Annex 3

Quality/volume measurement and inventory specification

Version 1.1

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A3.1 General Provisions

A3.1.1 The Quality/Volume Measurement and Inventory Specification regulates the principles of calculating quantity and quality of Natural Gas, as well as LNG quantity available at the Terminal.

A3.1.2 The Quality/Volume Measurement and Inventory Specification has been prepared in accordance with the principles of transparency and non-discrimination of Terminal Users.

A3.1.3 The quantity of Natural Gas in the Terminal will be calculated individually, for each Terminal User.

A3.1.4 The quantity of Natural Gas will be calculated in units of energy (kWh).

A3.2 Definitions

A3.2.1 Allowable Gas Loss – Natural Gas used as a fuel for the provision of Terminal Services within the limits set in clause 11.2 of the Terminal Rules.

A3.2.2 Total Gas Loss - Natural Gas, indicated in kWh, which includes the Allowable Gas Loss and Unallowed Gas Loss, calculated in accordance with the Annex 3, consisting of own consumption and the difference in measurements.

A3.2.3 Unallowed Gas Loss – Natural Gas used as a fuel for the provision of Terminal Services exceeding the limits set in clause 11.2 of the Terminal Rules. Other definitions in this Annex 3 will be applied as determined in the Terminal Rules.

A3.3 LNG quality specifications

A3.3.1 Delivered LNG quality needs to be such to fulfil the requirements of the Natural Gas transmission system once the LNG is regasified and injected into the transmission system. The Terminal User will be obliged to consider that the LNG quality changes over time, meaning that the quality parameters may be affected by the transport from the port of loading to the Terminal. The quality parameters might also change from delivery to the Terminal, due to the passage of time, to the point of Natural Gas injection into the transmission system.

A3.3.2 The temperature of the LNG when delivered shall not be warmer than -159.5 degrees Celsius.

A3.3.3 LNG quality specification will be available at the Terminal Operator´s webpage.

A3.4 Calculation of discharged LNG

A3.4.1 The quantity and quality report will be prepared by the independent party, Surveyor, and contain and specify the following:

General cargo information (name of the LNG Carrier, the voyage of the LNG Carrier, cargo discharge Terminal, the Terminal User or its authorized representative)

Measurement data on the LNG quantity before and after discharge:

- LNG volume (m^3) in the LNG Carrier’s tanks prior to cargo discharge
- LNG volume (m^3) in the LNG Carrier’s tanks after cargo discharge
- LNG temperature in the LNG Carrier before LNG discharge
- LNG density determined at the current temperature
- Average higher calorific value of the LNG and quality parameters based on the data from the port of loading and LNG ageing
- Natural Gas vapor displaced to the LNG Carrier during LNG discharge
- Quantity of Natural Gas consumed by the LNG Carrier during LNG discharge
- Quantity of the Natural Gas consumed by the LNG Carrier during transportation of LNG
- Quantity of LNG discharged at the Terminal, in units of energy (kWh), volume (m^3) and mass (kg)

The Terminal Operator will prepare a cargo acceptance certificate based on the quantity and quality report prepared by the Surveyor, which is final and binding and needs to be signed by the representatives of the Terminal Operator and the Terminal User. The specifics for measurement and testing can be found from section A3.14 Terminal Measurement manual.

A3.4.2 If the LNG discharge is stopped prior to completion upon request from the Terminal Operator to unmoor the LNG Carrier from the Terminal in cases provided for in the Terminal Rules, only the LNG quantity that was actually discharged from the LNG Carrier to the Terminal should then be included in the cargo acceptance certificate.

A3.5 Calculation of LNG regasified at the Terminal

A3.5.1 The total quantity of LNG regasified at the Terminal per each Gas Day will be determined by measurement devices installed at the FSRU.

A3.5.2 Daily nomination will be provided by the Terminal User to the Terminal Operator to enable allocation of the quantity of Natural Gas delivered to the entry point of the TSO network.

A3.5.3 The total quantity of regasified LNG per Gas Day will be assigned to Terminal Users in proportion to the daily nominations and calculated according to the formula provided in A3.4.4 of this annex. If a Terminal User fails to submit daily nomination, LNG regasification will be equal to the respective Gas Day in the latest approved monthly update of the Individual Annual Service Schedule.

A3.5.4 The total quantity of regasified LNG per Gas Day will be assigned to Terminal Users according to the following formula:

$$D_i^U = D^T \times \frac{N_i^U}{\sum_i^n N_i^U}$$

Where:
D_i^U - Quantity of regasified LNG at the Terminal per Gas Day for a certain Terminal User (kWh)
D^T - Total quantity of regasified LNG at the Terminal per Gas Day (kWh)
N_i^U - Regasification capacity of the Terminal nominated by a certain Terminal User (kWh)
n – Number of Terminal Users

A3.5.5 LNG quantity in units of energy (kWh) will be calculated according to the following formula:

$$E = V_{LNG} \times d \times Hm$$

Where:
E – LNG quantity specified in energy value (kWh)
V_{LNG} - LNG quantity specified in units of volume (m^3) at the measuring temperature
d – Average density of LNG (kg/m^3) at the average volume measurement temperature
Hm - Average higher calorific value LNG (kWh/kg)

A3.5.6 The regasified Natural Gas quantity in units of energy (kWh) will be calculated according to the formula below:

$$E = V_{NG} \times Hm$$

Where:
E- Natural Gas quantity specified in energy value (kWh)
V_{NG} - Natural Gas quantity in units of volume (m^3)

Hm- Average higher calorific value of LNG ($\mathrm{kWh/m^3}$)

A3.5.7 The LNG quantity specified in units of mass (kg) will be calculated according to the following formula:

$$\mathrm{M} = \mathrm{V}_{MLNG} \times \mathrm{d}$$

Where:

M- LNG quantity indicated in units of mass (kg)
$\mathrm{V_{MLNG}}$-LNG quantity indicated in units of volume ($\mathrm{m^3}$)
d- Average LNG density ($\mathrm{kg/m^3}$)

A3.5.8 Natural Gas quantity specified in units of mass (kg) will be calculated according to the following formula:

$$\mathrm{M} = \mathrm{V_{MNG}} \times \mathrm{d}$$

Where:

M- Natural Gas quantity specified in units of mass (kg)
V_{MNG}- Natural Gas quantity specified in units of volume ($\mathrm{m^3}$)
d- Average LNG density ($\mathrm{kg/m^3}$)

A3.6 Calculation and Accounting of Gas Loss

A3.6.1 The Terminal Operator will every day calculate the estimated quantity of gas loss at the Terminal per Gas Day, in accordance with the following:

Total Gas Loss of the Terminal per Gas Day will be determined according to the formula below:

$$\mathrm{L^D} = \mathrm{K^0} - \mathrm{K^1} + \mathrm{A^D} - \mathrm{D^R}$$

Where:

$\mathrm{L^D}$ LNG quantity consumed per Gas Day for the technological needs of the Terminal (kWh)
$\mathrm{K^0}$ LNG quantity in the Terminal at the beginning of a Gas Day (kWh)
$\mathrm{K^1}$ LNG quantity in the Terminal at the end of a Gas Day (kWh)
$\mathrm{A^D}$ LNG quantity accepted to the Terminal per Gas Day (kWh)
$\mathrm{D^R}$ Quantity of Natural Gas regasified in the Terminal per Gas Day (kWh)

A3.6.2 Total Gas Loss at the Terminal per gas quarter will be determined according to the following formula:

$$\mathrm{L^Q} = \sum_{\mathrm{i}}^{\mathrm{n}} \mathrm{L_i^D}$$

Where:

$\mathrm{L^Q}$- Total Gas Loss of the Terminal per Gas Quarter (kWh)
$\mathrm{L^D}$- Total Gas Loss per Gas Day (kWh)
$\mathrm{i} \in [1;\mathrm{n}]$
n- Number of days in a Gas Quarter

A3.6.3 Total Gas Loss at the Terminal per Gas Year will be determined according to the following formula:

$$L^A = \sum_{i}^{n} L_i^D$$

Where:
L^A- Total Gas Loss of the Terminal per Gas Year (kWh)
L_i^D- Total Gas Loss per Gas Day (kWh)
$i \in [1; n]$
n- Number of days in a Gas Year

A3.6.4 Allowed Gas Loss for each Gas Day will be determined based on the following formula:

$$AL^D \leq 0.03 \times A^A$$

Where:
AL^D- Allowed Gas Loss per Gas Day (kWh)
A^A- LNG quantity accepted to the Terminal per Gas Year (kWh)

A3.6.5 Unallowed Gas Loss will be determined based on the following formula:

$$UL^D = L_i^D - AL^D$$

Where:
UL^D- Unallowed Gas Loss per Gas Day (kWh)
L_i^D- Total Gas Loss per Gas Day (kWh)
AL^D- Allowed Gas Loss per Gas Day (kWh)

If the value of UL^D is 0 or lower, there was no unallowed loss in that Gas Day.

A3.6.6 The Terminal Operator will determine, on every Gas Day of the Terminal, the quantity of the regasified LNG belonging to each Terminal User at the beginning of each Gas Day, according to the following principles and formulas:

The quantity of regasified LNG that belongs to each Terminal User at the beginning of each Gas Day will be calculated according to the following formula:

$$Q_i^0 = Q_i^{0-1} - D_i^{R-1} - L_i^{U-1} + D_{Pi} + dD_f^0 - A_i - N_i$$

Where:
Q_i^0- Quantity of regasified LNG belonging to a certain Terminal User at the beginning of a Gas Day (kWh)
Q_i^{1-0}- Quantity of regasified LNG belonging to a certain Terminal User at the beginning of the previous Gas Day (kWh)
D_i^{R-1}- Quantity of regasified LNG in the previous day for a certain Terminal User (kWh)
L_i^{U-1}- Gas Loss of a Terminal User per previous Gas Day (kWh)
D_{Pi}- Quantity of LNG accepted to the Terminal from a certain Terminal User, or planned to be accepted to the Terminal (kWh) as a part of a Terminal User's schedule that had previously been approved by the Terminal Operator, depending on what the Terminal Operator later approves
dD_f^0- On a Gas Day, when the LNG quantity of a certain Terminal User is accepted to the Terminal and approved by the Terminal Operator, the difference between the actual LNG quantity accepted to the Terminal for a certain Terminal User and the last planned LNG quantity used for the purpose of LNG quantity calculation, according to the situation defined in the description of D_{Pi}

A_i- Quantity of Natural Gas lost during an incident, assigned to a certain Terminal User (kWh)
N_i- Difference (shortage or surplus) of LNG established during inventory taking and assigned to a certain Terminal User (kWh)
$i \in [1; n]$
n- Number of Terminal Users

A3.6.7 The Total Gas Loss on a Gas Day will be allocated to each Terminal User and determined on every Gas Day by the Terminal Operator based on the following formula:

$$L_i^U = L^D \times \frac{R_i^n}{\sum_i^n R_i^n}$$

Where:
L_i^U- Terminal User's Gas Loss per Gas Day
L^D- Total Gas Loss at the Terminal per Gas Day
R_i^n- Total quantity of regasified and/or reloaded LNG of a certain Terminal User per Gas Day (kWh)
$i \in [1; n]$
n- Number of Terminal Users

$$AL_i^U \leq 0.03 \times A_i^U$$

Where:
AL_i^U- Terminal User's allowed Gas Loss per Gas Day
A_i^U- Total daily gas quantity accepted to the Terminal for an individual Terminal User that includes transactions on the Secondary Market (kWh)
$i \in [1; n]$
n- Number of Terminal Users

$$UL_i^U = L_i^U - AL_i^U$$

Where:
UL_i^U- Terminal User's unallowed Gas Loss per Gas Day
L_i^U- Terminal User's Gas Loss per Gas Day
AL_i^U- Terminal User's allowed Gas Loss per Day
$i \in [1; n]$
n- Number of Terminal Users

A3.6.8 If LNG regasification or LNG Reload is not carried out at the Terminal by any Terminal User during a Scheduled Slot or under an approved Extension Service the Total Gas Loss on a Gas Day will be allocated to each Terminal User and determined on every Gas Day by the Terminal Operator based on the proportion to the actual LNG stored in the Terminal by each Terminal User based on the commercial Inventory calculation.

A3.6.9 If the LNG regasification is not carried out in the Terminal due to a fault of the Terminal User, the Total Gas Loss of the Terminal per Gas Day will be assigned to the Terminal Users responsible for disrupting the regasification process, in proportion to the LNG quantity nominated by them, and will be calculated according to the formula below:

$$L_i^U = \frac{L^U \times N_i^U}{\sum_{i=1}^{k} N_i^U}$$

Where:

L_i^U- Gas Loss per Gas Day of a Terminal User responsible for disrupting the regasification process in the Terminal (kWh)

L^D- Total Gas Loss at the Terminal per Gas Day (kWh), calculated in accordance with A3.5.1 in this annex.

N_i^U- LNG quantity nominated for LNG regasification by the Terminal User responsible for disrupting the LNG regasification process in the Terminal (kWh)

$i \in [1; k]$

k- Number of Terminal Users responsible for disrupting the LNG regasification process in the Terminal

A3.6.10 Total Gas Loss at the Terminal in cases when services provision is suspended due to maintenance of the Terminal (except where maintenance need is caused by Terminal User or force majeure) will be included in the accounting of Total Gas Loss per Gas Day.

A3.6.11 If the Terminal fuel withdrawn exceeds 3.0% of the quarterly Regasification rate (excluding Late Spot Scheduled Slots) due to circumstances dependent on the Terminal Operator's default, the Regasification Service charges owed by the Terminal User will be reduced in proportion to the fuel consumption exceeding 3.0% of the quarterly Regasification rate (such value being calculated using the LNG Price). In such case the Terminal User will have no other rights for further compensation and the Terminal Operator will not incur any liability arising from or associated with such fuel consumption.

A3.6.12 The Terminal Operator will compensate to Terminal Users the unallowed Gas Loss accumulated during certain gas quarter by reducing the Regasification Service charges owed by the Terminal User. Amount to be reimbursed to a certain Terminal user is calculated as follows:

$$C_i = L_i^U * W$$

Where:

C_i- Amount to be compensated to a certain Terminal user in EUR

L_i^U- Terminal Gas Loss for a certain Terminal User (kWh), on a certain a gas quarter

W – LNG Price on the day on which compensation is to be paid, as set out in Terminal Rules

$i \in [1; n]$

n- Number of Terminal Users receiving regasified LNG on a certain gas quarter

A3.7 Calculation of Loanable LNG Quantity

The procedures for the borrow and lending principles will be regulated by the Joint Terminal Use Contract. The calculations will be based on the physical cargo storage, i.e. the actual LNG quantity available at the Terminal and calculated for each Terminal User, as shown in 3.4.4.

A3.7.1 The Lender will be assigned the following: the Total Gas Loss at the Terminal attributable to regasified LNG quantity, regasified LNG shortage/surplus established during the inventory and attributable to the loaned regasified LNG quantity, the Total Gas Loss at the Terminal due to the fault of the Terminal User, and the Allowable Loss. The procedures for the lending and borrowing of the regasified LNG and the calculation thereof will be regulated by the Terminal Operator.

A3.8 Natural Gas Balancing

A3.8.1 The Terminal Operator will, on every Gas Day, calculate the actual LNG quantity available at the Terminal at the end of each Gas Day for each Terminal User as follows:

$$AQ_i^1 = AQ_i^0 + D_{Pi} - D_i^U - G_i^P - R_i^P + L_i^P$$

Where:

AQ_i^1- regasified LNG quantity for a certain Terminal User at the end of a Gas Day (kWh)
AQ_i^0- regasified LNG quantity for a certain Terminal User at the beginning of a Gas Day (kWh), which will correspond to the regasified LNG quantity for a certain Terminal User at the end of the previous Gas Day
D_{Pi}- LNG quantity discharged to the Terminal per Gas Day for a certain Terminal User (kWh)
D_i^U- LNG quantity regasified per Gas Day for a certain Terminal User (kWh)
L^U- Total Gas Loss at the Terminal per Gas Day for a certain Terminal User (kWh)
R_i^U- Loaned regasified LNG quantity of a certain Terminal User per Gas Day (kWh)
L_i^P- Borrowed LNG quantity of a certain Terminal User per Gas Day (kWh)
$i \in [1; n]$
n- Number of Terminal Users

A3.9 Natural Gas Inventory

A3.9.1 The Terminal Operator will carry out an inventory of Natural Gas stored in the Terminal at least once per year. For the purpose of calculations, the Terminal Operator will carry out monthly Natural Gas inventories.

A3.9.2 An extraordinary inventory in the Terminal can be carried out after the receipt of a reasonable request from the Terminal User.

A3.9.3 The inventory period will be the period from the date of completion of the latest inventory carried out at the Terminal to the date of beginning the current, annual, or extraordinary inventory.

A3.9.4 The Commercial Manager of the Terminal Operator will set the date and time of the inventory, appoint the inventory commission and a chairman of the latter.

A3.9.5 During the inventory, the actual quantity of Natural Gas stored in the FSRU, and the connecting pipeline will be determined.

A3.9.6 The shortage or surplus of LNG established during the inventory will be assigned to Terminal Users in proportion to the regasified LNG quantity to which they are entitled during the inventory period, according to the formula below:

$$TS_i = TS \times \frac{D_i^P}{\sum_i^n D_i^P}$$

Where:
TS_i- Shortage or surplus of LNG for a certain Terminal User (kWh)
TS- Total shortage or surplus of LNG established during the inventory (kWh)
D_i^P- Quantity of regasified LNG for a certain Terminal User in the Terminal during the reporting period (kWh)
$i \in [1; n]$
n- Number of Terminal Users

A3.9.7 When LNG is not being regasified at the Terminal, LNG shortage or surplus calculated during the inventory will be assigned to Terminal Users in proportion to their entitled LNG quantity at the beginning of the Gas Day, according to the below formula:

$$TS_i = TS \times \frac{AQ_i^0}{\sum_i^n AQ_i^0}$$

Where:
TS_i- Shortage or surplus of LNG for a certain Terminal User (kWh)
TS- Total shortage or surplus of LNG established during the inventory (kWh)
AQ_i- LNG quantity belonging to a certain Terminal User at the beginning of the Gas Day (kWh)
$i \in [1; n]$
n- Number of Terminal Users

A3.9.8 If a calculated shortage is exceeding the allowed measurement uncertainty, an investigation can be initiated to provide an explanation of the occurred difference.

A3.9.9 The LNG inventory conduction will result with an inventory summary and documents explaining the LNG quantity measurements, the established shortage or surplus, and their assignment among the Terminal Users. The inventory summary will be signed by all members of the inventory commission who participated in the inventory.

A3.9.10 The below corrections will be made in the Natural Gas calculation documents of the Terminal Operator, in accordance with the findings of the inventory commission:

1. The LNG quantity will be adequately increased to the LNG surplus assigned to each Terminal User.
2. The LNG quantity will be adequately decreased to the LNG shortage assigned to each Terminal User.

A3.10 Natural Gas Calculation in Case of an incidents at the Terminal

A3.10.1 In case of an incident (accident or failure) at the Terminal the investigation will be conducted according to procedures established by the legal regulations of the Republic of Finland.

A3.10.2 The Terminal Operator will inform the authorities and Terminal Users about the incident, as soon as possible, through Urgent Market Message (UMM) platform.

A3.10.3 The incident at the Terminal will be properly investigated by the appointed commission, in accordance with the legal regulations.

A3.10.4 The Natural Gas quantity lost during the incident as well as the quantity of LNG not regasified as the result of the incident will be calculated during the investigation.

A3.10.5 When the incident at the Terminal has been investigated, the certificate established by legal regulations will be signed by the commission, including all parties involved in the investigation.

A3.10.6 The Natural Gas calculation document will be corrected as listed below based on the incident investigation certificate prepared and approved:

1. Natural Gas lost as the result of an incident will be assigned to Terminal Users, proportionally to their regasified LNG quantity in the Terminal at the beginning of the Gas Day when the incident occurred and calculated as follows:

$$A_i = A \times \frac{AQ_i^0}{\sum_i^n AQ_i^0}$$

   Where:
   A_i- Quantity of Natural Gas lost during the incident, assigned to a certain Terminal User (kWh)
   A – Total quantity of Natural Gas lost during the incident(kWh)
   AQ_i- LNG quantity belonging to a certain Terminal User at the beginning of the Gas Day (kWh)
   $i \in [1; n]$
   n- Number of Terminal Users

2. The Natural Gas quantity will be reduced adequately regarding the quantity of Natural Gas lost during the incident and assigned to a certain Terminal User.
3. If the commission determines that the incident occurred due to the fault of the Terminal Operator, and as a result of the incident the Terminal withdraws Natural Gas as fuel in excess of the rate set out in the Terminal Rules, the Terminal User may be entitled to compensation in accordance with the Terminal Rules.
4. The LNG quantity not regasified as the result of the incident will be calculated as the difference between the regasified LNG quantity and the LNG quantity requested to be regasified in the monthly update of the Individual Annual Schedule within the period between the incident and the restart of the Terminal Operation:

$$S = \sum_i^n N_i^U - D^U$$

   Where:
   S- LNG quantity not regasified because of the incident (kWh)
   N_i^U- LNG quantity requested to be regasified in the period between the incident and the restart of the Terminal, in accordance with the monthly update of the Individual Annual Schedule
   D^U- LNG quantity regasified within the period between the incident and the restart of the Terminal (kWh)
   $i \in [1; n]$
   n- Number of Terminal Users

A3.11 Specification of LNG Quality

A3.11.1 The Terminal User is responsible for ensuring that the quality of delivered LNG corresponds to the standard quality of Natural Gas in Finland and Estonia.

A3.11.2 The Terminal Operator will not be responsible for the quality of LNG delivered to the Terminal.

A3.11.3 The Terminal Operator will ensure that the specifications of the LNG or regasified LNG delivered corresponds to the standard Natural Gas quality, provided that the Terminal Users are using the LNG Regasification Service in accordance with the Terminal Rules.

A3.11.4 The Terminal User will be obliged to consider that the LNG quality changes over time, meaning that the quality parameters may be affected by the transport from the port of loading to the Terminal. The quality parameters might also change from delivery to the Terminal, due to the passage of time, to the point of Natural Gas injection into the transmission system. The Terminal Operator will warn the Terminal User if the quality parameters at the port of loading are such that the regasified LNG at the injection point to the Transmission system might not be compliant with the existing regulations and therefore Natural Gas might not be injected into the transmission system.

A3.11.5 Both the Terminal User and the Terminal Operator will notify the other party if delivered or not yet delivered cargo represents or could represent Off-Specification LNG. The expected deviation should be included in the notification.

A3.11.6 The Terminal User is responsible in ensuring that the cargo quality delivered to the Terminal at the time of discharge corresponds to the LNG quality specification set by the Terminal Operator.

A3.11.7 The Terminal Operator will be obliged to take appropriate action to determine that the LNG intended for discharge at the Terminal and/or the LNG that is being discharged to the Terminal is in accordance with the LNG Quality Specification and will prevent discharge of ant LNG that might be considered Off-Specification LNG.

A3.11.8 The Terminal Operator will refuse the discharge request if the specified LNG is considered Off-Specification LNG. If it is not possible to determine that the LNG was Off-Specification, the Terminal Operator will be obliged to stop the already initiated discharge to the Terminal when it is established that the LNG does not correspond to the LNG Quality Specification.

A3.11.9 The Terminal Operator will, at the specific request of the Terminal User, based on historical LNG quality data and other presently available ageing models, preliminary predict changes in the LNG quality at the Terminal and will estimate the time when the LNG could become Off-Specification LNG.

A3.11.10 The Surveyor will, prior to discharge, check whether the LNG quality conditions have been met.

A3.11.11 The Surveyor will prepare an interim LNG Quality and Quantity Report for the LNG discharged to the Terminal, and the final LNG Quality and Quantity Report as soon as possible after the completion of LNG discharge.

A3.11.12 All reports, orders, specifications, and other documentation concerning the results of measuring LNG quality parameters will be verified by an independent Surveyor.

A3.12 Measuring Discharged LNG

A3.12.1 The Terminal User needs to ensure that the measurement of LNG quantity is carried out in accordance with international ISO standards. The ISO10976:2015, or a more recent standard that replaces it, will be considered the as a requirement for determining the level of LNG in the carrier tanks, temperature, pressure and technical specifications for the LNG Carrier.

A3.12.2 All gauges, and measurement equipment used at the Terminal used to measure the quantity of LNG needs to be calibrated and certified by independent laboratories, according to the rules the international standards applicable at that time.

A3.12.3 Natural Gas consumed by the LNG Carrier will be deducted from the total discharged LNG quantity.

A3.13 Audit of LNG and Dispatched Gas Quantities

A3.13.1 The Terminal Operator will be obliged to provide Terminal Users with access to information on the regasified LNG quantity owned by an individual Terminal User as well as the LNG quantity in the Terminal. The Terminal Operator will provide the information through the Terminal information exchange system.

A3.13.2 At the justified request of the Terminal User, the Terminal Operator may provide access to all data concerning the determination of the gas quality and quantity.

A3.14 Terminal Measurement Manual

The objectives of this Terminal Measurement Manual for (re)loading and unloading LNG is to provide the definitions and application procedures required for equipment selection, Calibration, back-up resolution and report process used for LNG Quantity delivered from and to LNG Carrier at Terminal via the Delivery Point. The definitions and procedures will be in accordance with the international standard and practice and Terminal Rules). This Measurement Manual can be amended if mutually agreed between Terminal and Terminal User in order to reflect international practice.

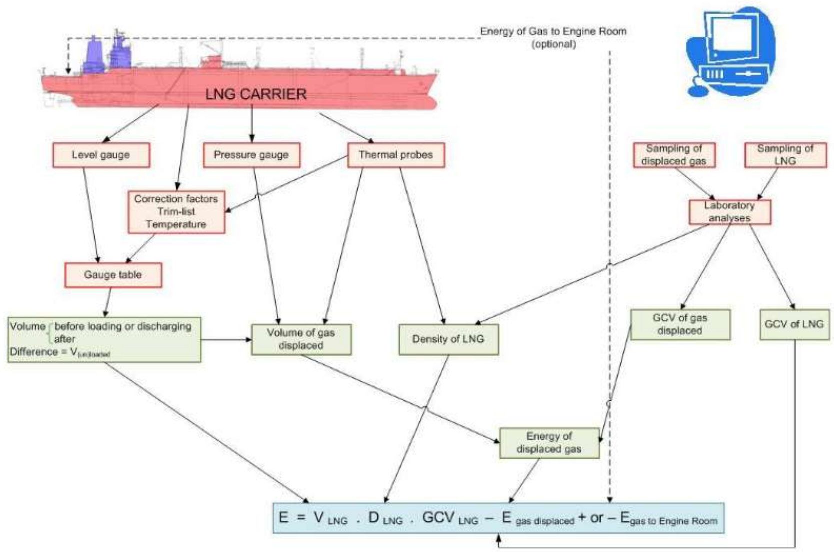
A3.14.1 Definitions & abbreviations

- LNG: Liquefied Natural Gas
- BOG: Boil Off Gas
- SI: The International System of Units
- MJ: Megajoules
- MMBtu: Metric Million British Thermal Unit
- Btu: British Thermal Unit
- kg: Kilograms
- GIIGNL: Groupe International des Importateurs de Gaz Naturel Liquéfié
- MWh: Megawatt Hour
- kWh: kilowatt Hour

A3.14.2 Process flow: responsibilities of the different parties involved: delivering LNG Carrier, terminal, surveyor

The flowchart below shows the three main elements that are needed to determine the final energy transferred:

- Quantity will be determined on board of the LNG Carrier
- Notwithstanding of the flowchart, Quality delivered will be determined by means of simulation
- Final calculation which combines the above information into one formula



A3.14.3 Duties

Quantity determination

- LNG Carrier: Measurement, record, calculation, documentation and signature
- Terminal Operator: Witness and signature
- Surveyor: Witness, verification, calculation, documentation and signature
- Terminal User: Witness, if any, and signature

Quality determination

- Terminal Operator: record, calculation, documentation and signature
- Surveyor: calculation, documentation and signature
- Terminal User: Witness, if any, and signature

A3.14.4 Procedure for energy determination

A3.14.4.1 Measuring units

The System International (SI) system of units is used throughout this Measurement Manual, except for the purpose of converting the total heating value of the LNG (un)loaded from Megajoules (MJ) to MMBtu and vice versa.

A3.14.4.2 Reference standards

All procedure and device used for this Measurement Manual shall comply with the recommendations the LNG custody transfer handbook published by the International Group of Liquefied Natural Gas Importers (GIIGNL) that are as following tables or others standard that shall be agreed between the Terminal User and Terminal.

Quantity

Measurement level gauge

- Float type: ISO 18132
- radars or microwave type: ISO 18132

Energy calculation

- LNG higher calorific value: ISO 6976
- LNG Density: ISO 6578
- Energy Balance: ISO 10976

LNG Custody transfer operations

- GIIGNL (International Group of Liquefied Natural Gas Importers) LNG CUSTODY TRANSFER HANDBOOK

A3.14.5 Quantity Measurement System by LNG Carrier

Overview of the different measurement procedures and requirements of the delivering/receiving LNG Carrier CTMS.

A3.14.5.1 General

The Terminal User shall supply, operate and maintain, or cause to be supplied, operated and maintained, measurement equipment on the LNG Carrier (used for transporting LNG to the Terminal) that will:

- Measure the liquid level in LNG tanks on the LNG Carrier.
- Measure the pressure and temperature of LNG on board the LNG Carrier.
- Measure the Trim/list of the LNG Carrier
- Measure the gas consumed during the operation on board the LNG Carrier.

All devices provided for this clause A3.14.5.1 shall be approved by the Terminal, acting as a reasonable and prudent Operator. The required degree of accuracy shall be within the permissible tolerances defined herein and in the applicable standards referenced herein.

All custody transfer gauging devices and systems shall be installed, operated and maintained according to the manufacturers' specification and standards used in the LNG industry.

A3.14.5.2 Tank Gauge Tables

The First Calibration: The Terminal User shall ensure that each tank of an LNG Carrier shall initially be calibrated by relating volume of LNG in the tank against tank level. Also, as part of this 'First Calibration' process the Terminal User shall provide or cause to be provided to Terminal a certified copy of tank gauge tables for each tank of each LNG Carrier verified by a competent impartial authority or authorities agreed upon by the Parties. The tank gauge tables shall include correction tables for list, trim, tank contraction and any other items requiring such tables for accuracy of gauging and shall indicate volumes in Cubic Meters expressed to the nearest thousandth (1/1000), with LNG tank depths expressed in metres to the nearest thousandth (1/1000).

Presence of Representatives: Both Terminal and the Terminal User shall both have the right to attend the volumetric calibration of each tank in an LNG Carrier each time it takes place.

Recalibration: In the event that any of the LNG tanks of the LNG Carrier experience an event of any sort that may create a reasonable doubt regarding the validity of the current tank gauge tables described in this clause A3.14.5.2 of this Measurement Manual, the Terminal User shall recalibrate the damaged tanks, and the LNG Carrier shall not be used for the transportation of LNG to Terminal until a new set of tank tables have been issued.

Notwithstanding, the Terminal User and Terminal may agree to defer the recalibration of the LNG tanks until the next time when such damaged tanks are warmed for any reason. In the event that changes do need to be made to the existing set of tank gauge tables, any corrections to quantities of LNG measured using the existing tables will be made from the time the deformation event occurred, unless the time the deformation event took place cannot be ascertained, in which case the Terminal User and Terminal shall agree on the time period for retrospective adjustments.

A3.14.5.3 Liquid Level Gauging Device

Each LNG tank of an LNG Carrier will be equipped with independent main and auxiliary liquid level gauging devices that preferably utilize different technologies. All liquid level gauging devices shall be installed, operated and maintained according to the manufacturers' specification and standards used in the LNG industry. For each LNG Carrier, the Terminal User shall identify the main and auxiliary liquid level gauging devices.

The measurement accuracy of the main and auxiliary liquid level gauging devices shall be better than plus or minus five millimetres (±5 mm). Indications from the two systems shall be routinely compared to ensure they are performing normally.

The liquid level from the level gauging device in each LNG tank shall be logged and/or printed.

A3.14.5.4 Temperature Gauging Device

Each LNG tank of any LNG Carrier will be equipped with a minimum of five (5) pairs of temperature gauging devices located on or near the vertical axis of such LNG tank, in such a way as not to be affected by the spray of LNG when the spray pumps are in operation.

Primary and redundant temperature gauges are required, and indications from the two (2) systems will be compared to ensure they are performing normally. Such temperature gauging devices will be installed at various locations from the top to the bottom of each tank to provide temperature measurements at various levels in the tank. The topmost temperature device will be located in the vapour space at all times, and the bottom temperature device will be located near the tank bottom for heel measurement.

In the temperature range of minus one hundred sixty-five degrees Celsius (- 165°C) to minus one hundred and forty-five degrees Celsius (- 145°C), the accuracy will be plus or minus zero decimal two degree Celsius (± 0.2°C). In the temperature range of minus one hundred and forty-five degrees Celsius (- 145°C) to plus forty degrees Celsius (+ 40°C), the accuracy will be plus or minus one decimal five degrees Celsius (± 1.5°C) or better.

The temperatures in each LNG tank shall be logged and printed.

A3.14.5.5 Pressure Gauging Device

Each LNG tank of each LNG Carrier will have at least one (1) absolute vapour pressure gauging device.

The measurement accuracy of each pressure gauging device will not exceed plus or minus one percent (± 0.5%) of full scale. The maximum integrated accuracy will not exceed plus or minus three (± 3) millibar or its equivalent in alternate units.

The pressure in each LNG tank will be logged and printed.

A3.14.5.6 List and Trim Gauging Device

A list gauging device and a trim gauging device will be installed on each LNG Carrier. These will be interfaced with the custody transfer system.

List and trim corrections will be made using devices whose accuracy is better than plus or minus zero decimal zero five (+/- 0.05°) degrees for list and plus zero decimal zero one metres (+/- 0.01 m) for trim.

The list and trim will be logged and printed.

A3.14.5.7 BOG Gas Flow Meter Device

The LNG Carrier will be equipped with minimum one boil-off gas flow meter which is capable of determining the mass (in kg) of the gas consumed by the LNG Carrier with an accuracy equal to or better than plus or minus 2.0% reading throughout the operation range of the meter as required by ISO 19970.

A3.14.6 Measurement Procedures onboard LNG Carrier

a) Overview & Timing

The measurement and testing method of LNG shall conform to international practice and be in accordance with referred ISO standards and documents. Any Dispute arising under this Measurement Manual shall be submitted to an Expert or an independent surveyor.

The condition of the LNG Carrier at the time of custody transfer shall be as described in Clause 6.1.2 of ISO 10976

The measurements referred to in this clause A3.14.6 shall be made at the same time. During this period in which the readings are taken, no LNG cargo, ballast, boil off Gas (unless gas consumption is planned to take place), fuel oil or other cargo transfer activity will be carried out on the LNG Carrier during such measurement.

Measurements shall first be made immediately before custody transfer commences. Accordingly, after connection of the loading arms, but prior to their cool down, and immediately before opening the manifold ESD valves of the LNG Carrier, the initial gauging shall be conducted upon the confirmation of stoppage of all spray pumps and compressors and shut-off of the Gas master valve to the LNG Carrier boilers or to any other Gas consuming unit unless gas consumption during custody transfer is planned to take place. The Gas master valve to the LNG Carrier boilers or to any other Gas consuming unit shall remain closed until after the second gauging, unless a regulatory change or the Terminal User requires the consumption of Gas during the LNG Carrier loading/unloading operations.

As far as practicable, the period between the time of measurement and start of cargo transfer should be narrowed to the minimum achievable. The same should apply for the final cargo custody transfer level measurement, once time is allowed to correctly drain cargo lines.

In case the LNG Carrier is fitted with a reliquification plant: If the reliquefication plant is running at the time of taking tank level measurements, for custody transfer purposes, then it should continue to do so during the tank level measurement process, as necessary to control tank pressures. The volume of condensate returned to the LNG tanks during the measurement process, by the reliquification plant, and the quantity of condensate contained in the reliquefication system, is immeasurable and is to be regarded as zero for CTMS purposes.

A second gauging shall be made immediately after custody transfer is completed. Accordingly, the second gauging shall be conducted upon the confirmation of shut-off of the manifold ESD valves and Gas master valve unless gas consumption during custody transfer has taken place, with transfer pumps off and allowing sufficient time for the liquid level to stabilize.

Measurements prior to and after the operation will be carried out based on the volumetric condition of the LNG Carriers lines upon arrival at the berth. Since significant volumes of LNG may remain in the LNG Carriers manifold and crossover, gauging will be performed with these lines in the same volumetric condition prior to and after the operation. If the LNG Carriers manifold and crossover lines are empty when measurement is taken before operation commences, they will be emptied prior to measurement following the completion of the operation. If the crossover lines are liquid filled when measurement is taken before operation commences, they will remain full until measurement is taken following the completion of the operation.

Unless otherwise agreed between Terminal User and Terminal, only the tanks involved in the operation will be taken into consideration for custody transfer purposes.

b) Liquid level

Liquid levels in each LNG tank of an LNG Carriers will be determined in accordance with ISO 10976. Measurement of the liquid level in each LNG tank of a LNG Carriers will be made in metres, accurate to the nearest millimetre by using the main liquid level gauging devices referred to in clause A3.14.5.3.

The same liquid level gauging device must be used for both the initial and final measurements during (un)loading. If the main level gauging device is inoperative at the time of commencement of (un)loading, necessitating use of the auxiliary level gauging device, the auxiliary level gauging device will be used at the time of cessation of (un)loading, even if the main level gauging device has subsequently become operative. Trim and list of the LNG Carrier will be kept unchanged while the referenced measurements are performed.

At least five (5) readings will be made following the manufacturer's recommendations on reading interval. The arithmetic average of the readings will be deemed the liquid level.

Such arithmetic average will be rounded to the nearest millimetre.

Any necessary corrections for trim, list, temperature or other adjustment as defined in the tank gauge tables as called for in clause A3.14.5.2 must be applied to the arithmetic reading to get the true level reading.

The liquid level will be logged and printed.

c) Temperature

At the same time as the liquid level is measured, all the temperatures in each LNG tank will be measured to the nearest zero decimal zero one degree Celsius (0.01°C) by using the temperature gauging device referred to in clause A3.14.5.4.

In order to determine the LNG liquid temperature, one (1) reading shall be taken at each temperature gauging device fully immersed in the liquid in each LNG tank. The arithmetic average of these readings, rounded to the nearest zero decimal one degree Celsius (0.1 °C) shall be deemed the final temperature of the liquid.

In order to determine the LNG vapour temperature, one (1) reading shall be taken at each temperature gauging device fully surrounded by vapour in each LNG tank. The arithmetic average of these readings, rounded to the nearest zero decimal one degree Celsius (0.1 °C) shall be deemed the final temperature of the vapour.

The temperatures in each LNG tank will be logged and printed.

d) Pressure

At the same time as the liquid level is measured, the absolute pressure in each LNG tank will be measured to the nearest one millibar (1 mbar) by using the pressure gauging device referred to in clause A3.14.5.5.

The determination of the absolute pressure in the LNG tanks of each LNG Carrier will be made by taking one (1) reading of the pressure gauging device in each LNG tank, and then by taking an arithmetic average of all such readings.

Such arithmetic average will be rounded to the nearest one millibar (1 mbar).

If the LNG tank pressure cannot be obtained by the absolute vapour pressure gauging device, the tank pressure may be read from a normal pressure gauge, provided a barometric pressure reading, accurate to zero decimal one millibar (0.1 mbar) must also be taken and recorded to correct such reading to absolute pressure.

The pressure in each LNG tank will be logged and printed.

e) List and Trim

The list and trim of the LNG Carrier will be measured at the same time as the liquid level and temperature of LNG in each LNG tank are measured by using the list gauging device and trim gauging device referred to in clause A3.14.5.6.

The measurement of the list and of the trim will be conducted to the nearest zero decimal zero one (0.01) degree for list and the nearest zero decimal zero one metres (0.01 m) for trim.

The determination of the list and of the trim of the LNG Carrier will be made by taking one (1) reading of the list and trim gauging devices.

Unless logistical not possible, LNG Carriers draft reading will be checked for comparison prior to starting the operation. In case of difference between visual reading and gauging devices prior to start LNG transfer: the LNG Carrier, inspector and Terminal will agree during preloading/predischarge meeting on the method to be used.

The list and trim of the LNG Carrier will be logged and printed.

f) BOG consumption

The values of the gas flow meters from all gas consuming devices will be recorded at the same time as the liquid level and temperature of LNG in each LNG tank are measured by using the flow meter devices referred to in clause A3.14.5.7.

The inspector will discuss with the LNG Carrier on what readings should be taken and these will be identified on the printout.

In case of volumetric flow meters, temperature and pressure of the gas flow meter will be recorded as to convert the volumetric reading to mass based.

g) Volume

The volume of LNG in each cargo tank shall be obtained by referencing the corrected average liquid level for each tank to the corresponding volume provided in the certified tank capacity tables (rounded to 0.001 m^3)

The final corrected volume of LNG in Moss type cargo tanks at the gauging shall be determined by correction for thermal expansion / contraction of cargo tank shell, as obtained from the LNG Carrier's tank capacity tables and as corresponding to the liquid temperature.

The volume of LNG unloaded shall be determined by deducting the total volume of LNG in all LNG tanks immediately after unloading is completed from the total volume in all LNG tanks immediately before unloading commences. The volume of LNG loaded shall be determined by deducting the total volume of LNG in all LNG tanks immediately before loading commences from the total volume in all LNG tanks after unloading is completed. The volume of LNG (un)loaded is therefore calculated to the nearest zero decimal zero zero one (0.001) cubic metre.

h) Procedure in case of Gauging Device Failure

Should the measurements referred to in this clause A3.14.6 become impossible to perform due to a failure of gauging devices, alternative gauging procedures will be determined by mutual agreement between the Terminal User and Terminal in consultation with the Independent Surveyor

A3.14.7 Quality Determination Method

The independent surveyor will provide a simulation of the quality using an agreed ageing estimating model.

a) For Unloading Operation

The estimation model should take into account:

- The quality of the LNG loaded in LNG Carrier
- The heel quantity and quality onboard the LNG Carrier prior loading

- The actual voyage conditions of the LNG Carrier from load port to FSRU
- Preferably the model uses historical data as a reference in order to simulate the unloaded quality.

The Terminal retains the right to compare the send-out profile of the FSRU, as measured by the gas chromatograph, to the simulated LNG composition up until the moment the send-out of the Cargo is completed and to veto the simulated LNG composition in the case of a substantial difference. In such case, the Terminal and Terminal User will meet and agree on the composition to be used to determine the energy delivered in consultation with the Independent Surveyor.

b) For Loading operation

Terminal will provide a composition taking into account the following parameters

- LNG quality previous unloaded cargo
- Ageing in the tank
- Sendout profile previous days
- Storage plan of LNG in the FSRU

All supporting documents will be provided to Terminal User for acceptance and in case of disagreement will be discussed in consultation with the Independent Surveyor

If both the Terminal and the Terminal User reasonably agree that the above results (as applicable) do not give a fair representation of the composition of the LNG, Terminal and the Terminal User will meet and decide in good faith the appropriate method to determine the composition of LNG.

A3.14.8 Calculations

Overview of the formulas required to determine the net energy delivered, a breakdown of formulas, roundings, standards used to arrive to the net energy delivered:

A3.14.8.1 Reference Conditions

Reference conditions to be used for purpose of calculation are the following:

- Combustion Reference Temperature: 25 °C
- Metering Reference Temperature: 0 °C
- Reference Pressure: 1013.25 mbar
- Real gas basis

A3.14.8.2 Higher Calorific Values and Wobbe

All Higher Calorific Value calculations are done in line with ISO 6976

a) Higher Calorific Value Mass Based (LNG)

The Higher Calorific Value Mass Based of the LNG shall be calculated using the below formula

$$Hm = \frac{\sum(Xi \cdot Hi)}{\sum(Xi \cdot Mi)}$$

Where:
Hm = Higher Calorific Value Mass Based of the LNG, in MJ/kg, rounded to three (3) decimal places
Hi = Higher Calorific Value (Mol Based) of component "i" in MJ/kmol as specified in Table 1
Mi = Molecular mass of component "i" in kg/kmol as specified in Table 1
Xi = Molar fraction of component "i" of the LNG; determined as described in clause A3.14.7 rounded to 0.000001, the molar fraction of Methane will be adjusted as to make the total fraction equal to 1.000000

b) Higher Calorific Value Volume Based (LNG)

Higher Calorific Value Volume Based of the LNG shall be calculated using the below formula

$$Hv = \frac{\sum(Xi \cdot Hi) \cdot Pref}{R \cdot Tref \cdot Zmix}$$

Where:
Hv = Higher Calorific Value Volume Based of the LNG, in MJ/m³, rounded to three (3) decimal places
Xi = Molar fraction of component "i" of the LNG; determined as described in clause A3.14.7 rounded to 0.000001, the molar fraction of Methane will be adjusted as to make the total fraction equal to 1.000000
Hi = Higher Calorific Value (Mol Based) of component "i" in MJ/kmol as specified in Table 1
Pref = reference pressure for metering = 101.325 kPa
R = universal gas constant = 8 8.3144621 J·mol−1·K−1
Tref = reference temperature for metering = 273.15 K
Zmix = compressibility factor of the LNG rounded to 0.00001 calculated as per below

$$Zmix = 1 - \left(\sum(Xi \cdot \sqrt{bi})\right)^2$$

Where:
Zmix = compressibility factor of the LNG rounded to 0.00001
Xi = Molar fraction of component "i" of the LNG; determined as described in clause A3.14.7 rounded to 0.000001, the molar fraction of Methane will be adjusted as to make the total fraction equal to 1.000000
√bi = summation factor component "I" as specified in Table 1

c) Wobbe Index

$$WI = \frac{Hv}{\sqrt{dr}}$$

$$dr = \frac{\sum(Xi \cdot Mi) \cdot Zair}{28.96546 \cdot Zmix}$$

Where:
WI = Wobbe Index of the LNG, in MJ/m³, rounded to three (3) decimal places
Hv = Higher Calorific Value Volume Based of the LNG, in MJ/m³, rounded to three (3) decimal places
dr = relative density of the LNG

Xi = Molar fraction of component "i" of the LNG; determined as described in clause A3.14.7 rounded to 0.000001, the molar fraction of Methane will be adjusted as to make the total fraction equal to 1.000000
Mi = Molecular mass of component "i" in kg/kmol as specified in Table 1
Zmix = compressibility factor of the LNG rounded to 0.00001
Zair = compressibility factor of air 0.999419

d) Higher Calorific Value Volume Based (Vapour Displaced)

Higher Calorific Value Volume Based of the vapour displaced is calculated using the below formula

$$Hv = \frac{\sum(Yi \cdot Hi) \cdot Pref}{R \cdot Tref}$$

Where:
Hv = Higher Calorific Value Volume Based of the vapour displaced, in MJ/m³, rounded to three (3) decimal places
Yi = Molar fraction of component "i" of the vapour displaced and the assumption will be made that the vapour composition consists of 100% Methane.

A3.14.8.3 LNG Density

The LNG Density is calculated using the formulas as described in ISO 6578, as set out below.

The LNG Density is calculated using the liquid temperature Tliq before unloading or after loading

$$d = \frac{\sum(X_i \cdot M_i)}{\sum(X_i \cdot V_i) - \left(K_1 + \frac{(K_2\text{-}K_1) \cdot X_n}{0.0425}\right) \cdot X_m}$$

Where
d = density of LNG, calculated using the composition of the LNG and the liquid temperature Tliq, in kg/m³ rounded to two (2) decimal places,
Tliq = temperature of the LNG in the LNG Carrier immediately before unloading/after loading in degrees Celsius, rounded to one (1) decimal place, in accordance with clause A3.14.6 c).
Xi = Molar fraction of component "i" of the LNG; determined as described in in clause A3.14.7 rounded to 0.000001, the molar fraction of Methane will be adjusted as to make the total fraction equal to 1.000000
Xm= the value of Xi for methane.
Xn= the value of Xi for nitrogen.
Mi = molecular mass of component "i" in kg/kmol as specified in Table 2a
Vi= molar volume of component "i" in m³/kmol at Tliq obtained by linear interpolation of the relevant data as specified in Table 2b
K1 = volume correction in m³/kmol at temperature Tliq obtained by linear interpolation of the relevant data as specified in Table 2c
K2 = volume correction in m³/kmol at temperature Tliq obtained by linear interpolation of the relevant data as specified in Table 2d

A3.14.8.4 Energy Delivered

a) Gross Energy

Gross Energy is calculated using the following formula:

$$Q_{gross} = \frac{V \cdot d \cdot Hm}{1055.056}$$

Where:

Q_{gross} = Gross Energy in MMBtu
V= Volume as calculated in accordance with clause A3.14.6 g) d= Density of the LNG as calculated in clause A3.14.8.3
Hm= higher calorific value mass based as calculated in clause A3.14.8.2 a)
1055.056: conversion factor: 1 MMBtu= 1055.056 MJ
Additional calculation of energy expressed in kWh is done by below formulae: Q [kWh] = Q [MMBTU] x 1055.056 / 3.6

b) Vapour Displaced

$$Qr = V \cdot \frac{273.15}{273.15 + Tvap} \cdot \frac{Pvap}{1013.25} \cdot \frac{Hvap}{1055.056}$$

Where:

Qr = Vapour Displaced quantity in MMBTU
V= Volume as calculated in accordance with clause A3.14.6 g) 273.15= Metering Reference Temperature in Kelvin degrees
Tvap= average temperature of the vapour immediately after unloading/before loading, calculated in accordance with clause A3.14.6 c), rounded to 0.1 °C
Pvap= average pressure of the vapour in mbar immediately after unloading / before loading, calculated in accordance with clause A3.14.6 d) rounded to 1 mbar
1013.25= Reference Pressure in mbar
Hvap= higher calorific value volume based of the vapour displaced calculated in accordance with clause A3.14.8.2.d)
1055.056: conversion factor: 1 MMBtu= 1055.056 MJ

Additional calculation of energy expressed in kWh is done by below formulae: Q [kWh] = Q [MMBTU] x 1055.056 / 3.6

c) BOG consumed

BOG consumption during the operation will be taken into account in the energy balance, this amount will be determined based upon the LNG Carrier counters, assuming that the BOG consists of 100% Methane

$$Qf = \frac{(GTE_{CCT} - GTE_{OCT}) \cdot GHV_{BOG}}{1055.056}$$

Where:

GTE_{CCT} = Sum of counters readings (in kg) to all gas consuming devices at CCT, taken in in accordance with clause A3.14.6 f)

GTE_{OCT} = Sum of counters readings (in kg) to all gas consuming devices at OCT, taken in in accordance with clause A3.14.6 f)

GHV_{BOG} = higher calorific value of gas consumed in MJ/kg: assumed 100% Methane @ combustion reference temperature 25 °C and calculated in accordance with ISO 6976.

1055.056: conversion factor: 1 MMBtu= 1055.056 MJ

Additional calculation of energy expressed in kWh is done by below formulae: Q [kWh] = Q [MMBTU] x 1055.056 / 3.6

In case the LNG Carrier has no counters to determine the amount of gas consumed during the operation, then both Terminal and Terminal User will agree on how to take into account the amount of gas consumed during the operation.

d) Net Energy Delivered

Net Energy Delivered ($Qnet$) is calculated using below formula and rounded to the nearest 1 MMBTU

Additional calculation of energy expressed in kWh is done by below formulae: Q [kWh] = Q [MMBTU] x 1055.056 / 3.6

In case of unloading:

$$Qnet = Qgross - Qr - Qf$$

In case of loading:

$$Qnet = Qgross - Qr + Qf$$

-

A3.14.9 Cool down Gas up

In case Gassing Up and/or Cool Down of the cargo tanks is planned, the calculation method will be discussed and agreed in advance of the operation between Terminal and Terminal User. Based on the documentation provided by the Terminal User, the method and how to take the quantities into account in the energy balance will be agreed in advance of the operation.

A3.14.10 Roundings

If the first of the figures to be discarded is five (5) or more, the last of the figures to be retained is increased by one (1).

If the first of the figures to be discarded is four (4) or less, the last of the figures to be retained is unaltered.

The following examples are given to illustrate how a number is to be established in accordance with the above:

Number to be rounded	Number after being rounded to first decimal place
2.24	2.2
2.249	2.2
2.25	2.3
2.35	2.4
2.97	3.0

A3.14.11 Tables

	Mi kg/kmol	Hi MJ/kmol @ 25 °C	√bi @ 0 °C
Methane	16.04246	890.58	0.04886
Ethane	30.06904	1560.69	0.0997
Propane	44.09562	2219.17	0.1465
Iso-Butane	58.1222	2868.2	0.1885
N-Butane	58.1222	2877.4	0.2022
Iso-Pentane	72.14878	3528.83	0.2458
N-Pentane	72.14878	3535.77	0.2586
N-Hexane	86.17536	4194.95	0.3319
Nitrogen	28.0134	0	0.0214
Oxygen	31.9988	0	0.0311
Carbon Dioxide	44.0095	0	0.0821

Table 1: This table is for reference only; values to be used are values as given in ISO 6976, reference conditions: 25 °C for combustion, 0 °C metering.

	Mi kg/kmol
Methane	16.042
Ethane	30.069
Propane	44.096
Iso-Butane	58.122
N-Butane	58.122
Iso-Pentane	72.149
N-Pentane	72.149
Nitrogen	28.013

Table 2a: This table is for reference only; values to be used are molecular weight as given in ISO 6578

	106 K	108 K	110 K	112 K	114 K	116 K	118 K
Methane	0.037234	0.037481	0.037735	0.037995	0.038262	0.038536	0.038817
Ethane	0.047348	0.047512	0.047678	0.047845	0.048014	0.048184	0.048356
Propane	0.061855	0.062033	0.062212	0.062392	0.062574	0.062756	0.062939
Iso-Butane	0.077637	0.077836	0.078035	0.078236	0.078438	0.078640	0.078844
N-Butane	0.076194	0.076384	0.076574	0.076765	0.076957	0.077150	0.077344
Iso-Pentane	0.090948	0.091163	0.091379	0.091596	0.091814	0.092032	0.092251

N-Pentane	0.090833	0.091042	0.091252	0.091462	0.091673	0.091884	0.092095
Nitrogen	0.043002	0.043963	0.045031	0.046231	0.047602	0.049179	0.050885

Table 2b: This table is for reference only; values to be used are molar volumes as given in ISO 6578

	105 K	110 K	115 K	120 K
16 kg/kmol	-0.000007	-0.000008	-0.000009	-0.000010
17 kg/kmol	0.000165	0.000180	0.000220	0.000250
18 kg/kmol	0.000340	0.000375	0.000440	0.000500
19 kg/kmol	0.000475	0.000535	0.000610	0.000695
20 kg/kmol	0.000635	0.000725	0.000810	0.000920

Table 2c: This table is for reference only; values to be used are volume correction k1 as given in ISO 6578

	105 K	110 K	115 K	120 K
16 kg/kmol	-0.000010	-0.000015	-0.000024	-0.000032
17 kg/kmol	0.000240	0.000320	0.000410	0.000600
18 kg/kmol	0.000420	0.000590	0.000720	0.000910
19 kg/kmol	0.000610	0.000770	0.000950	0.001230
20 kg/kmol	0.000750	0.000920	0.001150	0.001430

Table 2d: This table is for reference only; values to be used are volume correction k1 as given in ISO 6578

A3.14.12 Accuracy of devices

A3.14.12.1 Verification of Accuracy of Gauging Devices

Each Party, at its own risk, will have the right to inspect or cause to be tested at any time any measurement devices installed by the other Party, provided that the other Party will be notified reasonably in advance. The required degree of accuracy of such devices selected (which will in any case be within the permissible tolerances defined herein and in the applicable standards referenced herein) will be mutually agreed upon by the Parties. All costs and expenses for testing and verifying measurement devices will be borne by the Party who is testing or verifying the devices being tested and verified unless the testing is conducted at the request of the other Party and such testing does not disclose errors or inaccuracies which require correction in such measurement devices, in which event, the Party requesting such testing or verification will bear such costs; provided, however, that representatives of the Parties attending such tests and verifications will do so at the cost and risk of the Party they represent. Testing will be performed using methods recommended by the manufacturer of the equipment being utilised or any other method agreed upon by the Parties.

All devices' accuracy levels, measurements, testing, gauging and analyses and calibration of such equipment provided for in clause A3.14.5 will be witnessed and verified by an independent surveyor agreed upon by the parties. Prior to effecting such calibrations, measurements, testing, gauging and analyses, the Party responsible for such operations will notify the representatives of the other Party and the Independent Surveyor, allowing such representatives and the Independent Surveyor a reasonable opportunity to be present for all operations and computations; provided, however, that the absence of either or both of the representatives of the other Party or the independent surveyor after notification and reasonable opportunity to attend will not prevent any operation or computation from being performed.

The results of such independent surveyor's verifications will be made available promptly to each Party. All records of measurements and the computation results will be preserved by the Party responsible for effecting such measurements and held available to the other Party for a period of not less than one (1) year after such measurements and computations have been completed, or if longer until any dispute between the Parties relating in any way to such measurements and computations has been finally resolved.

The Independent Surveyor for measurement and calculations will be mutually agreed between the Terminal and Terminal User not less than one week before the LNG Carrier is to arrive at the Port. Neither Party will unreasonably withhold consent to appointment of an Independent Surveyor proposed by the other Party. The fees and charges of the Independent Surveyor for measurements and calculations will be borne equally by Terminal and Terminal User

A3.14.12.2 Measurement Equipment Maintenance

The Terminal User or LNG supplier shall maintain or cause to have maintained for the CTMS, which shall be agreed by the Parties:

- a CTMS maintenance procedure.
- a schedule of maintenance.

- a log of the maintenance carried out, which is verified by the LNG Carrier Master or his designate, which shall be retained on board for inspection, audit, as requested by the Terminal, the Terminal User or LNG supplier or the independent surveyor.
- calibration, testing and defect correction procedures

A3.14.12.3 Historical Corrections

If any LNG Carrier equipment or devices are found to be outside the allowable limits, or are inoperable, then they shall be rectified or replaced without unreasonable delay. Any discrepancies in invoices which are caused by the inaccuracy of any measuring equipment or device shall be corrected and agreed upon by the Terminal and Terminal User accordingly. Historical corrections to invoices shall be limited to a period of one (1) year or to the last time an adjustment was made, whichever is shorter. In the event that the period of error is shorter than one (1) year, but the exact duration of the inaccuracy is neither known nor agreed, corrections shall be made for each delivery made during the last half of the period since the date of the most recent calibration of the inaccurate device.

A3.14.12.4 Cost & expenses

- Costs and Expenses of test verification by the Parties – The costs and expenses associated with confirming the accuracy of the Terminal measurement and testing devices shall be borne by Terminal, and the costs and expenses of confirming the accuracy of Terminal User measurement and testing devices shall be borne by Terminal User.
- Costs and expenses for test verification by an independent party – Where the accuracy of measurement and testing devices is confirmed by a third party such as an independent surveyor, the Party requesting the independent verification shall bear the cost.