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Bunker cargo loading from oil terminal to bunker tanker using Coriolis mass flow meter

Chargement d'une cargaison de soute depuis le terminal pétrolier vers un navire avitailleur à l'aide d'un compteur massique à effet Coriolis

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 2, *Measurement of petroleum and related products.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The objective of this document is to harmonize the method of quantity measurement by establishing a consistent method of measurement from cargo loading at oil terminals to bunker delivery using a Coriolis mass flow meter (MFM). This is to ensure oil loss control along the bunker supply chain.

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capability.

Bunker cargo loading from oil terminal to bunker tanker using Coriolis mass flow meter

1 Scope

This document specifies quantity measurement using a Coriolis mass flow meter (MFM) for bunker cargo loading from an oil terminal to a bunker tanker during custody transfer. Sampling requirements during the custody transfer are also included in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 3170, *Petroleum liquids — Manual sampling*

ISO 3171, *Petroleum liquids — Automatic pipeline sampling*

ISO 6996, *Bunkering — Meter verification using master Coriolis mass flow meter*

ISO 8217, *Petroleum products — Fuels (class F) — Specifications of marine fuels*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

OIML R 117-1, *Dynamic measuring systems for liquids other than water — Part 1: Metrological and technical requirements*

API MPMS Chapter 4.8, *Manual of Petroleum Measurement Standards, Chapter 4.8 Operation of Proving Systems*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
accuracy
closeness of agreement between a measured quantity value and a true quantity value of a measurand

[SOURCE: ISO/IEC Guide 99:2007, 2.13, modified — Preferred terms “measurement accuracy” and “accuracy of measurement” deleted. Notes to entry deleted.]

3.2
adjustment
set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment include zero adjustment and offset adjustment.

Note 2 to entry: Adjustment should not be confused with *calibration* (3.9), which is a prerequisite for adjustment.

[SOURCE: ISO/IEC Guide 99:2007, 3.11, modified — Preferred term "adjustment of a measuring system" deleted. Note 1 to entry shortened. Note 3 to entry deleted.]

3.3
air buoyancy correction
correction applied to obtain the *mass in air* (3.22) from the *mass* (3.17) to take into account the reduction in mass due to the buoyancy effect of air

3.4
ancillary device
device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results

EXAMPLE Zero-adjustment device, repeating indicating device, printing device, memory device, totalizing indicating device, correction device, conversion device, pre-setting device, self-service device.

3.5
bunker cargo
fuels for use in marine engines and boilers

3.6
bunker cargo metering ticket
ticket (paper or electronic) issued at the end of a *bunker cargo* (3.5) loading

Note 1 to entry: The information listed on a ticket can be found in 9.6.2.

3.7
bunker tanker
petroleum product tanker that is used to load *bunker cargo* (3.5) from an oil terminal

3.8
bunker tanker representative
individual who represents the *bunker cargo* (3.5) receiver and is responsible for bunker cargo operations and documentation

3.9
calibration
operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

[SOURCE: ISO/IEC Guide 99:2007, 2.39, modified — Notes to entry deleted.]

3.10
calibration factor
numerical factor unique to each sensor derived during sensor *calibration* (3.9), which when programmed into the *transmitter* (3.41) ensures that the meter performs to its stated specification

[SOURCE: ISO 10790:2015, 3.1.10, modified — Term changed from "calibrating factor" to "calibration factor". Note 1 to entry modified and merged into the definition.]

3.11
calibration frequency
time interval between two consecutive *calibrations* (3.9)

3.12
commissioning
process whereby the critical precision parameters impacting custody transfer are verified and checked

Note 1 to entry: Any setting changes during commissioning or re-commissioning are traceable to factory settings and justified *adjustments* (3.2) to meet the *measurement uncertainty* (3.24) or type classification.

3.13
custody transfer point
point at which the *bunker cargo* (3.5) is defined as being loaded to the *bunker tanker* (3.7)

3.14
error
measured quantity value minus a reference quantity value

[SOURCE: ISO/IEC Guide 99:2007, 2.16, modified — Preferred terms “measurement error” and “error of measurement” deleted. Notes to entry deleted.]

3.15
linearity
consistency of change in the scaled output of a Coriolis *mass flow meter* (3.18), for a related, scaled change in the input of a mass flow meter

3.16
low flow cut-off
transmitter (3.41) setting which sets the meter output(s) to zero flow if the flow rate falls below a pre-set value

3.17
mass
true mass
physical quantity which can be ascribed to any material object and which gives a measure of its quantity of matter

[SOURCE: OIML D 28:2004, Clause 2, modified — Admitted term added.]

3.18
mass flow meter
MFM
device consisting of a flow sensor (primary device) and a *transmitter* (3.41) (secondary device) which primarily measures the mass flow by means of the interaction between a flowing fluid and the oscillation of a tube or tubes

3.19
mass flow meter bunker system
MFM bunker system
bunker cargo (3.5) custody transfer system combined with system integrity which determines the loaded quantity at a *custody transfer point* (3.13) based on the quantity obtained from a *mass flow meter measuring system* (3.20)

3.20
mass flow meter measuring system
MFM measuring system
system comprising a *mass flow meter* (3.18) and its *ancillary devices* (3.4) that produces the measured quantity at the *point of measurement* (3.32) in all conditions of fluid flow in accordance with the metrological requirements

3.21
mass flow rate
flow rate at which the quantity of fluid which passes through a *mass flow meter* (3.18)

Note 1 to entry: It is expressed as *mass* (3.17) and denoted in tonnes per hour.

3.22
mass in air
conventional mass
conventional mass value of a body equal to the *mass* (3.17) of a standard that balances this body under conventionally chosen conditions

Note 1 to entry: It is expressed in kilograms.

[SOURCE: OIML D 28:2004, Clause 4, modified — "mass in air" added as preferred term.]

3.23
maximum mass flow rate
Q_{max}
maximum flow rate up to which a *mass flow meter measuring system* (3.20) has been qualified to operate in compliance with the required *accuracy* (3.1)

Note 1 to entry: The maximum value is normally determined by the application.

3.24
measurement uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

[SOURCE: ISO/IEC Guide 99:2007, 2.26, modified — Admitted terms "uncertainty of measurement" and "uncertainty" deleted. Notes to entry deleted.]

3.25
meter reading
value obtained from the *non-resettable totalizer(s)* (3.31) or *resettable totalizer(s)* (3.34)

3.26
meter stability
property of a measuring instrument, whereby its metrological properties remain within the bounds of specifically defined criteria over time

Note 1 to entry: Stability may be quantified in several ways:

— Example 1: In terms of the duration of a time interval over which a metrological property changes by a stated amount.

— Example 2: In terms of the change of a property over a stated time.

[SOURCE: ISO/IEC Guide 99:2007, 4.19, modified — "meter stability" replaced "stability of a measuring instrument" and "stability" as the term. "within the bounds of specifically defined criteria over time" replaced "constant in time" in the definition.]

3.27
metering
measurement of quantity by a *mass flow meter measuring system* (3.20)

3.28
metering profile
graphical overview of the process parameters recorded during a bunkering operation and retained for the purpose of providing transparent assessment

3.29
minimum mass flow rate
Q_{min}
lowest flow rate required to which a metering system has been qualified to operate in compliance with the required *accuracy* (3.1)

Note 1 to entry: The minimum value is normally determined by the flow metering system.

3.30
minimum loaded quantity
smallest quantity of *bunker cargo* (3.5) for which the measurement is metrologically acceptable for a *mass flow meter measuring system* (3.20)

3.31
non-resettable totalizer
device that indicates the total cumulated flow quantity through a *mass flow meter* (3.18) after it is secured for use in a custody transfer such that its value is not resettable to zero or to other values

3.32
point of measurement
location on a terminal where a *mass flow meter* (3.18) is installed and at which the measured quantity (*mass in air* (3.22)) is computed and indicated

3.33
repeatability
proximity of a match among a series of results obtained with the same method on identical test material, under the same conditions (same operator, same apparatus, same laboratory and short intervals of time)

[SOURCE: ISO 22192:2021, 3.39]

3.34
resettable totalizer
device that indicates total flow quantity through a *mass flow meter* (3.18) from the start to the end of each batch and its value can be reset to zero

3.35
sample
bunker cargo (3.5) specimen defined by time, location and method of sampling

3.36
stored zero value
value stored in the electronics after a zero-adjustment procedure

Note 1 to entry: Stored zero value is recorded during every zero-offset determination.

3.37
surveyor
person engaged to independently inspect, measure, sample, investigate and report as required on the *bunker cargo* (3.5) operations

3.38
terminal representative
individual who represents or is appointed by the terminal and who is responsible for *bunker cargo* (3.5) operations and documentation

3.39
third party
person or organization that is unrelated to the manufacturer or supplier of the object of conformity or their customers

EXAMPLE Third-party testing laboratory, inspection body, certification body.

3.40
traceability
metrological property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of *calibrations* (3.9), each contributing to the *measurement uncertainty* (3.24)

[SOURCE: ISO/IEC Guide 99:2007, 2.41, modified — "metrological" deleted from the term and added to the start of the definition. Notes to entry deleted.]

3.41
transmitter
electronic control system that provides drive and transforms signals from a flow sensor to give output(s) of measured and inferred parameters, and that also provides corrections derived from parameters such as temperature

3.42
update
installation of new system components, hardware or software, which has no effect on the metering result

Note 1 to entry: No testing is required after installation.

3.43
upgrade
installation of new system components, hardware or software, which can have an effect on the metering result

Note 1 to entry: New certification testing is required after installation.

3.44
zero offset
measurement output indicated under zero flow conditions

Note 1 to entry: A zero offset can be caused by stress being applied to the oscillating tubes by the surrounding pipework and by process conditions.

Note 2 to entry: A zero offset can be reduced by means of *adjustment* (3.2).

3.45
zero-offset limit
maximum allowable observed *zero offset* (3.44) in relation to the *stored zero value* (3.36), used to determine when to re-zero the flow meter, generally defined by the manufacturer

[SOURCE: API MPMS 5.6:2021, 3.24]

3.46
zero stability
magnitude of the meter output deviation from the *stored zero value* (3.36) at zero flow after the zero-adjustment procedure has been completed

Note 1 to entry: It is expressed by the manufacturer as an absolute value in mass per unit time.

Note 2 to entry: The stated value for zero stability is valid for stable conditions where the fluid is free of bubbles and sediment.

3.47
zero verification procedure
procedure to verify that the *zero offset* (3.44) does not exceed the *zero-offset limit* (3.45)

4 Application

Figure 1 shows the application of requirements for bunker cargo loading using an MFM.

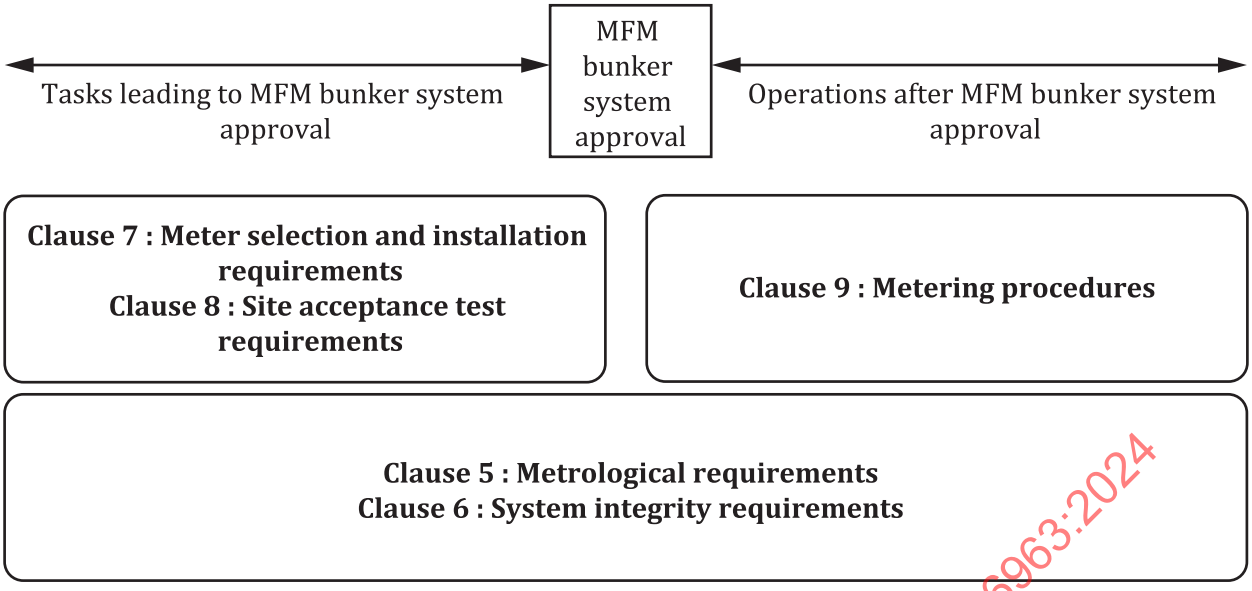

Figure 1 — Application of requirements for bunker cargo loading using an MFM

5 Metrological requirements

5.1 General

This clause specifies the MFM's metrological traceability, calibration and re-calibration requirements for the approval of the MFM measuring system applicable to the custody transfer of a bunker cargo loading. The MFM measuring system shall be operated within rated conditions as set out in these requirements (see 5.2 and 5.3) to meet the 0,5 % expanded measurement uncertainty. This clause also specifies the required maintenance and control of the in-service MFM measuring system.

5.2 Mass flow meter requirements

5.2.1 Every MFM shall be calibrated before custody transfer use for bunker cargo loading. This initial calibration shall include its adjustment device(s) and ancillary device(s).

5.2.2 The calibration shall be done using bunker fuel or equivalent fluid to meet the traceability and calibration uncertainty requirements. In cases where the primary calibration facilities are unavailable, the calibration requirements as stated in 5.2.3 and 5.2.4 shall apply for every MFM before approval for custody transfer use.

5.2.3 For water calibration (level 1) with direct traceability to SI unit of mass, the maximum error of measurement shall be not more than ±0,1 % of reading. A laboratory meeting the requirements of ISO/IEC 17025 shall carry out the calibration.

5.2.4 There shall be a letter, accompanied by relevant supporting documents, declaring that the meter performance meets the requirement of maximum measurement uncertainty for bunker fuel fluid flow measurement to be not more than 0,2 % (level 2).

NOTE Supporting documents include type evaluation certificates for regional directives (e.g. EC/EU type examination), and reports of calibration tests conducted as part of the process in obtaining these type evaluation certificates.

The report(s), supporting documents and letter shall be issued by either:

a) a national metrology institute; or

b) an appointed International Organization of Legal Metrology (OIML) issuing authority.

5.2.5 The MFM calibration report shall comprise the following details in addition to what is in ISO/IEC 17025:

a) expanded measurement uncertainty;

b) meter errors across the measurement range between the minimum mass flow rate, Q_{min}, and the maximum mass flow rate, Q_{max};

c) configuration and parameter setting values, including calibration factors to a specific MFM such as serial number and stored zero value.

5.2.6 The MFM used for flow measurements shall be calibrated at forward flow directions with at least five flow rates inclusive of calibrated Q_{min} and Q_{max} of the MFM. Each flow rate shall have at least three runs with repeatability of 0,05 % in accordance with API MPMS, Chapter 4.8, Table A-1.

5.3 MFM measuring system requirements

5.3.1 The expanded measurement uncertainty of overall performance of the MFM measuring system shall be not more than 0,5 %. It should take into consideration the following uncertainty sources:

— meter calibration;

— product condition (e.g. viscosity and density);

— process flow condition (e.g. aeration flow and flow turbulences);

— piping line system configuration and meter installation which can affect measurement conditions;

— any other source that can influence the mass flow measurement.

5.3.2 The expanded measurement uncertainty should include all the uncertainty components outlined in Table A.1.

5.3.3 The measurement uncertainty shall be assessed and evaluated in accordance with ISO/IEC Guide 98-3.

5.3.4 The requirements of zero-offset limit and zero verification include the following:

a) The maximum permissible zero offset shall be not more than 0,2 % of Q_{min}.

b) Zero setting and zero verification are required during commissioning. These operations shall be performed by a third party or an authorized/certified manufacturer agent.

c) Zero setting is done through measuring and storing the zero offset during the no flow condition, so that a new base line is formed for the measured mass flow when particular criteria (depending on meter type used) are met.

d) A periodical check on zero stability is required in accordance with the zero verification procedure set out in 5.4.2 and Annex B.

e) To achieve a proper zero adjustment and zero verification, the status of the Coriolis meter during no flow should be representative of single-phase flow conditions.

5.3.5 The low flow cut-off setting value shall be not more than 12 % of Q_{min}.

5.3.6 The operating mass flow rate for custody transfer shall not be less than Q_{min} and not more than Q_{max}. In addition, the transferred quantity shall not be less than the minimum loaded quantity in order to achieve the requirement of 0,5 % overall expanded measurement uncertainty of the metering system.

5.3.7 The flow measurement error due to aeration effects shall not cause the overall expanded measurement uncertainty of the MFM measuring system to exceed 0,5 %.

5.4 Post approval maintenance

5.4.1 Meter zero verification frequency

Zero verification shall be done every six months in the first year and annually thereafter. Certified and authentic copies of the latest zero verification report shall be kept at the terminal.

5.4.2 Zero verification procedure

Zero verification shall be carried out during a forward flow by filling the flow sensor with non-aerated bunker fuel. Follow the procedures outlined in Annex B.

5.4.3 Meter and ancillary devices verification and/or calibration frequency

The meter shall be verified annually in accordance with the requirements and procedures in ISO 6996. The meter stability shall not have a variance of more than 0,2 % of reading. The meter should be calibrated when required.

The ancillary devices shall be verified annually and should be calibrated when required.

NOTE Contractual agreements can apply.

5.4.4 Software upgrade or update

In the event that an upgrade or update of software is required for the MFM measuring system, verification shall be carried out to confirm that the performance of the MFM measuring system meets the metrological requirements.

6 System integrity requirements

6.1 General

Clause 6 is intended to be read in conjunction with Clauses 5, 7, 8 and 9. System integrity aims to ensure that:

a) the MFM bunker system is set up and approved for bunker cargo loading in accordance with the system integrity requirements specified in this document;

b) the MFM bunker system's measurement is secured against any interference before, during or after bunker cargo loading, and the bunker cargo quantity as measured is loaded to the bunker tankers.

This clause specifies the requirements and procedures to ensure the system integrity of an MFM bunker system. It includes documentation, and equipment checks for mechanical, software, electrical and operational security. It covers the stages of pre-installation, installation, commissioning, operations and maintenance as well as controls. Follow the metrological and system integrity requirements at each stage as specified in Table C.1.

6.2 Metrological control

6.2.1 Documentation

The MFM intended for the measurement of bunker cargo is subject to type or pattern evaluation testing to ensure conformity with the OIML R 117 series. Type evaluation ensures the reliability of the instruments by prescribing the metrological, technical and construction requirements on the design of the type of instruments.

6.2.2 Type approval and pattern evaluation

The MFM shall be subject to evaluation in accordance with OIML R 117-1 by OIML's recognized testing bodies and appointed issuing authorities and examination programmes or equivalent, to ensure the MFM is:

a) meeting the hardware and software integrity requirements set-out in OIML R 117-1;

b) appropriate for trade use;

c) applicable to bunkering application with characteristics and specifications;

d) evaluated under rated operating conditions.

6.3 Security features

6.3.1 Equipment security

The MFM bunker system shall be sealed against unauthorized adjustment, tampering or dismantling.

6.3.2 Software security

All MFM measuring system software shall be protected to prevent any unauthorized changes to the software and parameter settings. Any changes to the configuration of the software that affects measurement integrity shall be authorized by a third party and properly documented. The MFM measuring system shall be able to trace any changes affecting the custody transfer measurement.

6.3.3 Data security

A data logger shall be installed to record all data obtained from the MFM measuring system. The records shall include a history of operations, batches and critical alarms for future reference. These data shall be kept for a minimum of 90 days, or a period otherwise specified by local authorities. Any data interface shall be secured. The data logger is an integral part of the custody transfer and as such it should be secured to prevent tampering.

6.3.4 Critical alarm

A critical alarm is activated under the following conditions:

— power failure;

— equipment communication failure;

— meter failure (include flow computer).

Refer to 9.5.1 for the required actions.

6.4 Installation and commissioning

6.4.1 Pre-installation and MFM bunker system sealing plan

The MFM bunker system pipeline shall be designed or modified to meet system integrity requirements. Identification of the sealing points shall be carried out by the oil terminal at the planning phase of installing the MFM bunker system. The sealing plan and proposed piping diagram shall be filed and made available for reference.

All components of the MFM bunker system that affect measurement and system integrity shall be clearly labelled and sealed by a third party or an authorized/certified manufacturer agent.

Upon completion of sealing of the MFM bunker system, a seal verification report shall be filed by the system owner and shall be made available upon request for verification.

6.4.2 Installation and re-installation

The terminal shall ensure that the seals of the MFM remain intact and secured at all times, including during transit and installation. When re-application of the seals is required due to maintenance, the seals shall remain intact during transit and re-installation.

6.4.3 Commissioning

To ensure the readiness of MFM bunker system, each vendor shall complete a commissioning checklist as part of the documentation. It is the responsibility of the vendor to ensure that the commissioning of the MFM bunker system is completed.

The critical parameters of the meter configuration shall be checked. A copy of the meter configuration, before and after, shall be kept for audit trail purposes. Any changes in the meter configuration shall be documented with reasons by the terminal.

6.5 Operational security

The integrity of the MFM bunker system shall not be compromised during the loading of bunker cargo to bunker tankers. The oil terminal or user shall check for any critical alarms on the MFM bunker system and shall not proceed if a critical alarm is observed or activated.

The surveyor (when engaged) shall check for a breach of system integrity and the status of the critical alarm.

6.6 Maintenance control

6.6.1 Maintenance control of MFM bunker system

The MFM bunker system shall be maintained (as set out in 5.4) and made available for inspection and verification as required.

If an MFM is removed for maintenance purposes (such as re-calibration, upgrade and/or update of software or hardware), a third party or an authorized/certified manufacturer agent shall record and then verify that critical measurement parameters are not changed prior to recommissioning.

6.6.2 Re-commissioning

The terminal shall check that the configuration impacting measurement is maintained as was determined from the site acceptance test. Any setting change during re-commissioning shall be traceable. A checklist shall be maintained by the terminal together with other supporting documents prior to re-sealing the system.

Re-sealing shall be carried out by a third party or an authorized/certified manufacturer agent before use for custody transfer. Prior to re-sealing, zero verification shall be conducted according to 5.4.2.

When the meter is returned and resealed, the meter configuration shall be checked to ensure that the critical parameters in the configuration, before and after commissioning, are traceable.

7 Meter selection and installation requirements

7.1 General

This clause covers the selection and installation of an MFM bunker system to meet the requirements set out in Clauses 5 and 6. It includes site survey, selection, installation and commissioning. The process in this clause involves the terminal owner/operator and vendor.

7.2 Site survey at terminals

The objective of the survey is to identify a suitable location as the point of measurement to install the meter and system components. This is to ensure measurement integrity and system integrity for a uni-directional operation. The following should be considered:

a) location of manifolds;

b) location of loading lines;

c) location of cargo pumps;

d) location of flow boom(s);

e) piping arrangement (new pipe or existing pipe modifications);

f) location of spectacle blank(s);

g) location/relocation of new/existing valve(s);

h) meter location as close as possible to the transfer point;

i) installation location for other components of the metering system;

j) any other relevant factors.

7.3 Meter selection

Proper meter selection ensures that the MFM measuring system is fit for this application. The terminal operator shall:

a) provide all necessary information (e.g. parameters for meter selection) to the vendor;

b) ensure the vendor's recommendations on the meter sizing are based on the following criteria:

   1) the proposed metering system shall meet the requirements in this document;

   2) the selected MFM, including the ancillary devices, is pattern evaluated in accordance with OIML R 117-1.

7.4 Meter installation

7.4.1 Prior to meter installation, the metrological requirements in 5.2 shall be met.

7.4.2 In preparation for the meter installation, the system integrity requirements in 6.4.1 and 6.4.2 shall be met. The terminal operator shall:

a) provide a nuts and bolts sealing arrangement for flange and blank connections;

b) provide pipe support (if required) to the MFM;

c) use intrinsically safe cables for the terminal environment; cables shall be installed in conduits for protection against harsh environment and to ensure signal integrity;

d) provide a secondary source of power supply to the metering system in case of power failures.

7.4.3 Refer to Annex D for a typical schematic diagram for an MFM bunker system installation (see Figure D.1). The MFM bunker system shall include devices to measure and display the pressure and temperature of the bunker fuel.

7.4.4 Each MFM shall bear the following marking information by the meter vendor for verification purposes. The list below is not exhaustive:

a) manufacturer's identification mark, trademark or name;

b) designation selected by the manufacturer, if appropriate;

c) year of manufacture;

d) serial number.

7.4.5 The meter vendor can provide the information listed in 7.4.4 in a stamping plate to be permanently fixed on the MFM.

NOTE National regulations can apply.

7.5 Meter commissioning

7.5.1 The commissioning includes all work for ensuring the proper functionality of the MFM measuring system which includes zero adjustment and zero verification of the MFM. Refer to 6.4.3 on the readiness of the MFM bunker system.

7.5.2 At the end of the commissioning, the MFM bunker system shall be ready for the site acceptance test. Refer to Clause 8.

8 Site acceptance test requirements

The MFM bunker system is required to undergo and pass a site acceptance test to ensure that the metrological and system integrity requirements in this document are met for custody transfer.

The management of the terminal shall ensure the MFM bunker system set-up meets the relevant requirements stated in Clauses 5, 6, 7 and 9.

9 Metering procedures

9.1 General

This clause covers pre-loading, loading and post-loading documentation, and procedures for loading bunker cargo using an MFM bunker system in the terminals.

9.2 Documentation

9.2.1 General

All stakeholders involved in the bunker cargo loading operation shall complete, maintain and store traceable completed records of all steps involved in this operation. These documents shall contain terms which are consistent with this document.

A complete bunker cargo loading operation shall include the documentation specified in 9.2.3 and 9.2.4 bearing the terminal's name and jetty number.

Terminals may have their own formats for the above documents. Terminals shall have these documents available for verification when required.

The surveyor (when engaged) shall undertake and record the information in accordance with the agreement of the parties.

9.2.2 System documentation

The following documents shall be kept up to date and made available at the terminal for reference:

a) meter calibration certificate;

b) metering system diagram and sealing points;

c) meter seal verification report;

d) meter zero verification report;

e) meter verification report/meter proving report.

9.2.3 Pre-loading documentation

The following documents shall be completed and prepared, as required, at the pre-loading stage:

a) pre-loading information form;

b) system integrity seals document;

c) meter reading record;

d) pre-loading safety checklist.

9.2.4 Post-loading documentation

The following records shall be verified or provided:

a) meter reading record;

b) certificate of quantity (CQ)/bill of lading;

c) certificate of quality (COQ);

d) bunker cargo metering ticket.

9.3 Additional documentation at the terminal

9.3.1 Meter totalizer log

9.3.1.1 The terminal shall keep and maintain a meter totalizer log.

9.3.1.2 The entries of the meter totalizer log shall contain the following:

a) date and time of loadings;

b) product grade, totalizer reading, terminal's tank numbers and bunker tanker's name;

c) description of a document evidencing bunker cargo loading (e.g. CQ/bill of lading);

d) name and signature of the person preparing the entries.

9.3.1.3 The relevant section of the meter totalizer log showing all the totalizer movements related to the loading of the bunker cargo from the terminal shall be made available for inspection by the respective bunker tanker or appointed cargo surveyor (when engaged).

9.3.1.4 The meter totalizer log shall be kept at the terminal for a minimum period of 90 days, or a period otherwise specified by local authorities.

9.3.2 System documents at the terminal

The following documents shall be kept up to date and made available at the terminal for reference:

a) meter calibration certificate;

b) metering system diagram and sealing points;

c) meter seal verification report;

d) meter zero verification report.

9.4 Pre-loading procedures

9.4.1 Pre-loading conference

Prior to the commencement of a bunker cargo loading, a pre-loading conference shall be conducted between representatives of the terminal, the bunker tanker and the surveyor (when engaged). This meeting shall include safety, health and environmental checks, a review of the pre-loading safety checklist and establishing communication links.

The bunker cargo pre-loading safety checklist shall be presented by a representative of the terminal to a representative of the bunker tanker and the surveyor (when engaged) at the pre-loading conference. This should assist the parties involved in adhering to the relevant safety procedures of a bunker cargo loading operation. The safety checklist is an essential reminder of the principal safety factors and should be supplemented by continuous vigilance throughout the whole loading operation.

9.4.2 System integrity seals document

Before the commencement of the bunker cargo loading, the metering system diagram and all sealing points indicated in the document should be checked. The terminal representative, the bunker tanker representative and the surveyor (when engaged) should jointly confirm that the seals are intact. If the system integrity check cannot be carried out, the terminal representative shall undertake the required verification and attest to its integrity, a copy of which shall be provided to the bunker tanker representative and the surveyor (when engaged).

9.4.3 Meter reading record

9.4.3.1 The meter reading record shall be maintained by the terminal.

9.4.3.2 Where permitted, the terminal representative should invite the bunker tanker representative and the surveyor (when engaged) to witness and record the opening meter reading of the non-resettable totalizer in the meter reading record and ensure that the resettable totalizer meter reading is set to zero.

9.4.3.3 Otherwise, the terminal representative is responsible for setting the resettable totalizer to zero and attesting to the opening meter reading of the non-resettable totalizer. The bunker tanker representative and the surveyor (when engaged) may also monitor these activities as mentioned above remotely (e.g. closed-circuit television (CCTV), transmission of totalizer readings using information technology such as wireless and secure transmission of meter reading and viewing on a tablet).

9.4.3.4 Any cancellation or amendment in the register shall be attested to by the terminal representative.

9.5 Loading procedures

9.5.1 General

9.5.1.1 The bunker tanker representative shall prepare a bunker tanker for receiving bunker cargo.

9.5.1.2 The terminal representative shall be responsible for ensuring that the MFM bunker system integrity is not compromised for the purpose of bunker cargo loading. The terminal representative shall check for any critical alarms on the MFM bunker system and shall not proceed if a critical alarm is found to be activated.

9.5.1.3 The surveyor (when engaged) shall check for a breach of system integrity and the status of the critical alarm or be provided with an attested copy of system integrity checks.

9.5.2 Start of loading

9.5.2.1 Upon the completion of the pre-loading process, the terminal's representative shall ensure the bunker hose(s)/loading arms(s) and sampling equipment have been properly connected before the commencement of pumping. The terminal's representative shall ensure the line is fully packed to the loading valve at the terminal jetty.

The surveyor (when engaged) should verify the packed line along with the terminal's representative.

9.5.2.2 Upon completion and ready to commence pumping, the terminal representative and the bunker tanker representative shall agree that this is the start of loading.

The following list of actions shall be completed:

a) record the non-resettable totalizer reading;

b) reset the resettable totalizer to zero;

c) record the start time.

9.5.2.3 Every measure should be taken to maintain the packed line throughout the bunker cargo loading operations to minimize aeration.

9.5.2.4 Communication between the bunker tanker and the terminal shall be maintained throughout the entire bunker cargo loading operation.

9.5.2.5 The terminal representative shall ensure that the agreed pumping rate is adhered to within safe operating practices. The agreed pumping rate should not be exceeded unless requested by the bunker tanker representative. In addition, the agreed pumping rate shall not be lower than $Q_{\min}$ of the MFM.

9.5.2.6 When an order to stop pumping is given by the bunker tanker, the terminal shall stop the pumping immediately.

9.5.2.7 All stoppages and reasons for doing so shall be recorded and logged.

9.5.2.8 Stripping of nominated supplying tanks shall not be carried out concurrently during the loading operation.

9.5.2.9 The terminal representative shall notify the bunker tanker representative and the surveyor (when engaged) prior to the commencement of the stripping and line clearing operation. Stripping and line clearing of bunker hose(s)/loading arm(s) shall only be carried out at the end of the pumping operation. Any stripping of tanks should be carried out independently when there is no delivery from the other tanks. This is intended to reduce air entrainment during the loading operation.

9.5.2.10 The line clearing process shall not be repeated more than twice after the completion of the pumping operation.

9.5.3 End of loading

9.5.3.1 Once the pumping is stopped, the valves are fully closed and the non-resettable totalizer stops registering zero flow, the terminal representative and the bunker tanker representative shall agree that this is the end of loading.

9.5.3.2 Re-pumping of bunkers shall not be allowed.

9.5.3.3 The bunker cargo metering ticket shall be issued, and post-loading checks and documentation shall commence.

9.6 Post-loading procedures

9.6.1 Meter reading record

9.6.1.1 Where permitted, the terminal representative should invite the bunker tanker representative and the surveyor (when engaged) to witness and record the closing meter reading of the non-resettable totalizer in the meter reading record.

9.6.1.2 Otherwise, the terminal representative shall attest to the closing meter reading of the non-resettable totalizer or the bunker tanker representative and the surveyor (when engaged) may monitor and verify it remotely (e.g. CCTV, transmission of totalizer readings using information technology such as wireless and secure transmission of meter reading and viewing on a tablet).

9.6.1.3 The time of the end of loading and the closing meter totalizer reading shall be recorded in the meter reading record.

9.6.2 Bunker cargo metering ticket

The bunker cargo metering ticket can come in a printed paper or secured electronic ticket format.

The bunker cargo metering ticket shall contain the following information:

a) name of terminal;

b) meter unique identification number;

c) loading start date and time;

d) loading end date and time;

e) print time;

f) mass in air (this value is derived from a calculation involving air buoyancy correction).

9.6.3 Determination of loaded quantity

9.6.3.1 The loaded quantity shall be based on the bunker cargo metering ticket reading of mass in air.

9.6.3.2 The bunker tanker representative and the surveyor (when engaged) shall verify the loaded quantity as stated in the CQ/bill of lading.

NOTE For loading using the MFM bunker system, the COQ density is for fuel specification only and not for determination of the loaded quantity.

9.7 Others

9.7.1 MFM measuring system failure

9.7.1.1 In the event that there is a metering stoppage or failure prior to or in the middle of a loading operation and the loading cannot be continued, pumping shall cease immediately and the meter's totalizer readings shall be recorded.

9.7.1.2 The remaining quantity to be loaded shall be based on the terminal's certified measurement system and a separate CQ/bill of lading shall be issued. The final quantity delivered shall be the total quantity determined from the MFM bunker system and the terminal's certified measurement system.

9.7.2 Disputes

9.7.2.1 Quantity dispute

In the event of any dispute at the end of the loading with respect to the quantity of bunker cargo loaded, the terminal representative should invite the bunker tanker representative and the surveyor (when engaged) to re-verify the meter totalizer readings. Otherwise, the bunker tanker representative and the surveyor (when engaged) may re-verify remotely (e.g. CCTV, transmission of totalizer readings using information technology such as wireless and secure transmission of meter reading and viewing on a tablet). If the bunker tanker representative declines to verify, the terminal representative shall record it in a letter of protest (see Annex E for an example) and the surveyor (when engaged) shall record this in a statement of facts.

The bunker tanker representative and the surveyor (when engaged) shall perform at minimal the following:

a) Re-verify all sealing points based on the sealing plan and confirm all seals listed in the system integrity seals document are intact.

b) Confirm that all relevant lines have not been modified from that as stated in the piping diagram.

c) Obtain and examine photocopies of the relevant pages of the terminal's meter totalizer log, showing all the totalizer movements related to the cargo loading.

d) Examine and obtain copies of certificates or documents listed in 9.2.1, 9.3.1 and 9.3.2.

e) Record the reasons in a letter of protest and a statement of facts by the bunker tanker representative and the surveyor (when engaged), respectively, if any of the preceding steps a) to d) are disallowed.

The surveyor (when engaged) shall record all the relevant details and findings of the dispute in a statement of facts. This document should be completed and acknowledged by the bunker tanker representative.

If the dispute remains unresolved, the bunker tanker representative shall raise a letter of protest. Refer to Annex E for an example.

Refer to Annex F for a quantity dispute resolution for bunker cargo loading using MFM.

10 Bunker cargo quality

10.1 Bunker cargo specifications

10.1.1 The seller shall, unless otherwise agreed by the buyer, supply bunker cargo of a quality which meets the requirements of ISO 8217.

10.1.2 For any contracted grade of bunker cargo, which is not specified in ISO 8217, the seller and the buyer shall have prior written agreement with respect to the bunker cargo specifications. The seller shall warrant that the bunker cargo is homogenous and stable.

10.2 Sampling

10.2.1 Location of sampling equipment

10.2.1.1 For manual sampling, the custody transfer sample shall be taken at the manifold of the bunker tanker. When disputes arise, the custody transfer sample shall be the official sample for ascertaining the quality of the bunker cargo loaded.

10.2.1.2 Where there are physical limitations or constraints at the manifold of the bunker tanker which make custody transfer sampling at that point impossible or impractical, the sampling may be carried out at the terminal jetty. Such an exception shall be properly recorded in the bunker cargo pre-loading information form and signed by the bunker tanker representative and the terminal representative. The surveyor (when engaged) shall note this fact in the statement of facts of the bunker cargo survey report.

10.2.1.3 For automatic pipeline sampling, the location of the sampling shall be as close as possible to the custody transfer point.

10.2.2 Sampling procedure

10.2.2.1 Custody transfer sampling shall apply to all bunker cargo loadings where the sample collected shall constitute the representative sample of a bunker cargo loading.

10.2.2.2 The sampling procedures shall be carried out in accordance with ISO 3171 or ISO 3170, depending on the type of sampling equipment used.

10.2.2.3 Upon completion of the loading and sampling operations, the sample bottles shall be sealed in the presence of parties involved with uniquely numbered security seals and labelled for good traceability. See Annex G for an example of a sample label.

10.2.2.4 All samples for retention shall be kept for a minimum period of 30 days from the date of sampling, or an extended period as may be agreed by the parties involved.

10.3 Documentation

A COQ shall be issued by the terminal to the bunker tanker. Refer to Annex H for an example of a COQ.

Annex A
(informative)

Uncertainty budget table

Table A.1 shows the sources and components which contribute to uncertainty measurement.

Table A.1 — Uncertainty budget table

No.	Sources contributing to uncertainty measurement	Components
1	Reference standard and equipment (MFM) used	a) linearity, reproducibility, error b) long term instability c) laboratory calibration
2	Method and reference materials used (bunker fuel)	a) process-stripping and line packing b) hydraulic circuit, e.g. the “custody transfer point”
3	Environmental conditions (actual flow measurement and site conditions)	a) repeatability b) resolution
4	Properties and conditions of MFM	a) low flow cut-off b) zero instability c) operation conditions
5	Operator	repeatability

Annex B
(normative)

Zero verification procedure

B.1 The objective of the zero verification is to ensure the zero offset does not exceed the limit of 0,2 % of Q_{min}.

B.2 A change in zero offset can be caused by:

— changes in the tubes caused by stress due to variation in temperature, pressure, density, and environmental and marine conditions;

— poor installation practice;

— drift in electronic components in the transmitter;

— erosion/corrosion of flow tubes that can affect the pipe stiffness and thickness.

B.3 In addition to the manufacturer's recommended practice, the following steps shall be taken to ensure the appropriate conditions (typical and not limited to) for performing zero verification:

— verify there is no flow through the meter (i.e. meter not in operation);

— verify downstream and upstream valves are fully closed to ensure there is no leak through the valves.

B.4 When the above conditions are met, and considering the manufacturer's guidelines, a minimum of three zero readings at regular intervals shall be taken. The zero readings taken should not exceed 0,2 % of Q_{min}.

B.5 If the observed zero readings exceed 0,2 % of Q_{min}, it is due to the packing condition of the flow sensor tubes not being satisfactory. In this case, perform another zero verification to re-validate the zero readings observed.

B.6 If the zero verification still fails to meet these requirements after a few attempts, the meter shall not be used for custody transfer.

B.7 Zero verification is an indication of a meter's health. A non-satisfactory zero verification result will affect the overall accuracy.

A change in the zero reading can be caused by:

— erosion/corrosion of flow tubes, which affects the pipe stiffness and thickness;

— environmental conditions due to prolonged use.

B.8 The zero setting may be conducted if the meter is not able to meet the prescribed 0,2 % limit.

Annex C
(normative)

Metrological and system integrity requirements

Table C.1 shows the summary of the metrological and system integrity requirements as stated in the document.

Table C.1 — Metrological and system integrity requirements

Phase	Requirement	Remarks	Frequency
Meter selection and installation	Evaluated meter pattern	Refer to 6.2	—
	Meter and ancillary device calibration	Refer to 5.2	—
	Verification of critical parameters	Refer to 6.4.3	—
	Zero setting	Refer to 5.3.4	—
	System security	Refer to 6.3	—
System in-service	Zero verification	Refer to 5.4.2	Quarterly for first year and every six months for subsequent years
	Meter subsequent verification and/or calibration	Refer to 5.4.3	Annually
	Ancillary devices (Pressure and temperature transmitter) verification and/or calibration	Refer to 5.4.3	Annually