API *MPMS* Chapter 17.9/EI HM 49

Vessel Experience Factor (VEF)

Fourth Edition

XXX 202X

Contents

Introduction

There are usually differences between the quantity of a cargo measured in a calibrated shore tank or by a custody transfer meter, and the same cargo determined by vessel tank measurements.

A vessel is defined for this standard as a ship, tanker or a barge. The requirements of this standard apply equally to tankers and barges. For a given vessel, the use of quantity data from many voyages provides an indication of vessel measurement differences as a numerical ratio. This ratio can also include other load and discharge factors. For each voyage, a vessel load ratio (VLR) and vessel discharge ratio (VDR) can be calculated. The mean of the qualifying VLRs or theVDRs over several voyages is called the VEF (VEFL and VEFD for load and discharge, respectively).

The key aim of this document is to provide a single unambiguous figure for VEFL or VEFD and to remove the possibility of arbitrary inclusion or exclusion of data.

This document was developed by a joint American Petroleum Institute and Energy Institute Hydrocarbon Management Working Group.

Vessel Experience Factor (VEF)

1 Scope

This standard provides the calculation and application of a vessel experience factor (VEF). This standard provides guidance for data compilation, data maintenance, data validation, and recommendations on the appropriate use of a VEF involving vessels.

It also provides instruction for parcel tankers, compartmental VEFs, and vessel-to-vessel transfers. The methods are applicable to liquid bulk cargoes including crude oil, petroleum products, chemicals, and liquid petroleum gases.

2 Normative References

General

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.

API *MPMS*, Chapter 17.1, *Marine Measurement—Guidelines for Marine Cargo Inspection*

3 Terms and Definitions

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

3.1
clingage
The liquid film that adheres to the inside surface of a container after it has been emptied.

3.2
combination tow VEF
A VEF that is calculated using ratios derived from the combined totals of all barges operating in a tow formation.

3.3
compartmental VEF
A VEF based on ratios of only a specific vessel cargo compartment(s) configuration and corresponding shore quantities based on the standards as described for generating a valid VEF.

3.4
disqualified voyage
A voyage that is eliminated because the VLR or VDR differs by more than ±0.30 % of the mean vessel/shore ratio.

3.5
list
(a) The leaning or inclination of a vessel expressed in degrees port or degrees starboard;
(b) The transverse deviation of a vessel from the upright position, expressed in degrees.

3.6
list correction
The correction applied to the volume or gauge observed in a vessel's tank when the vessel is listing, provided that liquid is in contact with all bulkheads in the tank.

3.7
onboard quantity
OBQ
Refers to materials present in a vessel's cargo tanks, void spaces, and/or pipelines before the vessel is loaded. Onboard quantity includes a combination of water, oil slops, oil residue, oil/water emulsions, sludge, and sediment.

3.8
qualifying voyages
Voyages whose VLR or VDR are within the ±0.30 % of the mean vessel/shore ratio.

3.9
rejected `
A voyage that is eliminated due to the unsuitability of its cargo quantity determination.

3.10
remaining on board
ROB
Refers to material remaining in a vessel's cargo tanks, void spaces, and/or pipelines after the cargo is discharged. ROB includes any combination of water, oil, slops, oil residue, oil water emulsions, sludge, and sediment.

3.11
total calculated volume
TCV
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 also corrected by the applicable pressure correction factor (Cpl) and meter factor, plus all free water measured at observed temperature and pressure (gross standard volume plus free water).

3.12
trim
The condition of a vessel with reference to its longitudinal position in the water. It is the difference between forward and aft drafts and is expressed "by the head" or "by the stern."

3.13
trim correction
The correction applied to the volumes or gauge observed in a vessel's tank when the vessel is out of trim, provided that the liquid is in contact with all bulkheads in the tank. Trim correction may be accomplished by referring to the tri correction tables for each of the vessel's tank or by mathematical calculations.

3.14
vessel discharge ratio
VDR
The total calculated volume (TCV) by vessel measurement on arrival, less Remaining On Board (ROB), divided by the TCV by shore measurement at discharge.

3.15
vessel experience factor
VEF
A compilation of the history of the total calculated volume (TCV) vessel measurements, adjusted for onboard quantity (OBQ) or remaining onboard (ROB), to the TCV shore measurements. Separate VEF's should be developed for both load and discharge terminals. Preferably, information used in calculating a VEF should be based on documents that follow accepted industry standards and practices, such as inspection company reports.

3.16
vessel load ratio
VLR
The total calculated volume (TCV) by vessel measurement on sailing, less onboard quantity (OBQ), divided by the TCV by shore measurement at loading: [VLR =(TCV sailing volume – OBQ) / TCV received from shore at loading].

3.17
voyage number
An administrative number that may include one or many port calls with multiple load and/or discharge operations.

NOTE For the purpose of this standard, voyage numbering/designations are defined by the vessel and for simplicity referred to as “voyage” throughout this standard. In some cases, voyage numbers may not be available.

3.18
gross error voyage
Voyages where the VLR or VDR is less than 0.98000 or greater than 1.02000.

3.19
VEF voyage
A waterborne passage consisting of one or more cargoes carried from and to one or more load and discharge ports.

3.2 Acronyms

For the purposes of this document, the following acronyms apply.

B/L	bill of lading
CTPL	correction for the temperature and pressure of the liquid
OBQ	onboard quantity
ROB	remaining onboard
TCV	total calculated volume
VDR	vessel discharge ratio
VEF	vessel experience factor
VLR	vessel load ratio

4 Rationale and Data

4.1 VEF Rationale

The VEF is a loss control tool that can help determine whether differences measured between the vessel and the shore are typical. The VEF may then provide a reliable means for review of quantities loaded or discharged and provide meaningful cargo reconciliation.

As a result of differences between load and discharge operations, the load and discharge VEFs will not typically have the same values and therefore the load and discharge data shall be maintained separately.

When agreed, Bill of Lading or outturn quantities may be determined based on vessel received or delivered quantities adjusted by the VEF. In the event of a dispute regarding the application, or absence of an applicable VEF (load or discharge), resolution shall be made by the commercial parties involved.

4.2 Primary and Alternate Methods

This document provides a primary method for calculating a VEF. The primary method uses ±0.30 % of the mean vessel/shore ratio for outlier rejection and is the ratio of the sum of all qualifying voyages. See section 6.

If the primary method does not produce a VEF, then the alternate method should be used. The alternate method provides a statistical outlier rejection technique and uses an average of qualifying ratios. See Annex F Alternate Calculation Method.

4.3 Measurement Data

All measurement data used shall be based on consistent and recognized measurement standards for custody transfer purposes.

Vessel and shore calculations for each VEF line entry shall be based upon the same measurement standards to arrive at TCV, such as volume correction factors (CTPL), ROB/OBQ determinations, wedge calculations, and trim/list corrections.

Where TCV is stated in this document its weight equivalent may be used, as appropriate. TCV calculated using non-petroleum products are still considered for this document.

4.4 Data Gathering

Data required for VEF calculation shall be collected and recorded by the vessel for everyvoyage. The data should be in a clear, understandable format, as illustrated in the sample log presented in Annex A. The vessel is responsible for maintaining separate logs for both load and discharge operations and for making these records available.

When vessel records are unavailable or incomplete, data may have to be compiled from inspection company records. Data not provided by the vessel or independent inspection companies can only be used if agreed to by the commercial parties.

5 Primary Method Voyage Qualification and Rejection Criteria

5.1 Number of Voyages

The most recent 20 voyages shall be used, or as many as are available, up to a maximum of 20.

The vessel shall maintain data to support the calculation of the VEF by using the example form in Annex A. These data include:

a) Load (or discharge) date

b) Voyage number

c) Port (or ports for a multi-port voyage)

d) Cargo description

e) Vessel sailing TCV (or Vessel Arriving TCV)

f) OBQ TCV (or remaining on board (ROB) TCV)

g) Vessel loaded (or vessel discharged)

h) Vessel CTPL basis

i) Shore load TCV (or shore discharge TCV)

j) Shore CTPL basis

k) Load B/L basis (or discharge basis)

l) Comments (as applicable)

All voyages shall be listed in sequential order, with the most recent voyage first. Any multi-port/multi-grade

voyages shall be combined prior to adding to the list and a comment added to the worksheet to reflect this combination of ports into a single entry. The current voyage, whether part or full, shall not be included.

5.2 Rejected Voyages

The following voyages shall not be used in the calculation:

a) Gross error voyages
b) A voyage where any vessel tank measurements were used to establish the custody transfer quantity. This includes multi-parcel voyages where custody transfer quantities were based on a combination of both shore and vessel measurements.

Note: - quantities determined onboard FPSOs using meters in accordance with globally recognized standards are acceptable.

c) All voyages prior to any changes requiring the issuance of new capacity tables.
Note: Example of changes can be but not limited: measurement equipment, tables, vessel's structure, or other changes.

No voyages shall be excluded beyond the reasons given above, unless specifically agreed by all commercial parties.

6 Primary Method Calculation of a VEF

6.1 List the data for as many recent voyages as are available, up to a maximum of 20 voyages. For VEFL, use only load data and for VEFD use only discharge data.

a) The inspector is responsible for calculating the VEF.

b) These shall be the most recent voyages available and listed in chronological order; do not use the current voyage.

c) Quantities should be combined for multiple grades or parcels on the same voyage.

d) Units shall be consistent on the entire form, i.e., US barrels, cubic meters, metric tons, long tons, and rounded to the nearest whole number. If units are mixed, then the alternate method shall be used.

6.2 Calculate individual vessel/shore ratios for each voyage, rounding to five decimal places.

NOTE: When the figure to the right of last place to be retained is five or greater, the figure in the last place to be retained should be increased by one. If the figure to the right of the last place to be retained is less than five, the figure in the last place retained should be unchanged.

6.3 Exclude all rejected voyages from the calculation (see 5.2).

Calculate the mean vessel/shore ratiofrom the total remaining quantities rounding to five decimal places.

6.4 Exclude all disqualified voyages.

6.5 If at least five qualifying voyages remain, calculate the VEF from the qualifying voyages as follows:

a) Sum, the vessel quantities and shore quantities.

b) Divide total vessel quantity by total shore quantity.

c) Calculate and round to four decimal places to produce the VEF.

d) If there are not five qualifying voyages, then the VEF cannot be calculated and shall be reported as "Not Available"

7 Use and Application of the VEF

7.1 General

The vessel experience factor is a tool that is used primarily for loss control purposes in voyage reconciliation. The VEF can be used for the determination of custody transfer quantities when other contractual measurements are not available (e.g. active shore tanks) or when agreed by commercial parties.

7.2 Load and Discharge VEF

The VEFL should be applied to the vessel TCV loaded figure to compare with the shore TCV delivered figure.

The VEFD should be applied to the vessel TCV discharged figure to compare with the shore TCV received figure.

In the absence of a VEF (load or discharge) see section 4.1.

7.3 Compartmental VEF

Given the variation of tank combinations and tank load conditions, a VEF may be calculated for any tank or tank combination for which there is enough specific data to calculate such a VEF as per the requirements of this standard. In such cases, individual logs shall be maintained for each configuration or combination.

7.4 Combination Tow VEF

Multiple barges may be loaded with the shore tank only gauged at the beginning of the first barge and closed after the last barge is loaded. A combination tow VEF may be calculated for this combination tow provided that sufficient data is available from prior transfers using the same combination tow and the basic rules for qualification are followed

A combination-tow VEF should be applied if it is available. If a combination-tow VEF is not available, individual VEFs should be applied to each individual barge.

The voyage records should be maintained for each barge tow combination by adding the total shore TCV and the sum of all the vessel TCVs from all barges involved.

Annex A
(informative)

EXAMPLE OF A PRIMARY VEF METHOD WORKSHEET

A.1 A Primary VEF Method Worksheet should contain the following load information.

Example of Primary VEF Method
M/T Popsicle - Load Port VEF Worksheet

Unit of Measurement shall be consistent on the entire form (shore-vessel and all rows in data set)

					Quantities in [Unit of Measurement]										
					Vessel Sailing		Vessel		Shore		Load	Vessel /			
Sequential Voy #	Date	Voyage Number	Port	Cargo	TCV	OBQ	Loaded TCV	CTPL Basis	TCV (B/L)	CTPL Basis	B/L Basis	Shore Ratio	* Rejected Voyage	Qualifying Voyage	Comments
1	27/02-05/03/18	18-04A&B	Equitorial Guinea & Nigeria	Forcados; Aseng	684,436	124	684,312	54A	684,300	54A	Shore	1.00002	No	Yes	
2	2/14/18	18-03	Libya	Crude Oil	603,640	0	603,640	54A	602,180	54A	Shore	1.00242	No	No	
3	2/2/18	18-02	Russia	Crude Oil							Shore		Yes		Gross Error
4	1/16/18	18-01	Algeria	Crude Oil	666,623	101	666,522	54A	668,232	54A	Shore	0.99744	No	Yes	
5	10/27/17	17-17	Venezuela	Morichal 16	600,150	20	600,130	5A	600,501	5A	Shore	0.99938	No	Yes	
6	10/1/17	17-16A&B	Gabon	Crude Oil	714,083	65	714,018	54A	715,061	54A	Shore	0.99854	No	Yes	
7	9/2-9/8/17	17-15A&B	Saudi Arabia & UAE	Arab Light, LSC	670,893	64	670,829	54A	673,712	54A	Shore	0.99572	No	Yes	
8	8/10/17	17-14	Italy	Fuel Oil							Ship		Yes		Vsl figures with VEF applied
9	7/22/17	17-13	Russia	Crude Oil	673,499	256	673,243	54A	673,945	54A	Shore	0.99896	No	Yes	
10	7/10/17	17-12	Ukraine	VGO	586,302	27	586,275	6B	586,654	6B	Shore	0.99935	No	Yes	
11	6/14/17	17-11	Saudi Arabia, Kuwait	Arab Med; Kuwait	597,876	152	597,724	54A	598,473	54A	Shore	0.99875	No	Yes	
12	6/2/17	17-10	UAE	Fuel Oil							Ship		Yes		Ship to ship transfer
13	5/5/17	17-09	Indonesia	Crude Oil	679,994	65	679,929	5A	680,845	5A	Shore	0.99865	No	Yes	
14	4/3-4/6/17	17-08A,B&C	Estonia	Fuel Oil	650,112	75	650,037	6B	650,953	6B	Shore	0.99859	No	Yes	
15	3/3/17	17-07	Trinidad	Crude Oil	627,714	82	627,632	5A	627,944	5A	Shore	0.99950	No	Yes	
16	2/24/17	17-06	Bahamas	Naphtha	550,042	36	550,006	6B	550,335	6B	Shore	0.99940	No	Yes	
17	2/8/17	17-04	Bahamas	Naphtha							Ship		Yes		Lightering
18	2/1/17	17-03	St. Lucia	Crude Oil	645,973	0	645,973	5A	648,815	5A	Shore	0.99562	No	No	
19	1/15/17	17-02	Mexico	Maya Crude Oil	457,716	15	457,701	5A	458,477	5A	Shore	0.99831	No	Yes	
20	1/3/17	17-01	Curacao	Crude Oil							Ship		Yes		Lightering
				Sum of all non-rejected quantities			9,407,971		9,420,427						
				Mean Vessel/Shore Ratio			0.99868								
				+/- 0.30% of the Mean Vessel/Shore Ratio			0.99568		1.00168						
				Sum of all qualifying quantities			8,158,358		8,169,432						
				Vessel Experience Factor			**0.9986**								

Calculated as **(Mean Vessel/Shore Ratio * 0.997)** and **(Mean Vessel/Shore Ratio * 1.003)** with each value rounded to 5 Decimal places

*** Rejected Voyages**
As defined by Section 5.2
Reason(s) for voyage rejection should be listed under Comments

Figure A.1—Load Information

A.2 A Primary VEF Method Worksheet should contain the following discharge information.

Example of Primary VEF Method
M/T Popsicle - Discharge Port VEF Worksheet

Unit of Measurement shall be consistent on the entire form (shore-vessel and all rows in data set)

					Quantities in [Unit of Measurement]										
					Vessel Arrival		Vessel		Shore		Discharge	Vessel/			
Sequential Voy #	Date	Voyage Number	Port	Cargo	TCV	ROB	Discharged TCV	CTPL Basis	TCV (Outturn)	CTPL Basis	Outturn Basis	Shore Ratio	* Rejected Voyage	Qualifying Voyage	Comments
1	27/02-05/03/18	18-04A&B	Wilmington, Ca	Forcados; Aseng	684,436	124	684,312	54A	684,300	54A	Shore	1.00002	No	Yes	
2	2/14/18	18-03	Torrance, Ca	Crude Oil	603,640	0	603,640	54A	602,180	54A	Shore	1.00242	No	No	
3	2/2/18	18-02	Baytown Refinery, Tx	Crude Oil							Shore		Yes		Gross Error
4	1/16/18	18-01	Loop Terminal, La	Crude Oil	666,623	101	666,522	54A	668,232	54A	Shore	0.99744	No	Yes	
5	10/27/17	17-17	Altona Refinery, Australia	Morichal 16	600,150	20	600,130	5A	600,501	5A	Shore	0.99938	No	Yes	
6	10/1/17	17-16A&B	Antwerp, Belgium	Crude Oil	714,083	65	714,018	54A	715,061	54A	Shore	0.99854	No	Yes	
7	9/2-9/8/17	17-15A&B	Mossel Bay, South Africa	Arab Light, LSC	670,893	64	670,829	54A	673,712	54A	Shore	0.99572	No	Yes	
8	8/10/17	17-14	Cherry Point, Wa	Fuel Oil							Ship		Yes		Vsl figures with VEF applied
9	7/22/17	17-13	Nederland, Tx	Crude Oil	673,499	256	673,243	54A	673,945	54A	Shore	0.99896	No	Yes	
10	7/10/17	17-12	Fawley Refinery, England	VGO	586,302	27	586,275	6B	586,654	6B	Shore	0.99935	No	Yes	
11	6/14/17	17-11	Whiffen Head Terminal, NL	Arab Med; Kuwait	597,876	152	597,724	54A	598,473	54A	Shore	0.99875	No	Yes	
12	6/2/17	17-10	Long Beach, Ca	Fuel Oil							Ship		Yes		Ship to ship transfer
13	5/5/17	17-09	Texas City, Tx	Crude Oil	679,994	65	679,929	5A	680,845	5A	Shore	0.99865	No	Yes	
14	4/3-4/6/17	17-08A,B&C	Richmond, Ca	Fuel Oil	650,112	75	650,037	6B	650,953	6B	Shore	0.99859	No	Yes	
15	3/3/17	17-07	Chalmette, La	Crude Oil	627,714	82	627,632	5A	627,944	5A	Shore	0.99950	No	Yes	
16	2/24/17	17-06	Omisalj, Croatia	Naphtha	550,042	36	550,006	6B	550,335	6B	Shore	0.99940	No	Yes	
17	2/8/17	17-04	Whangarei Refinery, NZ	Naphtha							Ship		Yes		Lightering
18	2/1/17	17-03	Beaumont, Tx	Crude Oil	645,973	0	645,973	5A	648,815	5A	Shore	0.99562	No	No	
19	1/15/17	17-02	Tranmere, England	Maya Crude Oil	457,716	15	457,701	5A	458,477	5A	Shore	0.99831	No	Yes	
20	1/3/17	17-01	Sault Ste. Marie, ON	Crude Oil							Ship		Yes		Lightering
				Sum of all non-rejected quantities			9,407,971		9,420,427						
				Mean Vessel/Shore Ratio			0.99868								
				+/- 0.30% of the Mean Vessel/Shore Ratio			0.99568		1.00168						
				Sum of all qualifying quantities			8,158,358		8,169,432						
				Vessel Experience Factor			**0.9986**								

Calculated as **(Mean Vessel/Shore Ratio * 0.997)** and **(Mean Vessel/Shore Ratio * 1.003)** with each value rounded to 5 Decimal places

*** Rejected Voyages**
As defined by Section 5.2
Reason(s) for voyage rejection should be listed under Comments

Figure 2—Discharge Information

A.3 A Primary VEF Method Worksheet should contain the following load or discharge information.

a) Load or discharge date

b) Vessel's voyage number

c) Load or discharge port

d) Cargo description

e) Vessel departure or arrival TCV

f) OBQ or ROB

g) Vessel load or discharge TCV

h) Vessel CTPL basis

i) Load bill of lading or discharge outturn TCV

j) Shore CTPL basis

k) Basis of bill of lading or outturn TCV determination—shore, vessel with VEF, vessel without VEF

l) Vessel/shore ratio

m) Rejected voyage

n) Qualifying voyage

o) Comments

Note: Where TCV is stated, its weight equivalent may be used. See section 4.3.

A.4 It is important not to simply take all of the information presented on a Primary Method Worksheet at face value, but to review it for possible inconsistencies. For the example shown above, some points that should be raised with the vessel's officer-in-charge are (but not limited to) the following.

a) Why is there is a missing voyage on the voyage log (e.g. Voyage 17-05)?

b) What was the vessel doing for the approximate 11-week period between Voyages 17-17 and 18-01?

c) Are consistent units of measurement used throughout the form?

d) Verify voyage entries where vessel and shore TCV are the same, although possible is most likely vessel figures on an active tank job or alike.

e) Request to see raw data to support information on the voyage log.

Where issues such as these cannot be adequately explained by the vessel's officer-in-charge/operator, appropriate notations should be made on the VEF report and a letter of protest (LOP) issued to the vessel.

Annex B
(informative)

Operations at Multiple Ports or Berths

B.1 General

Operations at multiple ports or berths that have no available shore measurement for part of the operation can be best explained by means of examples. The calculation detailed in Annex B is for information only and any figures calculated by this method are not to be included in the final calculation of a VEF.

When multiple loadings or discharges occur, one of which there is no shore measurement, the quantity at that location may be determined by subtracting the total static shore volumes from the VEF adjusted vessel delivered/received quantity. See example in Annex B.

B.2 Example 1—Loading

The use of a VEF can be applied to calculate a parcel where a shore figure is not available. A vessel loads gas oil at three terminals within a port. Terminal A and B have shore measurements and Terminal C loads on running gauges without any metering. The VEFL is 1.0013.

Terminal	Shore TCV	Vessel Loaded TCV
A	72,323	72,401
B	113,678	113,878
C	Not measured	67,892
Total		254,171
VEF 1.0013 applied		253,841

Table B.1—Example Calculation 1

The quantities loaded as measured from Terminals A and B are subtracted from the VEF adjusted loaded quantity.

VEF adjusted l) vessel received	253,841
Terminal A shore figures	-72,323
Terminal B shore figures	-113,678
Calculated Terminal C shore figures	67,840

B.3 Example 2—Discharging, Discharge VEF Available

A vessel discharges crude oil at two terminals; Terminal A has outturn measurements and Terminal B is unable to make any shore measurements. The VEFD is 1.0002.

Terminal	Shore TCV	Vessel Discharged TCV
A	429,877	429,189
B	Not measured	85,813
Total		515,002
VEFD 1.0002 applied		514,899

Table B.2—Example Calculation 2

The outturn quantity from Terminal A is subtracted from the VEF adjusted discharged quantity.

VEF adjusted vessel discharged	514,899
Terminal A outturn	-429,877
Calculated outturn for Terminal B	85,022

Annex C
(informative)

Factors Affecting VEF Data

C.1 General

Reliable VEFs are derived from accurate data. Particular attention should be given to obtaining the current information and ensuring that the gauge locations, equipment, calibration tables, and procedures are consistently used onboard the vessel. Every reasonable effort should be made to mitigate the factors listed in this section in order to obtain a reliable VEF. The various factors mentioned are not seen as reasons to exclude particular data, but rather are mentioned as potential causes that may lead to the variability that the calculation method addresses.

C.2 Potential Biases to Data

C.2.1 Facility Bias

VEFs based on data from one facility may reflect bias inherent in that facility, including but not limited to:

- Tank calibrations
- Meter accuracy
- Manual gauging accuracy – level measurement and temperature
- Auto tank gauging accuracy – level measurement and temperature
- Line fullness
- Limitations on obtaining accurate measurements
- Calculations

C.2.2 Undetected Quantities

Clingage, or undetected quantities, may vary depending on the physical characteristics of the cargo, the ambient air and sea temperature, the type and capabilities of the vessel, the number of tanks, the cargo temperature throughout the voyage and during load or discharge, and the conditions under which the load or discharge are performed.

For example, the vessel discharge amount is likely to be overstated by an amount of undetected cargo ROB. This results in the measured ROB, in almost every case, being less than the cargo OBQ measured at the subsequent load port,assuming consistent measurement processes.

C.2.3 Buildup of Sediments/Sludge Over Time

Over time, crude oil carriers can accumulate sludge deposits. This quantity of sludge is removed when tanks are prepared for drydock. The hard sludge is removed when vessel is in drydock.

Sludge buildup depends on several factors, for example:

- the characteristics of the crude oil
- number and duration of the voyages,
- cargo temperature/heating and surrounding environment,
- type and frequency and efficiency of crude oil washing operations,
- Vessel tank design

This may account for the variation in the VLR and VDR from one drydock to the next.

C.2.4 Change of Cargo Service and Cargo Temperature

The VEF may be affected when a vessel changes service between heavy/high-viscosity products and light/low-viscosity products. For cargoes whose flow characteristics are poor at ambient temperatures, it is likely that the vessel will retaina larger amount of undetected ROB during colder weather; this could also be the case if discharge cargo temperature was significantly lower than load port cargo temperature.

C.3 Data Accuracy

Inconsistent measurement procedures and practices will increase data variability and lead to a less consistent VEF. The following should be avoided.

a) Imprecise or varying gauge reference points
b) Use of different types of gauging equipment (i.e. closed-system equipment or automated tank gauging equipment vs. manual equipment)
c) Outdated, incorrect, or inconsistent gauge, calibration, or correction tables
d) Vessels' computerized calibration tables (unless independently verified against certified calibration tables).

C.4 Lack of Voyage Data

Where a vessel has been in dedicated STS service or has recently changed ownership, the voyage data may not be sufficient or available to calculate a VEF.

For dedicated STS service it is possible to refer back at previous voyages past the latest available which may provide sufficient minimum qualifying voyages in order to calculate a VEF for loss control purposes. The use of this VEF for custody transfer determination shall be agreed between commercial parties.

For change of owner, it is possible to use data from previous records. The records can be found by referring to the vessel registration identifier (e.g. IMO) or the previous names of the vessel (ensuring the registration identifier is identical).

Annex D
(informative)

Measurement Limitations

D.1 General

Most measurement limitations have the potential to impact a VEF and they do not qualify to reject a voyage, the criteria for which are specified in Section 5. The following information may be considered in evaluating the VEF.

D.2 Reason for Vessel–Shore Quantity Differences

A vessel's quantity and shore quantity can differ for a number of reasons, including:

a) the inherent inaccuracies associated with measuring cargo found on board prior to loading (OBQ) or remaining on board after discharge (ROB), including undetected clingage;

b) inaccuracies in the vessel's engineering and architectural quantity calculations and measurement tables, including wedge calculations, trim, and list corrections;

c) modifications to vessel or shore tanks;

d) measurement errors.

e) volumetric shrinkage.

f) partly full or empty vessel or shore lines.

g) shore tank or meter calibration errors.

h) evaporative losses;

i) permanent or temporary shore tank deformation;

j) permanent or temporary vessel deformation, i.e. hogging or sagging;

k) weather conditions affecting measurement.

l) Volume of vessel lines included/not included in vessel tank calibration tables.

m) non-standard procedures used to determine vessel and shore quantities.

D.3 Vessel Calibration Tables

Calibration (ullage/innage) tables for each compartment (tank) should reflect the current configuration, capacity of tanks and lines, and gauge point locations. The tables should clearly identify and provide the following information:

a) current vessel name;

b) validated by classification society or independent organization recognized in tank calibration

c) tank/compartment number;

d) gauge location;

e) reference height;

f) reference point;

g) method of gauging (open/closed, manual/automatic, ullage/innage);

h) trim and list corrections;

i) wedge tables (or wedge data);

j) Volume of vessel lines included/not included in vessel tank calibration tables.

Cargo tanks should be calibrated by physical measurement rather than computations made from design drawings. Any inaccuracy of the vessel calibration tables will be reflected in the VEF. In the case of n ew vessel or barge construction, cargo tanks should be calibrated at the shipyard by an independent third party, using industry standards. The vessel's tanks should be recalibrated if structural changes have been made that affect measurement.

It is recommended that vessels that do not require class certification (i.e. barges) be physically calibrated based on current industry standards.

It is essential to use current calibration tables based on the correct reference point for the measurement equipment used.

D.4 Sea Conditions

Vessel quantities may be overstated or understated at locations where the vessel is gauged during periods of rolling seas or heavy swells, as is often the case at offshore facilities and during vessel-to-vessel transfers.

D.5 Vessel-to-Vessel Transfers

a.) When vessel-to-vessel transfers are undertaken, the custody transfer figures can be calculated in a number of ways with or without VEF applied. This can lead to a vessel having a voyage history without sufficient data necessary to calculate a VEF.

Annex E
(Informative)

The Role of the Vessel

E.1 General

The vessel should provide, maintain, and ensure availability of the most current certified and valid cargo tank calibration tables, including tank capacities, trim, list, wedge data tables, and cargo line volumes.

The vessel should establish a system for efficient data storage conforming to this standard. The vessel is responsible for the maintenance and retrieval of data to allow for accurate VEF determination for both load and discharge. This can include the data gathering form provided by the inspector, see Annex G.

E.2 Equipment and Gauge Referenced Points

The same gauging location(s) should be used for each compartment as identified on the calibration tables, i.e. gauged from the same location at load and discharge port. The equipment should be calibrated.

The type of gauging equipment and reference point should consistently be used, i.e.open/closed, manual/ automatic, ullage/innage. The reference location (i.e. lip of valve, hatch flange, or edgeof flame screen rest) should be clearly identified at each gauging point.

Annex F
(Normative)
Alternate Calculation Method

This should be used when the primary method does not provide a VEF value or where the units of measure are mixed e.g. barrels and metric tons.

F.1 Background

Chapter 17.9 3rd. Edition Alternate Method originated in the Dixon Q-test analysis and its application is as alternate to the Primary Method when certain conditions are met.

The original Q-Test document from Dean and Dixon circa 1953 and few articles by David Rorabacher who appears on several other pieces as reference.

1. Dixon Q-test is a simplified method to determine if a value is an outlier in a data set.

2. The Original VEF Chapter Alternate Method (from Ch 17.1 Annex C prior to Ch 17.9 2004 and current 2019 standard) are a modified 'modified Dixon Q-test for multiple outliers', it follows the single outlier principle and then loops over all the remaining values in the data set eliminating them until no more are discarded.

3. The alternate calculation method employs a statistical method for establishing the reliability of individual load (or discharge) ratios and for estimating the confidence limits (probability = 90 %) for the range of acceptable values.

4. The data set to include up to 20 voyage records and 5 qualifying minimum was set by the Chapter 17.9 workgroup and intended to maintain consistency in record keeping and reporting among the two methods.

F.2 Statistical Basis and Significance

The alternate calculation method employs a statistical method for establishing the reliability of individual load (or discharge) ratios and for estimating the confidence limits (probability = 90%) for the range of acceptable values.

F.3 Voyage Criteria

Data from a minimum of five qualified voyages is needed to calculate a VEF.

F.4 Calculation

In this method, only vessel load ratios or vessel discharge ratios, which are statistically significant at the 90% probability level, are included in the calculation of the VEF. The implementation procedure in this Annex is the standard, not the spreadsheet.

a) The Inspector is responsible for calculating the VEF. List the data for as many voyages as are available, up to a maximum of 20 voyages.

    1) These shall be the most recent voyages available and listed in chronological order. Do not use the current voyage.

b) Quantities should be combined for multiple grades on the same voyage, unless a compartmental VEF is being calculated.

c) Do NOT include both load and discharge information on the same form.

d) Data from different voyages do not need to be in consistent units and can be mixed, i.e. some voyages

measured in barrels and some in tons. However, vessel and shore data for each individual voyage shall be in consistent units and shall not be mixed.

e) Calculate the individual ratio for each voyage, rounding to five decimal places.

f) Report the final VEF to four decimal places.

F.5 Rejected Voyages

a) A voyage where any vessel tank measurements were used to establish the custody transfer quantity. This includes multi-parcel voyages where custody transfer quantities were based on a combination of both shore and vessel measurements.

Note: Quantities determined onboard FPSOs using meters in accordance with globally recognized standards are acceptable.

b) All voyages prior to any changes requiring the issuance of new capacity tables.
Note: Example of changes can be but not limited: measurement equipment, tables, vessel's structure, or other changes.

No voyages shall be excluded beyond the reasons given above, unless specifically agreed to by all commercial parties.

F.6 Process

The calculation routine is as follows for either load data or discharge data:

Step (a): Let there be n admissible VLR or VDR. List these in ascending order and label r_1 to r_n.

Step (b): Establish whether or not r_1 or r_n are statistically significant at the 90 % probability level. To do this:

1) Calculate the terms RL and RH, according to the following formula:

For n = 3 to 7 inclusive:

$$R_L = \frac{r_2 - r_1}{r_n - r_1} \quad \text{and} \quad R_H = \frac{r_n - r_{n-1}}{r_n - r_1}$$

For n = 8 to 10 inclusive:

$$R_L = \frac{r_2 - r_1}{r_{n-1} - r_1} \quad \text{and} \quad R_H = \frac{r_n - r_{n-1}}{r_n - r_2}$$

For n = 11 to 13 inclusive:

$$R_L = \frac{r_3 - r_1}{r_{n-1} - r_1} \quad \text{and} \quad R_H = \frac{r_n - r_{n-2}}{r_n - r_2}$$

For n = 14 to 20 inclusive:

$$R_L = \frac{r_3 - r_1}{r_{n-2} - r_1} \quad \text{and} \quad R_H = \frac{r_n - r_{n-2}}{r_n - r_3}$$

2) Compare values of R_L and R_H with the critical value corresponding to the value of n shown in Table F.1.

3) Delete r_1 if the value of R_L is greater than the critical value as determined in (ii).

4) Delete r_n if the value of R_H is greater than the critical value as determined in (ii).

Step (c): If, as a result of Step b, any VLR or VDR have been deleted, re-label the remaining VLR or

VDR as r_1 to r_n.Repeat Step b until no more VLR or VDR are deleted.

Step (d): Calculate the average (mean), r, to five decimal places, using the sum of remaining ratios divided by the number of ratios.

Step (e): Round the average, r, to four decimal places and record it.

1) Compare values of R_L and R_H with the critical value corresponding to the value of n shown in Table F.1.
2) Delete r_1 if the value of R_L is greater than the critical value as determined in (ii).
3) Delete r_n if the value of R_H is greater than the critical value as determined in (ii).

Example of Calculation for Load Data

Step (a): List VLR in ascending order and label r_1 to r_{10}:

Voyage Number	VLR	Label
9	0.99755	r_1
10	0.99858	r_2
8	0.99906	r_3
1	0.99986	r_4
7	1.00086	r_5
3	1.00105	r_6
5	1.00225	r_7
4	1.00278	r_8
6	1.00548	r_9
2	1.01207	r_{10}

Step (b):

1) Since the number of VLR is 10, calculate R_L and R_H for n = 10.

$$R_L = \frac{r_2 - r_1}{r_9 - r_1} = \frac{0.99858 - 0.99755}{1.00548 - 0.99755} = \frac{0.00103}{0.00793} = 0.130$$

$$R_H = \frac{r_{10} - r_9}{r_{10} - r_2} = \frac{1.01207 - 1.00548}{1.01207 - 0.99858} = \frac{0.00659}{0.01349} = 0.489$$

2) Compare R_L = 0.130 and R_H = 0.489 with the critical value at the 90 % probability level corresponding to n = 10 shown in Table F.1, i.e. 0.477.

3) As R_L = 0.130 is less than the critical value of 0.477, do not delete r_1.

4) As R_H = 0.489 is greater than the critical value of 0.477, delete r_{10}.

Step (c): Re-label the remaining ratios r_1 to r_9. Repeat Step (b) and confirm that in this example, no more VLR have been deleted.

Step (d): Calculate the mean, r, of the nine remaining ratios to four decimal places, and report as the vesselexperience factor: r = 1.0008

Table F.1—Critical Values at the 90 % Probability Level

n	Critical Value
3	0.941
4	0.765
5	0.642
6	0.560
7	0.507
8	0.554
9	0.512
10	0.477
11	0.576
12	0.546
13	0.521
14	0.546
15	0.525
16	0.507
17	0.490
18	0.475
19	0.462
20	0.450

Annex G
(Informative)

Voyage Data Gathering Form

G.1 General

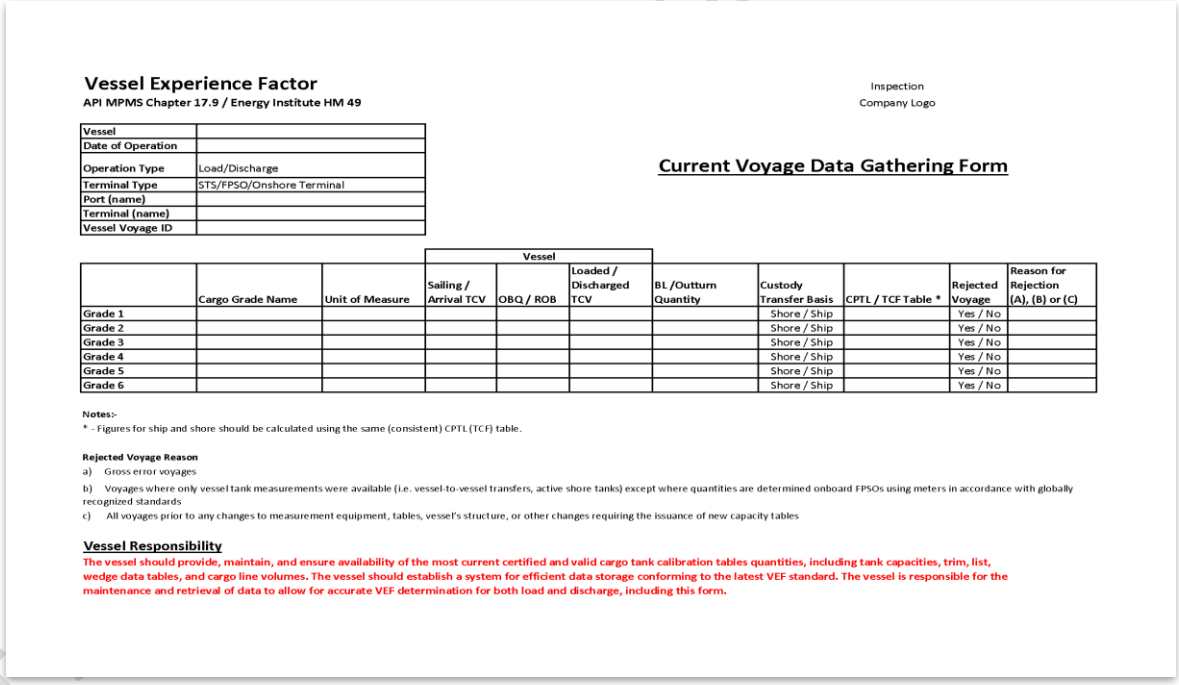
It is recognized that data gathering is a critical aspect to ensuring an accurate vessel experience factor. It is mentioned earlier within section 5.1 that the responsibility for providing the data to calculate the VEF remains with the vessel personnel, however, not all the shore information is made available, an example of this will be the CPTL / Table and method used for the Bill of Lading as the raw data used is not provided to the vessel. In such cases, some of the data will be assumed and potentially create differences from one port to another.

G.2 Data Gathering Form

To try and address the above-known issue, a data gathering form has been created and would be completed by the attending inspector and left with the vessel personnel at the end of the transfer (loading/discharge) at a particular port. A new form will be used for each port, even if it is part of the same voyage.

Although this form is primarily used for load operations and calculating the VEFL, this can also be adapted to collect the discharge information to enable a VEFD to be established.

This form should be used as a supplementary document to help improve accurate data recording for VEF calculations, and to verify the voyage data reported on the vessel's sequential log and/or VEF report.



Vessel Experience Factor

API MPMS Chapter 17.9 / Energy Institute HM 49

Inspection
Company Logo

Vessel	
Date of Operation	
Operation Type	Load/Discharge
Terminal Type	STS/FPSO/Onshore Terminal
Port (name)	
Terminal (name)	
Vessel Voyage ID	

Current Voyage Data Gathering Form

			Vessel							
	Cargo Grade Name	Unit of Measure	Sailing / Arrival TCV	OBQ / ROB	Loaded / Discharged TCV	BL /Outturn Quantity	Custody Transfer Basis	CPTL / TCF Table *	Rejected Voyage	Reason for Rejection (A), (B) or (C)
Grade 1							Shore / Ship		Yes / No	
Grade 2							Shore / Ship		Yes / No	
Grade 3							Shore / Ship		Yes / No	
Grade 4							Shore / Ship		Yes / No	
Grade 5							Shore / Ship		Yes / No	
Grade 6							Shore / Ship		Yes / No	

Notes:-

* - Figures for ship and shore should be calculated using the same (consistent) CPTL (TCF) table.

Rejected Voyage Reason

a) Gross error voyages

b) Voyages where only vessel tank measurements were available (i.e. vessel-to-vessel transfers, active shore tanks) except where quantities are determined onboard FPSOs using meters in accordance with globally recognized standards

c) All voyages prior to any changes to measurement equipment, tables, vessel's structure, or other changes requiring the issuance of new capacity tables

Vessel Responsibility

The vessel should provide, maintain, and ensure availability of the most current certified and valid cargo tank calibration tables quantities, including tank capacities, trim, list, wedge data tables, and cargo line volumes. The vessel should establish a system for efficient data storage conforming to the latest VEF standard. The vessel is responsible for the maintenance and retrieval of data to allow for accurate VEF determination for both load and discharge, including this form.

Figure G.1 – Voyage Data Gathering Form Example

G.3 Actions for the Inspector

The attending inspector should complete the above example form for each port with a separate line for each grade loaded at that port and leave with the vessel personnel. If it is not possible or practicable to leave the completed form on board, every effort should be made to transfer this form electronically to the vessel after the operation.

G.4 Responsibility for the Vessel

The Vessel personnel will store this data form with their vessel paperwork for the voyage or in a separate VEF folder for ease of access. This should be provided to a cargo inspector when requested to enable extraction of the data into a VEF page.

It is recommended that the vessel personnel should also utilize this data to update their own records, in line with this standard, as this should ensure consistent data being used by the vessel and the inspection companies. Should a discrepancy be observed between the data recorded on the voyage data gathering form and the vessel's sequential log / VEF report, then this should be investigated and noted.

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[4] API *MPMS*, Chapter 5, *Metering* (all sections)

[5] API *MPMS*, Chapter 12.1, *Calculation of Static Petroleum Quantities*

[6] API *MPMS*, Chapter 12.2, *Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors*

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[8] API *MPMS*, Chapter 17.12/EI HM 51, *Procedures for Bulk Liquid Chemical Cargo Inspections*

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