchorage near Boston where part of its cargo is lightered to a barge. The barge subsequently discharges at one shore terminal, and the vessel then transports and discharges the balance of the cargo ashore at another shore terminal.

The completed forms at the back of this appendix (Figure B.1 through B.5) are intended to illustrate how to analyze and reconcile a complex voyage that includes a lightering operation to a barge. This process allows the voyage to be broken down into components where each element of the loading, lightering and discharge can be analyzed.

B.1.1 Cargo Transfers Used in the Example

1. Vessel “A” loads 211,863 barrels of fuel oil at Venezuela.
2. Vessel “A” transports the cargo to Boston anchorage and lighters 35,918 barrels of fuel oil to a Barge “B.”
3. Barge “B” transports its cargo to Braintree, MA.
4. Vessel “A” transports the balance of the fuel oil to Boston Terminal.

B.1.2 Explanation of the Example Forms (Figures B.1 through Figure B.5)

1. Figure B.1 is the VAR Summary for the entire 211,863 barrels of fuel oil.
2. Figure B.2 details the lightering of the 35,918 barrels of fuel oil to Barge “B.”
3. Figure B.3 details the discharge of the remaining fuel oil from Vessel “A” to Boston Terminal.
4. Figure B.4 details the loading of Barge “B” (at anchorage) and its discharge ashore (at Braintree, MA).
5. Figure B.5 is the summary of the lightered quantities based on gauging both Vessel “A” and Barge “B” at anchorage.

B.1.3 Analyzing the Voyage

B.1.3.1 Figure B.1: The VAR Summary

The VAR Summary form (see Figure B.1) accounts for the entire cargo at loading, lightering at anchorage, and discharging both the barge and the balance on board the vessel. It reveals a shore-to-shore overall NSV cargo loss of 205 barrels (0.097 %) as follows:

Bill of Lading at the Load Port: 211,863 NSV Barrels
Total Discharged Ashore: –211,658 NSV Barrels (from both Barge “X” and Vessel “A”)
Shore-to-shore Loss: 205 NSV Barrels

B.1.3.2 Figure B-2: The Vessel-To-Vessel VAR

The Vessel-to-vessel VAR (see Figure B-2) should disclose any quantity variations that may have occurred during lightering to Barge "B":

1. TCV quantity received by the barge, based on gauging Vessel "A" (VAR line 2);
2. TCV quantity received by the barge, based on barge gauging (VAR line M);
3. a theoretical TCV quantity received by the barge based on Vessel "A" gauges adjusted for the VEF of Vessel "A" (VAR line R).

The quantity delivered to Barge "B" based on gauging Vessel "A" is calculated as follows:

<table>
<thead>
<tr>
<th>Quantity on board Vessel &quot;A&quot; Upon Arrival at Anchorage:</th>
<th>211,986 TCV Bbl (line K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of ROB on Board Vessel &quot;A&quot; after Loading Barge &quot;B&quot;:</td>
<td>176,071 TCV Bbl (line L)</td>
</tr>
<tr>
<td>Volume transferred to Barge &quot;B&quot; Based on Gauging Vessel &quot;A&quot;</td>
<td>35,915 TCV Bbl (line M)</td>
</tr>
</tbody>
</table>

The quantity received by Barge "B" based on gauging the barge can now be compared to the quantity delivered based on gauging Vessel "A":

<table>
<thead>
<tr>
<th>Quantity received by Barge &quot;B&quot; Based on Gauging Barge &quot;B&quot;:</th>
<th>35,918 TCV Bbl (line 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity received by Barge &quot;B&quot; Based on Gauging Vessel &quot;A&quot;:</td>
<td>35,915 TCV Bbl (line M)</td>
</tr>
<tr>
<td>Difference:</td>
<td>&lt; 3 TCV Bbl &gt; (line N)</td>
</tr>
</tbody>
</table>

A theoretical quantity delivered by Vessel "A" can also be calculated by applying the VEF of Vessel "A" to the volume delivered by Vessel "A":

\[
\text{Theoretical Qty Delivered from Vessel "A" (line R):} = \frac{35,915 \text{ TCV Bbl (Basis Vessel "A" Gauges)}}{1.00106 \text{ (VEF of Vessel "A")}}
\]

B.1.3.3 Figure B.3: The Shore Discharge VAR for Vessel "A"

The shore discharge VAR for Vessel "A" (Figure B-3) allows comparison of the following quantities:

1. the quantity received ashore from Vessel "A" based on gauging shore tanks (VAR line 2);
2. the quantity on board Vessel "A" on sailing from the anchorage (VAR line A);
3. the quantity on board Vessel "A" on arrival at the shore terminal (VAR line K);
4. the quantity delivered ashore by Vessel "A" based on gauging vessel tanks (VAR line M);
5. a theoretical shore quantity received from Vessel "A" based on Vessel "A" gauges adjusted for the vessel's VEF (VAR line R);
6. the transit quantity difference (departure from anchorage to arrival at terminal) (VAR line U).

**B.1.3.4 Figure B.4: The Loading and Discharge Quantities for Barge “B”**

The loading and discharge quantities for Barge “B” allow comparison of the following quantities:

1. the quantity received by Barge “B” from Vessel “A” based on barge gauges after application of the barge LVEF (VAR line 1);
2. the quantity received from Barge “B” by the shore terminal based on gauging shore tanks (VAR line 2);
3. the quantity gauged on board Barge “B” on sailing from the Vessel “A” anchorage before application of the LVEF (VAR line A);
4. the quantity gauged on board Barge “B” on arrival at the shore terminal (VAR line K);
5. the theoretical quantity on board Barge “B” based on barge gauges after application of the barge LVEF (VAR lines 1 and H);
6. the theoretical shore quantity received from Barge “B” based on barge gauges adjusted for the barge’s DVEF (VAR line R);
7. the transit quantity difference (barge on departure from anchorage to arrival at the terminal) (VAR line U).

**B.1.3.5 Figure B.5: The Summary of Vessel-to-vessel Transfers**

This form is particularly useful when a mother vessel lighters to several shuttle vessels, where each shuttle vessel is listed individually. However this example illustrates how the Summary is completed by indicating the following:

1. the quantity lightered to Barge “B” by Vessel “A” based on gauging Vessel “A”;
2. the quantity received by Barge “B” from Vessel “A” based on gauging Barge “B.”

**B.2 Example of a Simple Voyage Analysis and Reconciliation**

In this example (Figure B.6 through Figure B.8), a vessel is loaded with crude oil in England and the entire cargo discharges in Houston, a single load port and a single discharge port. The receiver purchased the cargo on an FOB basis and thus incurred the risk of loss for the voyage. The initial outturn volumes indicated an apparent loss of 2,458 NSV barrels (0.48%).

Figure B.6 through Figure B.8 are intended to be examples of how the relevant data may be organized to determine the probable cause(s) for the apparent loss of cargo.

**B.2.1 Cargo Transfer Used in the Example**

2. Vessel “C” transports the cargo to Houston where it is discharged.
B.2.2 Explanation of the Example Forms (Figure B.6 through Figure B.8)

1. Figure B.6 is the VAR Loading and Discharge report for the entire 511,956 barrels of crude oil.

2. Figure B.7 is the VSRR listing the NSV quantities initially measured, and summarizing the differences based VAR report indications.

3. Figure B.8 is a VAR detailing quantity adjustments made as a result of analyzing the differences listed on the VSRR.

B.2.3 Analyzing the Voyage

B.2.3.1 Figure B.6: The VAR Loading/Discharge Report

The VAR Loading/Discharge form (see Figure B.6) accounts for the entire cargo at loading and discharging the vessel. It reveals a shore-to-shore overall NSV cargo loss of 2,458 barrels (0.480%) as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Reported Quantity</th>
<th>Cause of Difference</th>
<th>Quantity of Difference</th>
<th>Adjusted Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bill of Lading at the Load Port</td>
<td>511,730 Bbl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Discharged Ashore</td>
<td>509,272 NSV Bbl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shore-to-shore Loss</td>
<td>2,458 NSV Bbl</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B.2.3.2 Figure B.7: The VSRR Report

On the VSRR, six differences are reported from the VAR and information was found to explain four of those differences. Note that the adjustment of the discharge port theoretical difference reflects a combination of all three reconciling items. This leaves most of the apparent loss unexplained and the analyst can focus the investigation on the apparent loss of 1,175 barrels of product indicated by the sharp increase in the theoretical difference at the discharge port.

<table>
<thead>
<tr>
<th>Reported Difference</th>
<th>Reported Quantity</th>
<th>Cause of Difference</th>
<th>Quantity of Difference</th>
<th>Adjusted Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Difference</td>
<td>+ 236 Bbl</td>
<td>Measurement Error</td>
<td>– 286 Bbl</td>
<td>– 50 Bbl</td>
</tr>
<tr>
<td>OBO/ROB Difference</td>
<td>– 445 Bbl</td>
<td>Undetected ROB</td>
<td>– 77 Bbl</td>
<td>– 522 Bbl</td>
</tr>
<tr>
<td>Line Fill Discrepancy</td>
<td>0 Bbl</td>
<td>Discharge Port Line Fill</td>
<td>+ 105 Bbl</td>
<td>0</td>
</tr>
<tr>
<td>S &amp; W Difference</td>
<td>– 437 Bbl</td>
<td>Undetected S &amp; W at Load Port</td>
<td>– 437 Bbl</td>
<td>– 437 Bbl</td>
</tr>
<tr>
<td>Other Four Differences</td>
<td>– 1,812 Bbl</td>
<td>No Cause Found</td>
<td>0</td>
<td>– 1,344</td>
</tr>
<tr>
<td>TOTAL ALL DIFFERENCES</td>
<td>– 2,458 Bbl</td>
<td></td>
<td></td>
<td>– 2,353</td>
</tr>
</tbody>
</table>

B.2.3.3 Figure B.8: The Voyage Analysis Report Adjusted

An adjusted VAR may then be completed that identifies the possible application of the variances found while completing the VSRR. Note that, in this illustration, the 105 barrel line fill discrepancy has been added to the outturn volume. Transit, S & W and OBO/ROB variances are also included in this example.

Note: The application of line fill or any other variances is shown here for illustration only. Any decision affecting cargo volumes and/or variances must be taken solely by the parties involved and API takes no position regarding such decisions.
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Insert Figure B.1 here
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Insert Figure B.2 here

Figure B.2—Voyage Analysis Report (VAR)

<table>
<thead>
<tr>
<th>Loading</th>
<th>Discharge</th>
<th>Valves/</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Port Name</td>
<td>Facility</td>
<td>Remarks</td>
</tr>
<tr>
<td>Vessel</td>
<td>Type</td>
<td>Cargo</td>
<td>Fuel Oil</td>
</tr>
<tr>
<td>March 01, 2008</td>
<td>March 02, 2008</td>
<td>March 03, 2008</td>
<td>March 04, 2008</td>
</tr>
<tr>
<td>Description</td>
<td>API/FL</td>
<td>TCV</td>
<td>PV</td>
</tr>
</tbody>
</table>

I. COMPARISON OF SHORE QUANTITIES WITH DECK QUANTITIES

<table>
<thead>
<tr>
<th>Bill of Lading</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Tonne</td>
<td>25,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
</tr>
<tr>
<td>Net Tonne</td>
<td>24,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Difference</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Percentage</td>
<td>25%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Load</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Theoretical Shore Diff.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

II. VESSEL/SHORE QUANTITIES AT LOAD PORT

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Bil</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Tonne</td>
<td>25,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td></td>
</tr>
<tr>
<td>Net Tonne</td>
<td>24,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>25%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Theoretical Shore Diff.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

III. VESSEL/SHORE QUANTITIES AT DISCHARGE PORT

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Bil</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Tonne</td>
<td>25,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td></td>
</tr>
<tr>
<td>Net Tonne</td>
<td>24,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>25%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Theoretical Shore Diff.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

IV. VELOCITY COMPARISON OF LOADING AND DISCHARGING PORTS

<table>
<thead>
<tr>
<th>Port</th>
<th>Bil</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Tonne</td>
<td>25,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td></td>
</tr>
<tr>
<td>Net Tonne</td>
<td>24,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>25%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Theoretical Shore Diff.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

V. VELOCITY COMPARISON OF LOADING AND DISCHARGING PORTS

<table>
<thead>
<tr>
<th>Port</th>
<th>Bil</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Tonne</td>
<td>25,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td></td>
</tr>
<tr>
<td>Net Tonne</td>
<td>24,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>25%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Load</td>
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<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Theoretical Shore Diff.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Comments: (Loaders Banked on Shore Available for API/FL, Weight Lightened to Shore 25' (See Figure 4)
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Insert Figure B.3 here

### Figure B-3—Voyage Analysis Report (VAR)

<table>
<thead>
<tr>
<th>Description</th>
<th>API</th>
<th>DNV</th>
<th>P&amp;G</th>
<th>GSV</th>
<th>BIL</th>
<th>NSW</th>
<th>Calculation Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity unit</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
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#### I. COMPARISON OF SHORE QUANTITIES IN CUSTOMER TRANSFER

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<th>Description</th>
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<th>DNV</th>
<th>P&amp;G</th>
<th>GSV</th>
<th>BIL</th>
<th>NSW</th>
<th>Calculation Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity unit</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
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</tbody>
</table>

#### II. SHIP/SHORE QUANTITIES AT (1) LOAD PORT(S)

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<th>P&amp;G</th>
<th>GSV</th>
<th>BIL</th>
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<th>Calculation Precision</th>
</tr>
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<tbody>
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<td>£/ton</td>
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<td>£/ton</td>
<td>£/ton</td>
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#### III. SHIP/SHORE QUANTITIES AT (1) DISCHARGE PORT(S)

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<th>P&amp;G</th>
<th>GSV</th>
<th>BIL</th>
<th>NSW</th>
<th>Calculation Precision</th>
</tr>
</thead>
<tbody>
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<td>Quantity unit</td>
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<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
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</tbody>
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#### IV. SHIP/SHORE COMPARISON OF LOADING AND DISCHARGE PORT(S) TOP TABLE MUST BE CONSISTENT

<table>
<thead>
<tr>
<th>Description</th>
<th>API</th>
<th>DNV</th>
<th>P&amp;G</th>
<th>GSV</th>
<th>BIL</th>
<th>NSW</th>
<th>Calculation Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity unit</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
<td>£/ton</td>
</tr>
</tbody>
</table>

### Comments

NA/NA Problem at Discharge Port.

Prepared by [Name] Company [Company Name]

[Notes or Additional Information]
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Insert Figure B.4 here

### Figure B-4 — Voyage Analysis Report (VAR)

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Port of Loading</th>
<th>Port of Discharge</th>
<th>Vessel Tonnage</th>
<th>Vessel ID</th>
<th>Voyage Tonnage</th>
<th>Vessel ID</th>
<th>Transp. Tonnage</th>
<th>Transp. ID</th>
<th>Port of Call</th>
<th>Port of Call</th>
</tr>
</thead>
<tbody>
<tr>
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#### I. COMPARISON OF SHORE QUANTITIES IN CUSTODY TRANSFER

<table>
<thead>
<tr>
<th>Item</th>
<th>Bill of Lading</th>
<th>Outturn</th>
<th>Off Take</th>
<th>Net</th>
<th>Gain</th>
<th>Gain %</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCM</td>
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<td>17520</td>
<td>17520</td>
<td>17520</td>
<td>0</td>
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<tr>
<td>CBM</td>
<td>17520</td>
<td>17520</td>
<td>17520</td>
<td>17520</td>
<td>0</td>
<td>0%</td>
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#### II. VELOCITIES OR SHORE QUANTITIES AT (1) LOAD PORTS

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Port of Loading</th>
<th>Vessel Tonnage</th>
<th>Vessel ID</th>
<th>Rate (t/h)</th>
<th>TCM</th>
<th>CBM</th>
<th>Loaded</th>
<th>Difference</th>
<th>Difference %</th>
</tr>
</thead>
<tbody>
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#### III. VELOCITIES OR SHORE QUANTITIES AT (2) DISCHARGE PORTS

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Port of Discharge</th>
<th>Vessel Tonnage</th>
<th>Vessel ID</th>
<th>Rate (t/h)</th>
<th>TCM</th>
<th>CBM</th>
<th>Discharged</th>
<th>Difference</th>
<th>Difference %</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>

#### IV. VESSEL’S COMPARISON OF LOADING AND DISCHARGING PORTS: VSS TABLE MUST BE COMPLIANT

<table>
<thead>
<tr>
<th>Transp.</th>
<th>Difference</th>
<th>Difference %</th>
<th>TCM</th>
<th>CBM</th>
<th>Port of Loading</th>
<th>Port of Discharge</th>
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<th>Vessel ID</th>
<th>Rate (t/h)</th>
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</thead>
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</tr>
</tbody>
</table>

#### Comments

Transfer volume based on output from PPG 11 PVT.
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Insert Figure B.5 here

Figure E-6—Summary of Vessel-to-Vessel Transfers

<table>
<thead>
<tr>
<th>No. of Transfers</th>
<th>Lightning Position</th>
<th>Station/Air Only</th>
<th>Vessel Name</th>
<th>Vessel Name</th>
<th>Vessel Name</th>
<th>Vessel Name</th>
<th>Vessel Name</th>
<th>Vessel Name</th>
<th>Vessel Name</th>
</tr>
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<tbody>
<tr>
<td>Route</td>
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<td>33</td>
<td>22.83</td>
<td>22.83</td>
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<td>22.83</td>
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<td>33</td>
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<tr>
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<td>33</td>
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<td>33.07</td>
<td>33</td>
<td>22.83</td>
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<tr>
<td>3. Difference for Mother Vessel</td>
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DATA OF TRANSFERS

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Insert Figure B.6 here

<table>
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Figure B.5—Voyage Analysis Report (VAR)

### I. COMPARISON OF SHORE QUANTITIES IN CARGO FOOD TRANSFER

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<tr>
<th>Description</th>
<th>PV</th>
<th>FV</th>
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<tbody>
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### II. TERRESTRIAL QUANTITIES (in TONS)

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<tbody>
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### III. VESSEL QUANTITIES (in TONS)

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<th>Description</th>
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<th>FV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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### IV. COMPARISON OF LOADING AND DISCHARGE VOLUME

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<th>Description</th>
<th>PV</th>
<th>FV</th>
</tr>
</thead>
<tbody>
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</table>

### V. SUMMARY

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<th>Description</th>
<th>PV</th>
<th>FV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

**Prepared by**

Title

Company

Date/Completed (MDY)
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Insert Figure B.7 here.
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Insert Figure B.8 here