LNG AND GAS QUALITY AND MEASUREMENT MANUAL FOR LNG CARRIERS CALLING AT TERMINAL

OFFSHORE LNG TOSCANA S.p.A. (OLT)

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1. LNG and Gas Quantity, Quality and Pressure Specifications

The User shall notify the Operating Company of the LNG composition in the Cargo Information Notice in accordance with the Terminal Manuals, including the physical properties such as Wobbe Index, Gross Calorific Value, density as loaded, and density as predicted at time of arrival at the Terminal. The data also shall include the actual composition and level of contaminants (such as sulphur and oxygen) to allow the Operating Company to determine whether vaporized LNG can meet the SRG Network Code specifications.

1.0. LNG Quality Specifications for the Delivery Point

The LNG Quality Specifications, based upon the SRG Network Code specifications, are as follows:

Tabella 1: LNG quality specifications (**)

Property		Specification	Unit
Wobbe Index	Minimum	47,31	MJ/Sm³
	Maximum	53,00	MJ/Sm³
Gross Calorific Value	Minimum	(*)	MJ/Sm³
	Maximum	(*)	MJ/Sm³
H2S + COS (as sulphur)	Maximum	6.6	mg/Sm3
Mercaptans (as sulphur)	Maximum	15.5	mg/Sm3
Total sulphur (as sulphur)	Maximum	150	mg/Sm3
Mercury (Hg)	Maximum	10	Nano g/Sm³
Hydrocarbon dew point (cricondentherm)	Maximum	- 5	°C (1-70bara)
Water (H2O)	Maximum	0,1	ppm (vol)
Oxygen (O2)	Maximum	100	ppm (vol)
Carbon dioxide (CO2)	Maximum	100	ppm (vol)
Solids		No deposits on 60 mesh strainers	
LNG density	Minimum	420	kg/m³
	Maximum	470	kg/m³

GCV, Wobbe Index reference standards: ISO 6976:1995 for calorific values (combustion reference temperature: +15°C, standard cubic meter +15°C @ 1,01325 bara)

(*): if Wobbe Index is inside the specification range GCV and single components compositions are acceptable

(**): at the time of current revision, SRG is revising quality specifications due to change of GCV/WI units from MJ to kWh. Please consider that 1 kJ/$Sm^3_{15°/15°}$ = 0.0002775 kWh/ $Sm^3_{25°/15°}$ and 1 kWh/ $Sm^3_{25°/15°}$ = 3603.6 kJ/$Sm^3_{15°/15°}$. Once official specifications will be issued, present Manual will be revised accordingly.

1.1. Impurities

The delivered LNG shall not contain solid matter, contaminants, or extraneous material that might interfere with its merchantability or cause injury to, or interference with, the proper operation of the Terminal.

If the total sulphur content is less than five (5) mg/Sm³, it is not necessary to analyse the sample for hydrogen sulphide and mercaptans sulphide.

To avoid internal clogging or erosion of equipment, the delivered LNG shall not contain any fluid component (*e.g.*, aromatics, C6H6, CO2, CH3OH, etc.) in a concentration higher than fifty per cent (50%) of the solubility limit in LNG of that particular fluid component in the operating pressure range of 0 to 100 bar absolute and operating temperature range of -162 to + 50°C. C6H6: max. 1 ppm, CH3OH: max. 0.5 ppm.

The LNG Quality Specifications are subject to change at any time as required to conform with the Gas Quality Specifications.

1.2. Gas Quality Specifications for the Delivery Point

Once the LNG is regasified and treated using the nitrogen injection facility onboard the FSRU, it shall meet the Gas Quality Specifications.

2. LNG and Gas Measurement, sampling and testing

2.0. Definitions

Terms defined in the main body of the Access Code and appearing in this Annex 5 are used herein as defined in the Access Code. Reference to GPA, API, ISO, EN or ASTM Standards and procedures shall be to the latest officially published revisions at March 1st 2008.

2.1. LNG testing and measuring methods: tank gauge tables

2.1.1. Calibration of LNG Tanks

Prior to the utilization of any LNG Carrier, the User shall: (a) in the case of an LNG Carrier for which the tanks and volume measuring devices have never been calibrated, arrange for each LNG tank and volume measuring device of such LNG Carrier to be calibrated for volume against level by a qualified surveyor agreed by the User and the Operating Company, or (b) in the case of an LNG Carrier for which the tanks and volume measuring devices have previously been calibrated, furnish to the Operating Company evidence of such calibration by a qualified surveyor and, if required, arrange for the re-calibration of all tanks and volume measuring devices by a qualified surveyor agreed by the User and the Operating Company.

2.1.2. Preparation of Tank Gauge Tables

The LNG Carrier shall have tank gauge tables verified by a qualified surveyor. Such tank gauge tables shall include sounding tables, correction tables for list (heel) and trim, volume corrections to tank service temperature and other corrections, if necessary. The tank gauge tables certified for use by the relevant classification society for the LNG Carrier or by such party agreed between the Parties and available for inspection by the Maritime Authorities, shall be verified by such qualified surveyor. The LNG Carrier shall present their inspection certificates evidencing last inspection.

2.1.3. Accuracy of Tank Gauge Tables

The tank gauge tables prepared pursuant to Section 2.1.2 above shall indicate volumes in cubic meters expressed to the nearest thousandth, with tank depths expressed in meters to the nearest thousandth.

2.1.4. Witnessing of Tank Calibration

The Operating Company shall have the right for its representative to witness the tank calibrations referred to in Section 2.1.1 above. The User shall give reasonable advance notice to the Operating Company of the timing of such tank calibrations.

2.1.5. Re-calibration of LNG Tanks in Case of Distortion, Reinforcement or Modification

In the event that any LNG tank of any LNG Carrier suffers distortion or undergoes reinforcement or modification of such a nature as to cause either the User or the Operating Company reasonably to question the validity of the tank gauge tables referred to in Section 2.1.2 above, the User shall arrange for such LNG tank to be re-calibrated in the same manner as set forth in Sections 2.1.1 and 2.1.2 hereof during any period when such LNG Carrier is out of service for inspection and/or repairs. The User shall bear the costs of re-calibration unless such re-calibration was done at the Operating Company's request and did not demonstrate any inaccuracy in the tank gauge tables, in which case the Operating Company shall pay the costs of re-calibration. Except as provided in this Section 2.1.5, no other re-calibration of any LNG tank of any LNG Carrier shall be required.

2.2. LNG testing and measuring methods: selection of gauging devices

2.2.1. Liquid Level Gauging Devices

- **a.** ISO 10976 specifies that 'At least two independent means of determining liquid level shall be available for each cargo tank. The primary and secondary level measurement systems shall be independent, such that failure of one does not affect the other'.
- **b.** ISO 10976 defines the measurement accuracy of both the primary and secondary liquid level gauging devices shall be plus or minus five (+/- 5) millimeters (some ATGs are not able to meet this verification tolerance, in which case a verification tolerance of +/- 7.5 mm may be applied).
- **c.** Gauging devices shall be suitable for offshore measurement.

2.2.2. Temperature Gauging Devices

- **a.** ISO 10976 specifies 'There should be a minimum of five temperature sensors in each tank and at least one temperature sensor shall be located above the maximum fill height so as to remain in the vapour space . Each temperature sensor shall be supported by a secondary sensor mounted adjacent to the primary sensor. The ATT system shall read and provide individual temperatures for both liquid and vapour space and allow their averages to be determined. In any case, LNG Carriers equipped with fewer temperature sensors (but still in accordance with the IGC Code requirements) may be considered.
- **b.** Two sensors including spares shall be installed at the tank bottom and the tank top, in order to constantly measure the temperatures of liquid and vapour, respectively. The remaining sensors shall be installed at equally spaced distances between the tank bottom and top. All of the sensors shall be mounted such that they are not affected by the spray of LNG when the spray pumps are in operation.
- **c.** ISO 10976 specifies that the accuracy of the temperature gauging devices shall be as follows:

Temp. Range, °C	Range,
-165 to -145	+/-0.2

2.2.3. Pressure Gauging Devices

- **a.** Each LNG tank of each LNG Carrier shall have one (1) absolute pressure gauging device.
- **b.** ISO 10976 specifies that the measurement accuracy of the pressure gauging device shall be plus or minus +/- 0.3 kPa

2.3. LNG testing and measuring methods: measurement procedures

2.3.1. General

a. ISO 10976 is identified as the current standard defining measurement of cargoes on board LNG carriers.
b. Gas to Boilers line must be isolated, spray pumps and boil-off gas compressors stopped, loading arms connected and LNG Carrier's manifold valves closed before any gauging can take place. If gas burning is permitted then the Gas Flow meters must be recorded at the same time as OCT and CCT are performed. The Master of the LNG Carrier shall ensure that its gauging equipment and computers are in good working order and calibrated by a qualified organization. Calibration certifications shall be available on request.
c. OCT gauging shall be made after the Master has confirmed that the LNG Carrier is ready to unload and before starting the LNG transfer pumps.
d. CCT gauging shall take place after completion of unloading, with transfer pumps off and allowing sufficient time for the liquid level to stabilize.
e. Volumetrically the condition of the cargo arms and the unloading line should be in the same condition for OCT and for CCT, either empty or full. Any other equipment eventually in use should be in the same condition for OCT and CCT.
f. The User, the Operating Company or their representatives shall have the right to be present during any gauging, but the absence of a representative shall not prohibit any gauging taking place.

2.3.2. Liquid Level

a. Measurement of the liquid level in each LNG tank of each LNG Carrier shall be made to the nearest millimetre by using the main liquid level gauging device referred to in Section 2.2.1 hereof. Should the main device fail, the auxiliary device shall be used for both OCT and CCT.
b. Five (5) readings shall be made in as rapid succession as possible. The arithmetic average of the readings shall be deemed the liquid level. The supplier of the measuring equipment shall make sure that the CTMS is able to compensate for dynamic movement while the LNG Carrier is moored at the Terminal. The internal level sampling rate of the CTMS shall be fast enough to enable an appropriate processing, resulting in above specified readings with time intervals of typically fifteen (15) seconds to be stable within CTMS accuracy limits. Such information shall be included as part of the LNG Carrier calibration already approved by a qualified surveyor. Any variation in the prescribed number of measurement readings that may be required to compensate for dynamic movement of the LNG Carrier while moored at the Terminal is to be provided by the supplier of the measuring equipment. Such information shall be included as part of the LNG Carrier calibration tables already approved by a qualified surveyor.
c. Such arithmetic average shall be calculated to the nearest zero decimal one (0.1) millimetre and shall be rounded to the nearest millimetre.
d. The same liquid level gauging device shall be used for both the initial and final measurements during Unloading at the Delivery Point. If the main level gauging device is inoperative at the time of commencement of Unloading, necessitating use of the auxiliary level gauging device, the auxiliary level gauging device shall be used at the time of cessation of Unloading, even if the main level gauging device has subsequently become operative. Trim and list of the LNG Carrier shall be kept unchanged while the referenced measurements are performed.
e. The liquid level in each LNG tank shall be logged or printed.

2.3.3. Temperature

a. At the same time liquid level is measured, temperature shall be measured to the nearest zero decimal one degree Celsius (0.1°C) by using the temperature gauging devices referred to in Section 2.2.2 hereof.
b. In order to determine the temperature of liquid and vapour in the tanks of the LNG Carrier, one (1) reading shall be taken with each primary temperature gauging device in each LNG tank . An arithmetic average of such readings with respect to vapour and liquid in all LNG tanks shall be deemed the final temperature of vapour and liquid.
c. Such arithmetic average shall be calculated to the nearest zero decimal zero one degree Celsius (0.01°C) and shall be rounded to the nearest zero decimal one degree Celsius (0.1°C).
d. The temperature in each LNG tank shall be logged or printed.

2.3.4. Pressure

a. At the same time liquid level is measured, the absolute pressure in each LNG tank shall be measured to the nearest one (1) mbarA by using the pressure gauging device referred to in Section 2.2.3 hereof.
b. The determination of the absolute pressure in the LNG tanks of each LNG Carrier shall 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.
c. Such arithmetic average shall be calculated to the nearest zero decimal one (0.1) mbarA and shall be rounded to the nearest one (1) mbarA
d. In the event that an LNG Carrier utilizes units other than mbarA, then the Operating Company and the User may convert to mbarA using recognised international conversion factors.
e. The pressure in each LNG tank shall be logged or printed.

2.3.5. Procedures in Case of Gauging Device Failure

Should the measurements referred to in Sections 2.3.1, 2.3.2, 2.3.3 and 2.3.4 hereof become impossible to perform due to a failure of gauging devices, alternative gauging procedures shall be determined by mutual agreement between the Operating Company and the User in consultation with the independent surveyor.

2.3.6. Determination of Volume of LNG Unloaded

a. The list (heel) and trim of the LNG Carrier shall be measured at the same time as the liquid level and temperature of LNG in each LNG tank are measured. ISO 10976 specifies that the tolerance permitted on Draft readings is +/- 50 mm. The tolerance permitted on List measurement is +/- 0.05 Degrees. The LNG Carrier's cargo transfer piping shall contain hydrocarbons in the same state during final gauging as at initial gauging. Vapor lines that are connected to the vapor header shall be opened to ensure that the vapor pressure in all LNG tanks is equalized. Such measurements shall be made immediately before any Cargo operation commences and immediately after Unloading is completed and after cargo arms and vessel lines are drained.. The volume of LNG, stated in cubic meters to the nearest zero decimal zero zero one (0.001) cubic meter, shall be determined by using the tank gauge tables referred to in Section 2.1 hereof and by applying the volume corrections set forth therein.

b. The volume of LNG unloaded shall be determined by deducting the total volume of LNG in all tanks immediately after Unloading is completed from the total volume in all tanks immediately before Unloading commences. This volume in cubic meters of LNG Unloaded shall be rounded to the nearest zero decimal zero zero one (0.001) cubic meter.

c. On completion of the CCT measurements, all measurements recorded from the CTMS shall be printed to three certificates – as follows:

Certificate of Opening Custody Transfer measurements
Certificate of Closing Custody Transfer measurements
Certificate of Unloading – summarizing the data from the OCT and CCT Certificates

These three documents shall be produced in original form and signed by all of the interested Parties, originals of which shall be distributed to said interested Parties

2.4. LNG testing and measuring methods: determination of composition of LNG

For LNG custody transfer purposes, the amount of energy transferred from the LNG Carrier to the Terminal will be measured in accordance with the methods described in the GIIGNL LNG Custody Transfer Handbook 2010.

2.4.1. General

a. The Operating Company shall sample and analyze the LNG Unloaded in accordance with this Section 2.4. For the determination of composition either a continuous sampling with subsequent analysis as per Section 2.4.2 or on-line sampling and analysis as per Section 2.4.4 shall be used. The Operating Company shall decide which sampling/analysis system shall be used for determining of the official composition of the discharged LNG.

b. The LNG sampling/analysis systems shall be in accordance with the ISO 8943-2007 standard for continuous and on-line intermittent analysis systems and to UNI EN ISO 10715 "Norma Italiana Gas Naturale – Linea guida per il campionamento."

c. Representatives of the User may be present and witness device calibrations and sampling/analyses procedures, but absence of a representative shall not prohibit the execution of these activities.

2.4.2. LNG Sampling System

a. An LNG sampling system shall be located in a weather tight enclosure on the Terminal at a suitable position on each Terminal main discharge line and shall be configured so as to guarantee that representative continuous samples are drawn from the LNG transfer lines during the period of steady full rate discharge. This consists of two (2) LNG sample take-off systems with integrated vaporization, stabilization and control to ensure control of the phase change of the LNG to gas. From both sample take-off the vaporized LNG will be delivered to a single automated sampling system for filling of sample cylinders.

b. The sampled gas is delivered to an online gas chromatograph and used for on-line intermittent analysis.
Alternatively, backup samples shall be charged on a continuous basis into CP/FP sample containers to be analysed in an on shore laboratory.
This sampling shall be performed at an even rate during the period starting about one (1) hour after continuous Unloading at full rate has commenced and ending about one (1) hour prior to the suspension of continuous full rate Unloading.

c. The sampling equipment shall be such as to guarantee that representative samples are drawn from the LNG transfer line at all times during Unloading. It shall be designed to extract, transport and condition representative LNG samples to be delivered to a sample container consisting of three (3) five hundred (500) cc. stainless steel sample cylinders and to the analyzers under conditions that are required for proper operation in terms of accuracy, repeatability, reproducibility and availability.

d. After completion of the discharge, the collected composite gas sample shall be available in three (3) stainless steel gas sample cylinders. One sample cylinder shall be sent for analysis at an independent onshore laboratory using industry accepted standard methods, one sample cylinder shall be made available to the User (delivered to the LNG Carrier), and one sample cylinder shall be retained by the Operating Company for at least thirty (30) days. In case of any dispute concerning the accuracy of any analysis, the Operating Company sample shall be further retained until the Operating Company and the User agree not to retain it.

2.4.3. LNG On-line Composition Analysis

a. The intermittent on-line analyses the sampled gas uses the on-line gas chromatographs to determine the molar fractions of hydrocarbons and nitrogen in accordance with the ISO 8943-2007. A separate gas chromatograph shall be used for each line, and analyses shall be made at suitable fixed intervals of five minutes.

b. For each line, the composition shall be the average of the readings taken in the time from about one (1) hour after continuous Unloading at full rate has commenced up to about one (1) hour prior to the suspension of continuous full rate Unloading. The composition of the discharged LNG shall be determined by taking the average of the two (2) lines.

c. The intermittent on-line analysis system is the primary system. CP/FP samples are to be used in case of unavailability/misfunctioning of the primary system.

d. Triplicate runs shall be made on the reference gas and the sample gas to determine that the repeatability of peak areas is within acceptable limits. The calculated results of such triplicate runs shall be averaged. The gas chromatography analysis shall be carried out according to the ISO 6974 Part 4 and the LNG density determined in accordance with the revised Klosek-McKinley method.

e. Individual composition readings and the averages shall be rounded to at least zero point zero one per cent (0.001%). If required, the methane concentration shall be corrected to give a sum of composition percentages of 100% the rounding of molar composition values should be consistent with that specified in the test method.

f. The on-line chromatographs shall be calibrated and/or have calibration checks performed within the time period of twenty-four (24) hours before commencement of the discharge.

g. Test method ISO 19739:2004 shall be used to determine the total sulphur content of the LNG Unloaded. If the total sulphur content is less than five (5) mg/Sm^3, it is not necessary to analyze the sample for hydrogen sulphide.

h. In the event that the on-line monitoring of a Cargo Unloading would indicate that the Cargo does not meet the LNG Quality Specifications set forth in this Annex 5, the applicable provisions of Clause 3.7.1.3 shall apply.

2.4.4. Specification of the Analyser System

a. The on-line gas chromatograph used for the intermittent on-line analysis shall be installed to verify the quality of the LNG transferred at the delivery point. The gas chromatograph shall be self-calibrating and shall, by direct measurement or by calculation, provide an accurate analysis of the composition of the LNG, its density, Wobbe Index and Gross Calorific Value. The analysis cycle for each of the gas chromatographs shall be five (5) minutes.

Process analyzers are installed inside a analyzer house. The temperature inside the analyzer house shall be controlled to ensure ambient conditions at all times.

In particular, provision for analysis consists of:

1. One (1) composition analyzer (gas chromatographs) 100% redundant
2. One (1) H2S, mercaptans, and total sulphur analyzer (gas chromatograph)
3. Dew point analyzer (hydrocarbon / water)
4. Density analyzer
5. O2 analyzer
6. Laboratory sampling system

b. The gas chromatograph will be used to analyze the composition (C1 to C6+, N2, CO2) and to calculate GCV, WI, Dr, D, and Z where:
GCV - Gross Calorific Value
WI - Wobbe Index
Dr - Relative density
D - Dew point
Z - Compressibility factor
To check the accuracy of GCV-Dr-Z-CO2-N2, two (2) test gas samples shall be used containing all the components to be determined, one (1) with GCV between thirty-seven decimal three (37.3) and thirty-eight decimal one (38.1) MJ/Sm3 and the other with GCV between thirty-eight decimal nine (38.9) and forty decimal two (40.2) MJ/Sm3. For each test sample, five (5) analyses shall be carried out, discarding the first two (2). On the last three (3) analyses, the average composition and the related chemical-physical parameters shall be calculated, verifying that the relative error calculated to meet the requirements of the test gas analysis certificate shall be within the limits specified below. The test method that is being reported by the Gas Chromatograph (GC) will define the applicable level of precision. The test method advised is to be ISO 6974 Part 4 compliant (see V 3.3 above)

C1 – C2	0.1 % molar
C3 – N2 – CO2	0.05 % molar
GCV	50 kJ/Sm3
Dr	0.001
Z	0.001

To check the repeatable use of the equipment in accordance with the table below, at least seven (7) consecutive analyses of a gas sample containing all the relevant components shall be carried out, discarding the first two (2) analyses. For this trial, a certified gas mixture or ‘working gas’ should be used.

GCV	0.5 %
Dr	0.5 %
Z	0.1 %
CO2	0.1 %
N20	0.1 %

c. The gas chromatograph for H2S, mercaptans, and total sulphur analysis and calculation shall be within the limits specified below:
Repeatability: ± 2% of full scale
Sensitivity: ± 0.5% of full scale
The analysis cycle time: 6 min.

d. The dew point analyzer (hydrocarbonIwater) shall be within the limits specified below:
Accuracy: ±0.5°C
Repeatability: ± Vendor STD
Measurement frequency: 6 cycles/hour recommended (12 maximum)
Resolution: 0.1 °C

H.C. dew point range: -40 + +20°C

e. The density analyzer shall be within the limits specified below:
Accuracy: +/- 0.1% of reading
Repeatability: +/- 0.02% of reading
Response time: < 60 sec.

f. Oxygen (O2) in the process analyzer shall be within the limits specified below:
Accuracy: +/-1% F.S.
Repeatability: +/- 1% of SPAN
Sensitivity: Vendor STD
Response time: Vendor STD

g. The moisture, H2O analyzer shall be within the limits specified below:
Accuracy: ±1°C
Sensitivity: 0.1 ppmV
Resolution: 0.1 °C

2.4.5. Procedure in Case of Analysis System Failure

a. In the case of a failure of the continuous sampling system or the on-line analysis system, the results of the other system shall be used for the LNG composition.

b. In the case of a failure of both the continuous sampling system and the on-line sampling system, the arithmetic average of the analysis results of the five (5) immediately preceding Cargoes (or the total Cargoes delivered if less than five (5)) of similar composition to that expected for the current Cargo from the same loading port, including the Cargoes of other Users, shall be deemed to be the composition of the LNG. If the above is not deemed reliable by the independent Cargo Surveyor, the weathered composition according to MOLAS model will be used for the determination of LNG quality within 5 working days after discharge of the LNG carrier .

c. In case of a LNG cargo arriving from a reloading operation, the composition of LNG at the loading port shall not in any case be taken as a base for determining the quality of Cargo (ref par 2.4.5.b) unless User (or its appointed Cargo Surveyor) certificates that the LNG quality analysis at the loading port is performed accordingly to GIIGNL LNG Custody Transfer Handbook (fourth (2015) edition) section 18 recommendations (i.e. proper measurement of the gas return flow and quality).

2.4.6. On-line Composition Analysis for Gas Return

As Terminal is not equipped with a system for Gas Return Analysis, GHV value for Gas Return is 33.935 MJ/m3 in standard conditions as specified, which is equal to a quality of ninety per cent (90%) methane and ten per cent (10%) nitrogen.

2.5. LNG testing and measuring methods: method to determine energy transferred

The amount of energy transferred from each LNG Carrier shall be calculated by an independent cargo surveyor appointed by all interested Parties in accordance with the Measurement Testing and Calculations defined within this document. The target inaccuracy for the determination of the energy received is in accordance to the applicable standards (ref GIIGNL LNG Custody Transfer Handbook – Third Edition 2010).
The amount of LNG Unloaded shall be exclusive of the volume of vapor returning to the User's LNG Carrier during Unloading of LNG.

During these transfer operations, the volume of LNG Unloaded is replaced by Gas sent back by the Terminal.
A small amount of LNG remains in the LNG Carrier's tanks after Unloading has finished. The energy transferred, E, corresponds to the difference between the energy transferred as LNG and as gas [return gas (NG) + gas used by the LNG Carrier's engines, if applicable (MG)]:

$$\mathbf{E = E_{LNG} - E_{NG} - E_{MG}}$$

The evaluation of these energies is done by determining the volumes and/or mass transferred and the mean mass and/or volume-based calorific value during the transfer process, which is:

<u>For LNG:</u>

$\mathbf{E_{LNG} = V_{LNG} \times \delta_{LNG} \times H_{LNG}}$

with:

V_{LNG}: volume of LNG measured in the LNG Carrier's tanks;

δ_{LNG}: density of LNG calculated based on chromatographic analysis and temperature of the LNG; and

H_{LNG}: mean mass-based Gross Calorific Value (GCV) of LNG calculated, as above through chromatographic analysis of the LNG.

<u>For the Return Gas (NG)</u>:

$\mathbf{E_{NG} = V_{NG} \times H_{NG}}$

with:

V_{NG}: volume of Gas replacing the Unloaded LNG. This volume as specified, brought to standard conditions (288.15 K and 1013.25 mbar), is calculated from the volume of LNG transferred and the temperature and pressure conditions of the gas phase in the tanks at the end of Unloading; and

H_{NG}: volume-based Gross Calorific Value of Gas, calculated through chromatographic analysis of the return gas.

The following diagram represents the energy transferred between the Unloaded LNG and the return gas.

<u>Note</u>: Natural evaporation of the Cargo during Unloading is not included in the calculation; in fact, the loss of LNG is compensated for by less Gas returning to the LNG Carrier's tanks.

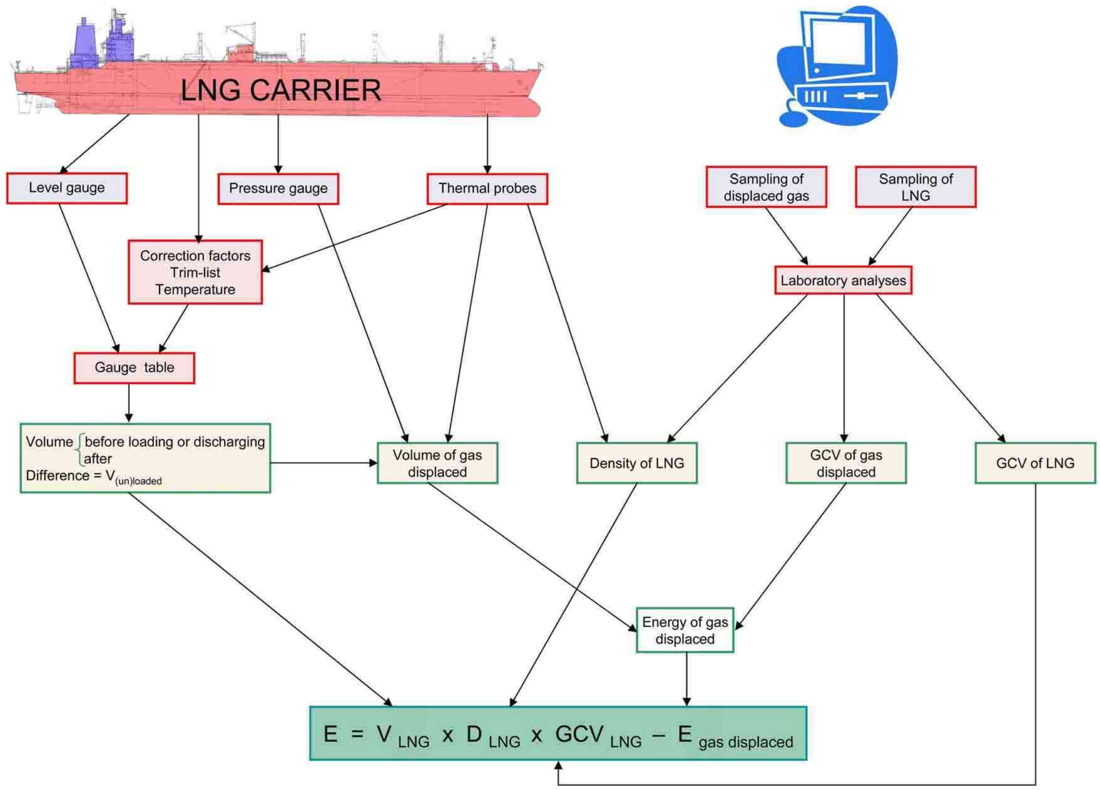

Figura 1: Principle of cargo inspection

2.6. LNG testing and measuring methods: methods of calculating energy transferred

2.6.1. Calculation of gross energy discharged

The calculation of gross energy discharged is a function of:

1. V_{LNG} : volume of LNG discharged,
2. δ_{LNG} : density of LNG discharged, and
3. H_{LNG}: mass-based Gross Calorific Value of LNG discharged.

$$E_{LNG} = V_{LNG} \times \delta_{LNG} \times H_{LNG}$$

2.6.2. Calculation of Volume of LNG Discharged V_{LNG}

Method of Calculation

The volume of LNG discharged is calculated as the difference in volumes of LNG contained within the tanks before and after Unloading.
The volume of LNG contained within the tank at a given point is determined by the reading from a gauge table, as a function of the corrected LNG level.
The corrected LNG level is obtained from the level measured in a tank (mean of level gauges), with correction factors (as mentioned above) applied if necessary.
The volume of the LNG Carrier at a given point is the sum of the volumes contained within all the tanks onboard the LNG Carrier.

Units and Rounding

Volume is expressed in m^3.
The volume of LNG, before and after Cargo inspection, is determined to three (3) decimal places; the net volume is calculated as a difference and for the energy calculations made to three (3) decimal places (*e.g.*, 0.001).

2.6.3. Calculation of Density of LNG Discharged δ_{LNG}

The density is calculated from different models based on state equations, corresponding state equations, etc., with the following input data:

1. The composition of LNG from chromatographic analysis after sampling and vaporisation; the values for molar composition are made to five (5) decimal places; and
2. The LNG temperature, measured in the LNG Carrier's tanks; the temperature of LNG is measured in °C to one (1) decimal place (*e.g.*, 0.1).

The calculation should use the revised Klosek and McKinley (KMK)[1] method for determining LNG density.

Application Areas for the Calculation Method

The limits of the Klosek and McKinley method for LNG composition and temperature are:

Methane (CH_4)	> 60 % mol.
Iso- and normal butanes ($iC_4 + nC_4$)	< 4 % mol.
Iso- and normal pentanes ($iC_5 + nC_5$)	< 2 % mol.
Nitrogen (N_2)	< 4 % mol.
Temperature (T)	< 115 K < - 158.15 °C

The Klosek Mac Kinley Method Formula

The method for calculating LNG density is based on an empirical evaluation of molar volumes of mixtures in a considered thermodynamic state. The density is calculated as follows:

$$\rho_{LNG} = \frac{M_{mix}}{V_{mix}}$$

with:

ρ_{LNG}: density of LNG in [kg·m^{-3}]
M_{mix}: molecular mass of mixture in [kg·kmol^{-1}]

$$M_{mix} = \sum M_i \cdot X_i$$

where:

M_i : molecular mass of constituent *i*;
X_i : molar fraction of constituent *i*.
V_{mix} : molar volume of mixture expressed in [l·mol^{-1}]

$$V_{mix} = \sum X_i \cdot V_i - \left[K_1 + (K_2 - K_1) * \left(\frac{X_{N_2}}{0.0425} \right) \right] * X_{CH_4}$$

where:

X_i : molar fraction of constituent *i*
V_i : molar volume of constituent *i* at the temperature of LNG
K_1, K_2 : correction factors

The values of K1 and K2, expressed in l/mol, are determined by tables as a function of the molar mass of LNG at temperatures of between 105 K and 135 K. The tables showing molar volumes in [l·mol^{-1}] for the hydrocarbons from C_1 to C_5, as a function of varying temperature from 106 K to 118 K are used by this method. (Tables Annex 5) No rounding is made when calculating K1, K2 and V_{mol}.

Units and Rounding for the Calculations

Density calculations are made without rounding, as per the rules for KMK calculations (note NBS 1030 December 1980); density is expressed in [kg·m^{-3}].

2.6.4. Calculation of Mass-based Calorific Value of LNG Discharged - Hm_{LNG}

Method of Calculation

The calculation of the mass-based gross calorific value of LNG is determined from the molar composition, the molar mass and the molar calorific value of the different components. The molar mass and the molar calorific values for each component are included in the Schedule 1 tables below.

Their correlation is shown here with:

$$Hm_{LNG} = \frac{\sum_{i=1}^{N}\left[x_i * H_i^o(t_1)\right]}{\sum_{i=1}^{N} x_i * M}$$

where:

Hm_{LNG} : mass-based calorific value of the mixture, [MJ·kg^{-1}]
$H^0i(t_i)$: molar calorific value of component *i*, [MJ·kmol^{-1}], at 15°C combustion temperature
x_i : molar fraction of component *i*
M_i : molar mass of component *i* [kg·kmol^{-1}]

Units and Rounding

The mass-based gross calorific value is expressed in [MJ·kg^{-1}], in specified reference combustion conditions of 15°C. The physical constants for molar-based gross calorific value and molar mass of the different components are found in the standard ISO 6976 – 1995. No rounding for Hm_{LNG} is used in calculating gross energy discharged.

2.6.5. Calculation of Volume-based Calorific Value of LNG Discharged - Hv_{LNG}

Method of Calculation

The calculation of the volume-based gross calorific value (for Real Gas conditions) of LNG is determined from the volume-based calorific value, the molar composition and the summation factor of the different components and the molar gas constant. The volume-based calorific value and the summation factor for each component are included in the Schedule 1 tables below.
Their correlation is shown here:

$$Hv_{LNG} = \frac{\sum_{i=1}^{N}\left[x_i * Hv_i\right]}{Z_{mix}}$$

with:

$$Z_{mix} = 1 - \left[\sum_{i=1}^{N} x_i * \sqrt{b_i}\right]^2$$

where as:

Hv_{LNG} :	is the volume-based calorific value (for Real Gas conditions) of the mixture, [MJ·m3^{-1}]
x_i :	is the molar fraction of component *i*
Hv_i :	is the volume-based calorific value of component *i*, [MJ·m3^{-1}] , at reference conditions of 15/15°C & 101.325 kPa
Z_i :	is the compression factor at the metering reference conditions
$\sqrt{b_i}$:	is the summation factor of component *I*, (at 15°C & 101.325 kPa)

Units and Rounding

The volume-based gross calorific value is expressed in [MJ·m3^{-1}], at a specified reference combustion temperature of 15°C, a metering temperature of 15°C and an atmospheric pressure of 101.325 kPa (for Real Gas conditions). The physical constants for volume-based gross calorific value are found in the standard ISO 6976 – 1995. No rounding for Hv_{LNG} is used in calculating gross energy discharged.

2.6.6. Calculation of the Wobbe Index of LNG Discharged - WI

The method of calculation is based on a real gas with the following formula:

$$WI = \frac{Hv_{LNG}}{\sqrt{d}}$$

with:

$$d = \sum_{i=1}^{N} \left(x_i * \frac{M_i}{M_{air}} \right) * \frac{Z_{air}}{Z_{mix}}$$

where as:

WI:	is the Wobbe Index value of the mixture, [MJ·m3^{-1}]
Hv_{LNG} :	is the volume-based calorific value (for Real Gas conditions) of the mixture
d:	relative density of the real gas mixture
M_i :	is the molar mass of component *i* [kg·kmol^{-1}]
M_{air} :	is the molar mass of dry air (28.9626 kg·kmol^{-1})
Z_{mix} :	is the compression factor at the metering reference conditions
Z_{air} :	is the Real Gas compressibility factor for dry air equal at 288.15K & 101.325 kPa (0.99958)

Units and Rounding

The Wobbe Index is expressed in [MJ·m^{-3}], at a specified reference combustion temperature of 15°C, a metering temperature of 15°C and an atmospheric pressure of 101.325 kPa (for Real Gas conditions).. The physical constants for Wobbe Index of the different components are found in the standard ISO 6976 – 1995. No rounding is used in calculating Wobbe Index.

2.6.7. Calculation of the Return Gas Energy to the LNG Carrier

The calculation of energy returning to the LNG Carrier E_{NG} is based on the following values:

1. The volume of gas V_{NG}; and
2. The volume-based Gross Calorific Value of the return gas H_{NG}.

As Terminal does not provide the measurement of volume-based Gross Calorific Value for the return gas H_{NG}, the determined value will be 33.995 MJ·m^{-3} in standard conditions as specified for Real Gas conditions**,** which is equal to a quality of ninety per cent (90%) methane and ten per cent (10%) nitrogen.

2.6.8. Calculation of Return Gas Volume - V_{NG}

The NG volume transferred is calculated as a difference from the volume of LNG transferred corrected according to:

1. The temperature of the gas phase; and
2. The pressure of the gas phase.

Between two (2) cargo inspections, natural evaporation is taken into account with volume of LNG transferred, if the corresponding drop in LNG level is measured.

Outside of cargo inspections (before and after), this evaporation is not taken into account as it is reincorporated within the Terminal.

Method of Calculation

The volume of gas returned to the LNG Carrier between two (2) cargo inspections, corresponding to the geometric volume of LNG discharged, shall be done under specific pressure and temperature conditions: 101.325 kPa and 15°C, respectively; the volume shall be corrected according to temperature and pressure conditions of the gas phase to the LNG Carrier

Standard conditions (101.325 kPa; 15 °C)

$$V_{NG} \approx V_{LNG} * \frac{288.15}{273.15+t} * \frac{P}{1013.25}$$

V_{LNG}: Volume of gas under observed pressure and temperature conditions; no rounding is made in calculating return gas volume;

P: observed absolute pressure, expressed in mbar, in the LNG Carrier's tanks; for calculations, measurements made to the nearest mbar;

t: observed vapor temperature of gas phase in degrees Celsius. The value for this is equal to the mean temperature indicated by the temperature probes not immerged in the LNG in place in the LNG Carrier's tanks; for calculations, temperatures taken to the nearest 0.1 °C.

Units and Rounding

The return gas volume V_{NG} is expressed in cubic meters [m^3] as specified under standard pressure and temperature conditions (101.325 kPa.; 15 °C), with no rounding performed for calculating return gas energy.

2.6.9. The Gross Calorific Value of the Return Gas - H_{NG}

The volume-based Gross Calorific Value of return gas is calculated from the molar composition, determined by chromatographic analysis, in accordance with the standard ISO 6976 – 1995.

In all cases, when Unloading, the Operating Company shall take into account the Gross Calorific Value of the return gas and use this in the calculation of energy transferred; this will provide better accuracy to the annual usage report for each carrier in question

Method of Calculation

The method of calculation is based on a real gas with the following formula:

$$H_{NG} = \frac{\sum_{i=1}^{N} \left[x_i * Hv_i \right]}{Z_{mix}}$$

with:

$$Z_{mix} = 1 - \left[\sum_{i=1}^{N} x_i * \sqrt{b_i} \right]^2$$

where as:

H_{NG}: is the volume-based calorific value (for Real Gas conditions) of the gas return mixture, [MJ·m3^{-1}]
x_i: is the molar fraction of component *i*
Hv_i: is the volume-based calorific value of component *i*, [MJ·m3^{-1}] , at reference conditions of 15/15°C & 101.325 kPa
Z_{mix}: is the compression factor at the metering reference conditions
$\sqrt{b_i}$: is the summation factor of component *I*, (at 15°C & 101.325 kPa)

Units and Rounding

The volume-based Gross Calorific Value is expressed in [MJ·m^{-3}] with as specified reference combustion conditions 15°C standard pressure and temperature conditions (1013.25 mbar; 15 °C) as specified. The physical constants for volume-based Gross Calorific Value and molar masses of the different components are detailed in the standard ISO 6976 – 1995. No rounding is performed for return gas energy calculations.

2.6.10. Calculation of Net Energy Discharged (Formulas and Rounding for the Calculation)

Method of Calculation

In summary, the net energy discharged is expressed according to the formula:
Standard conditions (1013.25 mbar; 15 °C)

$$E_{LNG} = V_{LNG} \left[\left(\rho_{LNG} * H_{LNG} \right) - \left(\frac{288.15}{273.15 + t} * \frac{P}{1013.25} * H_{NG} \right) \right]$$

Units and Rounding

All of the calculations concerning discharged net energy are made without rounding and use the following input data:

V_{LNG}: expressed in [m^3] to three (3) decimal places

ρ_{LNG}: expressed kg/m^3 without rounding in the calculation; no rounding in the calculation of K1, K2 and Vmol; the molar composition of LNG is given to five (5) decimal places or if it is a molar % to three (3) decimal places; the temperature of LNG in °C is given to one (1) decimal place.

H_{LNG}: mass-based calorific value of LNG is expressed in [MJ·kg^{-1}] without rounding in the calculation; the molar composition of LNG is given to five (5) decimal places or if it is a molar % to three (3) decimal places

t: temperature of the return gas expressed in [°C] and given to one (1) decimal place

P: pressure of the return gas expressed in bar given to three (3) decimal places or in mbar to the nearest mbar

H_{NG}: calorific value of return gas expressed in [MJ·m^{-3}] without rounding in the calculation; the molar composition of LNG is given to five (5) decimal places or if it is a molar % to three (3) decimal places

E_{NG}: net energy discharged expressed in [GJ] without rounding.

Conversions

MJ to MMBtu (ASTM E380-72)

1 MMBtu (reference combustion T) = 1055.056 MJ (reference combustion T).

1 kJ·mol^{-1} = 0,00423 MJ·m^{-3}

2.7. UNLOADING CERTIFICATE AND DISCHARGE REPORT

For unloading certificates and discharge reports, the values for the Cargo are detailed as follows:

V_{LNG} before Unloading	: in [m^3] to three (3) decimal places
V_{LNG} after Unloading	: in [m^3] to three (3) decimal places
V_{LNG} discharged	: in [m^3] to two (2) decimal places
LNG temperature before Unloading	: in [°C] to one (1) decimal place
Pressure of tanks after Unloading	: in [mbar] to nearest one (1) mbar
Temperature of NG after Unloading	: in [°C] to one (1) decimal place
Composition of LNG	: in [mol %] to three (3) decimal places
Composition of return gas	: in [mol %] to three (3) decimal places
Wobbe Index	: in [MJ·m^{-3}] to two (2) decimal places
GCV, NCV volume and mass based	: in [MJ·kg^{-1}] or per m^3 to two (2) decimal places
Density of LNG	: in [kg·m^{-3}] to three (3) decimal places
Density of gaseous LNG	: in [kg·m^{-3}] to three (3) decimal places
Specific gravity of gaseous LNG	: no units to three (3) decimal places

Quantity of LNG energy returning to LNG Carrier	:in [GJ] to the nearest GJ (no figures after the decimal point) and [MMBtu] to two (2) decimal places
Quantity of net LNG energy discharged	: in [GJ] to the nearest GJ (no figures after the decimal point) and [MMBtu] to two (2) decimal places

SCHEDULE 1

Constituent-Specific Values of the Natural Gas Mixture

HV_i : volume-based calorific value (15/15°C & 101.325 kPa) of constituent *i*
HM_i: molar-based calorific value (15°C) of constituent *i*
M_i: molar mass of constituent *i*
$\sqrt{b_i}$: summation of factor (15°C & 101.325 kPa) for constituent *i*

Component	Property			
	HV_i [MJ/m³]	HM_i [kJ/mol]	M_i [kg/kmol]	$\sqrt{b_i}$
Methane (CH4)	37.706	891.56	16.043	0.0447
Ethane (C2H6)	66.07	1,562.14	30.070	0.0922
Propane (C3H8)	93.94	2,221.10	44.097	0.1338
n-Butane (nC_4H_{10})	121.79	2,879.76	58.123	0.1871
iso-Butane (iC_4H_{10})	121.40	2,870.58	58.123	0.1789
n-Pentane (nC_5H_{12})	149.66	3,538.60	72.150	0.2510
Iso-Pentane (nC_5H_{12})	149.36	3,531.68	72.150	0.2280
Nitrogen (N_2)	-		28.0135	0.0173
Carbon dioxide (CO2)	-		44.010	0.0748

Source: ISO 6976:1995

Constituent Molar Volumes

Component	Molar volume, l/mol						
	118 K	116 K	114 K	112 K	110 K	108 K	106 K
CH_4	0.038817	0.038536	0.038262	0.037995	0.037735	0.037481	0.037234
C_2H_6	0.048356	0.048184	0.048014	0.047845	0.047678	0.047512	0.047348
C_3H_8	0.062939	0.062756	0.062574	0.062392	0.062212	0.062033	0.061855
iC_4H_{10}	0.078844	0.078640	0.078438	0.078236	0.078035	0.077836	0.077637
nC_4H_{10}	0.077344	0.077150	0.076957	0.076765	0.076574	0.076384	0.076194
iC_5H_{12}	0.092251	0.092032	0.091814	0.091596	0.091379	0.091163	0.090948
nC_5H_{12}	0.092095	0.091884	0.091673	0.091462	0.091252	0.091042	0.090833
N_2	0.050885	0.049179	0.047602	0.046231	0.045031	0.043963	0.043002

Source: N.B.S. - Technical note 1030 December 1980.

Volume Correction Factor - $k_1 \times 10^{-3}$

Molecular weight of mixture g/mol	Volume reduction, l/mol						
	105 K	110 K	115 K	120 K	125 K	130 K	135 K
16	-0.007	-0.008	-0.009	-0.010	-0.013	-0.015	-0.017
17	0.165	0.180	0.220	0.250	0.295	0.345	0.400
18	0.340	0.375	0.440	0.500	0.590	0.700	0.825
19	0.475	0.535	0.610	0.695	0.795	0.920	1.060
20	0.635	0.725	0.810	0.920	1.035	1.200	1.390
21	0.735	0.835	0.945	1.055	1.210	1.370	1.590
22	0.840	0.950	1.065	1.205	1.385	1.555	1.800
23	0.920	1.055	1.180	1.330	1.525	1.715	1.950
24	1.045	1.155	1.280	1.450	1.640	1.860	2.105
25	1.120	1.245	1.380	1.550	1.750	1.990	2.272

Source: N.B.S. - Technical note 1030 December 1980.

Volume Correction Factor – $k_2 \times 10^{-3}$

Molecular weight of mixture	Volume reduction, l/mol						
	105 K	110 K	115 K	120 K	125 K	130 K	135 K
16	-0.010	-0.015	-0.024	-0.032	-0.043	-0.058	-0.075
17	0.240	0.320	0.410	0.600	0.710	0.950	1.300
18	0.420	0.590	0.720	0.910	1.130	1.460	2.000
19	0.610	0.770	0.950	1.230	1.480	1.920	2.400
20	0.750	0.920	1.150	1.430	1.730	2.200	2.600
21	0.910	1.070	1.220	1.630	1.980	2.420	3.000
22	1.050	1.220	1.300	1.850	2.230	2.680	3.400
23	1.190	1.370	1.450	2.080	2.480	3.000	3.770
24	1.330	1.520	1.650	2.300	2.750	3.320	3.990
25	1.450	1.710	2.000	2.450	2.900	3.520	4.230

Source: N.B.S. - Technical note 1030 December 1980.

3. MEASUREMENTS AND TESTS FOR EXPORT GAS AT THE INTERCONNECTION POINT

3.1. Gas Deliveries

To accurately measure the Gas after regasification entering into the Grid, a complete measuring system is provided.
The metering system is located on the Terminal, and is built in accordance with the current standards and requirements laid down by international and domestic legislation and EU Directive 2004/22/EC on Measuring Instruments (MID) which are applicable to the fiscal metering of natural gas. The MID was implemented in Italy by Legislative Decree No. 22 of 2 February 2007.

3.1.1. Volume Measurement

Exported Gas will be fiscally metered using ultrasonic meters with 100% backup.

3.1.2. Quality Measurement

Within practicable limits, the analyzer will perform a continuous measurement of the defined components.

Two (2) on-line gas chromatograph systems (operating in duty/standby configuration) shall be installed on the common export line downstream of the metering runs to verify that the quality of the Gas exported into the Grid is in full compliance with the entry point specifications. The system shall be self-calibrating and shall, by direct measurement or by calculation, provide an accurate analysis of the composition of the export gas, its density, Wobbe Index and Gross Calorific Value. The analysis cycle for each of the gas chromatographs will be five (5) minutes.

Manual sampling points enable the verification of the NG composition in a laboratory analyzer in case of a dispute or unavailability of the online analyzer.

In case of analyzer unavailability or malfunctioning, the flow meter will measure the flow (see 3.1.3 below) based on the last available "good" data, which may be from up to 9 days earlier (in accordance with the Operating Manual between SRG and OLT Offshore). For longer unavailability periods, manual sampling will be used, in agreement with the parties involved.

The gas chromatographs are in accordance with the requirements of SRG Network Code (chapter 11 "*Qualità del Gas*").

3.1.3. Flow Computers

Each fiscal metering stream will have dedicated digital flow computers which will communicate with their respective flow meters over a Fieldbus interface and download data received from the gas chromatographs and field instruments for continuous calculation of the following:

- Volumetric flow rate;
- Volumetric flow totalization;
- Mass flow rate and totalization
- Flow direction;
- Total energy;
- Heat value calculation;
- Gas composition;
- Density (calculated in accordance with ISO 6976);
- Compressibility factor;
- Process temperature; and

- Process pressure.

The flow computer will provide gas flow calculations at the “Reference Conditions” (as provided by ISO 13443 - Pressure 101,325 kPa, Temperature 288,15 K (=15°C)). The flow computer will use input from ultrasonic flow meters to measure pressure, temperature and gas composition compressibility factor in accordance with ISO 12213.

3.1.4. Overall Accuracy of Measurement System

Overall uncertainty will meet ISO 5168 limits.

3.1.5. Fiscal Metering Supervisory System (EMMS)

Redundant EMMS will be provided for flow and gas quality data interface, acquisition, management, storage and reporting. The EMMS will check and validate the gas composition data coming from the analyzers.

3.1.6. Fiscal Metering of Fuel Gas Usage

Any fuel gas for use within the Terminal will be fiscally metered.

The fiscal metering systems will consist of two (2) parallel meter runs (2 x 100%) fitted with measuring devices and in line with the Italian fiscal authority requirements.

3.1.7. Calibration

Calibration of the flow computers will be in compliance with SRG requirements.

4. INVENTORY BALANCING

Inventory balancing will be performed when necessary and under the authorization and requirements of the Italian fiscal authority.

5. DEFINITIONS AND REFERRED STANDARDS

5.1. Acronyms list

API	:	American Petroleum Institute
ASTM	:	ASTM International - formerly American Society for Testing and Materials
ATG	:	Automatic tank gauge
ATT	:	Automatic tank thermometer
BOG	:	Boil-off gas
CCT	:	Closing Custody Transfer
CP/FP	:	Constant Pressure, Floating Piston – applies to gas sample cylinders
CTS	:	Custody Transfer System
CTMS	:	Custody Transfer Measurement System
EN	:	Euro Norm
ISO	:	International Standards Organization
FAT	:	Factory Acceptance Test – normally performed at the vendor’s factory
GCV	:	Gross Calorific Value
GPA	:	Gas Producers Association
EMC	:	Electromagnetic compatibility
GCU	:	Gas combustion unit

GIIGNL	:	Groupe International des Importateurs de Gaz Naturel Liquefie
GNG	:	Gaseous natural gas
H2S	:	Hydrogen Sulphide
IACS	:	International Association of Classification Societies
IAPH	:	International Association of Ports and Harbours
ICS	:	International Chamber of Shipping
IEC	:	International Electrotechnical Commission
IGC Code	:	International Gas Carrier Code
IMO	:	International Maritime Organisation
ISGOTT	:	International Safety Guide for Oil Tankers and Terminals
MOLAS	:	Calculation Models Of LNG Ageing During Ship Transportation
MPMS	:	Manual of Petroleum Measurement Standards
MSDS	:	Material safety data sheet
NBS	:	National Bureau of Statistics (US)
OBQ	:	On board quantity
OCT	:	Opening Custody Transfer
SAT	:	Site Acceptance Test – performed at the ship yard

5.2. List of latest referred Standards with full titles

Measurement

ISO 10976:2012	Refrigerated light hydrocarbon fluids – Measurement of cargoes onboard LNG carriers
ISO 5725-1 1994	Accuracy (Trueness and precision) of measurement methods and results - Part 1: General Principles and definitions
ISO 18132-1 2011	Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels -- General requirements for automatic tank gauges -- Part 1: Automatic tank gauges for liquefied natural gas on board marine carriers and floating storage.
ISO 8311 :1989	Refrigerated light hydrocarbon fluids – Calibration of membrane tanks and independent prismatic tanks in ships – Physical measurement.
ISO 8943:2007	Refrigerated light hydrocarbon fluids -- Sampling of liquefied natural gas -- Continuous and intermittent methods.
ISO 10715:1997	Natural gas – Sampling guidelines

Analysis

ISO 6326-4	Natural gas -- Determination of sulphur compounds -- Part 4: Gas chromatographic method using a flame photometric detector for the determination of hydrogen sulfide, carbonyl sulfide and sulphur-containing oderants **N.B. – this standard has been revised by <u>ISO 19739:2004</u>** - see below
ISO 19739:2004	Natural gas – Determination of sulphur compounds using gas chromatography
ISO 6974:	ISO 6974 comprises 6 parts, parts 1 and 2 being guidelines and measuring-system characteristics and statistics for processing of data, parts 3 to 6 being the test methods.
ISO 6974-1:2001	BS EN ISO 6974-1:2001 Natural gas - Determination of composition with defined uncertainty by gas chromatography. Guidelines for tailored analysis

ISO 6974-2:2002	BS EN ISO 6974-2:2002 Natural gas - Determination of composition with defined uncertainty by gas chromatography. Measuring-system characteristics and statistics for processing of data
ISO 6974-3:2001	BS EN ISO 6974-3:2001 Natural gas. - Determination of composition with defined uncertainty by gas chromatography. Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and hydrocarbons up to C8 using two packed columns
ISO 6974-4:2001	BS EN ISO 6974-4:2001 Natural gas - Determination of composition with defined uncertainty by gas chromatography. Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line measuring system using two columns
ISO 6974-5:2001	BS EN ISO 6974-5:2001 Natural gas - Determination of composition with defined uncertainty by gas chromatography. Determination of nitrogen, carbon dioxide and C1 to C5 and C6+ hydrocarbons for a laboratory and on-line process application using three columns
ISO 6974-6:2008	BS EN ISO 6974-6:2008 Natural gas - Determination of composition with defined uncertainty by gas chromatography. Determination of hydrogen, helium, oxygen, nitrogen, carbon dioxide and C1 to C8 hydrocarbons using three capillary columns.
ISO 10715:1997	Natural gas - Sampling guidelines
UNI EN ISO 10715	Norma Italiana Gas Naturale – Linea guida per il campionamento.
GPA 2261 – 2000	Analysis for Natural Gas and Similar Gaseous Mixtures by Gas Chromatography
ASTM D1945 -03(2010)	Standard Test Method For Analysis of Natural gas by Gas Chromatography