Appendix 4
MEASURING, METERING, QUALITY

1 METHODOLOGY OF THE MEASUREMENTS PERFORMED IN THE LOADING PORT

At the Operator's request, the Shipper shall provide it with the following information:

- detailed description of the LNG sampling and the LNG vaporisation method and characteristics of the equipment used,
- detailed description of the chromatographic method used to analyze the LNG main components (hydrocarbons and nitrogen), including the calibration and characteristics of the equipment used,
- detailed description of the chromatographic method used to analyze the LNG sulphur-based components (H2S, COS, mercaptans, total sulphur), including the the calibration and characteristics of the equipment used,
- detailed description of the method used to detect mercury in LNG, including the calibration and characteristics of the equipment used,
- detailed description of the method used to detect oxygen in LNG, including the calibration and characteristics of the equipment used,
- traceability of reference standard products used for measurements, with certificates.

2 MEASUREMENTS PERFORMED ON THE CARGO IN THE TERMINAL

2.1 CARGO INSPECTION OPERATIONS

Two Cargo inspection operations are carried out onboard the Vessel, before and after unloading respectively:

- Cargo inspection before unloading after the issuing of the Notice of Readiness and before gas and liquid crossfeed valves are opened;
- Cargo inspection after unloading after the liquid manifold is drained and the gas and liquid manifold valves are closed.

If the piping filling state is different before and after unloading, the corresponding Cargo volume variation must be taken into account in calculating the Unloaded Quantity. For this purpose, the Shipper shall provide the Operator with a calculation of the manifold volumes it intends to use and the procedure for cooling and draining these manifolds.

If the Shipper operates the Vessel's machinery on Natural Gas when it is connected to the gas arm, the energy consumed is then either determined by the gas meter of the Vessel's machinery if applicable, or by a set quantity taken as gas in kind of 0.04% of the total Unloaded Quantity.

2.2 GAUGING AND CALCULATION OF THE LNG VOLUME UNLOADED

The gauging procedures must comply with the recommendations of the current version of the LNG custody transfer handbook of the Liquefied Natural Gas Importers Group (GIIGNL).

The primary and secondary measuring systems are of capacity type, float type and/or microwave type (radars); they must comply with the recommendations of the standard ISO 18132.

The LNG volume unloaded, expressed in cubic meters, is determined by the difference between the volumes of LNG contained in the vessel's tanks before and after unloading. Each of the Vessel tanks must be fitted with two gauging systems, a main system dedicated to Cargo inspection operations and an emergency system. The maximum permissible error in the main gauging system must not exceed plus or minus 7.5 mm. The primary and secondary gauging systems will be identified during the cargo inspection operations before unloading, without modification during the unloading. In the event of a failure of the main gauging system, the emergency system is used; if its maximum permissible error exceeds plus or minus 7.5 mm, especially on an old Vessel, the Shipper and the Operator shall agree on a method to estimate the LNG volume unloaded.

The total uncertainty in measuring the LNG volume unloaded as a result of the gauging system measuring uncertainty, gauge tables and correction tables associated with each of the Vessel's tanks must be less than 0.3%, in accordance with the European Union Law N° 71/349/CEE dated 12 October 1971 transposed to the French law.

2.3 DETERMINING THE LNG TEMPERATURE AND GAS PHASE TEMPERATURE

Each of the Vessel's tanks must be fitted with temperature sensors located such that at any time at least one sensor is located in the liquid and one in the gas phase, the other sensors being uniformly distributed over the tank height. The LNG temperature before unloading is determined as the arithmetic mean of the measurements of the temperature sensors immersed in the liquid. The gas phase temperature after unloading is determined as the arithmetic mean of the measurements of temperature sensors located above the liquid phase.

The total uncertainty on the temperature, including uncertainty on the different devices of the temperature measuring system, must be less than the value given in the following table, in accordance with the recommendations of the standard ISO 8310.

	total uncertainty of the measuring chain Class A
Liquid phase – LNG	**± 0,3 °C**
Gas phase	**± 2 °C**

2.4 DETERMINING THE PRESSURE IN THE VESSEL'S TANKS

The measuring procedures must comply with the recommendations of the current version of the LNG custody transfer handbook of the GIIGNL.

Each of the Vessel's tanks must have at least one pressure sensor in contact with the gas phase. The average pressure in the tanks is determined before and after unloading as the arithmetic mean of the measurements read in each tank. The required accuracy of the absolute pressure measuring system is specified ± 10 mbar or ± 1% of the full-scale of the sensors, going from 800 mbar to 1400 mbar.

3 MEASUREMENTS PERFORMED IN THE TERMINAL

3.1 LNG SAMPLING AND RETURN GAS SAMPLING

LNG in-line sampling: The Operator uses a so-called "in line" discontinuous sampling method, as defined in the LNG European standard EN 12838 and the standard ISO 8943 from 2007, which makes it possible to:

- continuously sample and vaporise LNG under nominal unloading conditions (i.e. not including the start and end of unloading); sampling is performed by means of an Pitot tube isolated by maintaining it under vacuum conditions or by re-circulating LNG located in the centre of the unloading pipe, after the unloading arms; the transfer line, which meets the standard ISO 8943, maintains the LNG sub-cooled until it is vaporised in an electric vaporizer, by Joule effect, at regulated temperature;
- transfer the vaporised gas at a stabilized pressure and flow rate to a chromatograph via suitable and identified piping;
- and perform chromatographical analysis at regular intervals (at least three times an hour).

LNG cylinder sampling: In parallel with in-line sampling, LNG in the gaseous state may be sampled periodically by sampling cylinders. The systems for sampling and transferring the evaporated gas to the sampling cylinders are the same as for in-line sampling. When unloading each cargo, three samples (one for the shipper, one for the operator and one for an independent laboratory) are taken simultaneously and in parallel in cylinders when half of the cargo is unloaded, and kept sealed by the Operator for two weeks after unloading. The cylinder samples are only analyzed at the Shipper's explicit request and only applies to the measurement of major components

Sampling of return gas: The return gas sent back by the Terminal to the Vessel is sampled directly in the return gas pipe with a so-called "in line" discontinuous sampling method, under nominal unloading conditions (i.e. not including the start and end of unloading); it is transferred to a chromatograph for analysis at regular intervals (at least three times an hour).

3.2 ANALYSIS OF COMPONENTS; CALIBRATION AND CHECKING OF CHROMATOGRAPHS

3.2.1 ANALYSIS OF THE MAIN COMPONENTS OF LNG AND RETURN GAS

The main components of LNG and return gas are analyzed by chromatography in gaseous phase in accordance with parts I and IV of the standard ISO 6974. An analysis is performed at least three times an hour and the analysis results are validated and standardized when the sum of the molar concentrations of the main components of the analyzed gas is between 0.98 and 1.02. The content of the LNG and return gas is determined, for each component, as the arithmetic mean of the analysis results obtained under nominal unloading conditions (i.e. not including the start and end of unloading).

If the chromatograph is unserviceable or jittering after first third of unloading under steady state conditions, the chromatographic analysis carried out during this first third shall be used for Cargo inspection.

If the chromatograph is unserviceable or jittering during the first third of unloading under steady state conditions, three (3) samples in cylinder with a double ogive shall be taken in parallel at regular intervals; a cylinder of each of the samples shall then be chromatographically analyzed as soon as the chromatograph is operational again and calibrated in accordance with the procedures in force.

When equipment checking for traces elements contained in LNG is faulty after the first third of unloading under steady state conditions, the analysis results obtained during this first third shall be the ones used for Cargo inspection.

If the equipment checking for trace elements is unserviceable during the first of unloading under steady state conditions, the reference values taken in this case are the ones obtained during the LNG last unloading operations carried out in the Terminal or those obtained during loading in the case of the 1st delivery.

3.2.2 CALIBRATION AND CHECKING OF THE ANALYSIS CHROMATOGRAPHS OF MAIN COMPONENTS

Outside the unloading phases, the chromatographs are constantly swept with vector gas. The chromatograph in the gaseous phase is calibrated by carrying out at least five consecutive analyses with a reference gaseous mixture in accordance with the current standard ISO 6141 or 6142, the last three analyses being kept to determine the area of the peaks of each component of this gas. This calibration is performed each year, or following a check having revealed a non-conformity, or after a maintenance action having required the instrument to be stopped. The chromatographs are checked with a working gas produced from the gas regularly received at the Terminal, at least once a quarter.

3.2.3 ANALYSIS OF TRACE ELEMENTS

Sulphur-based compounds are analyzed in accordance with the standard ISO 19739 and mercury in accordance with part II of the standard ISO 6978. The methods described in these standards may be tailored according to the measuring instruments available and the recommendations of the suppliers of such instruments.

3.3 DETERMINATION OF THE GROSS HEATING VALUE (GHV), WOBBE INDEX AND THE DENSITY

The GHV and volumetric Wobbe Index are established for a real gas in accordance with the method recommended by the current standard ISO 6976, the reference conditions of which are as follows:

- volumetric measuring conditions: 0°C and 1,01325 bar absolute (so-called "normal" conditions);
- combustion conditions: 0°C and 1,01325 bar absolute.

The mass GHV calculations are established in accordance with the same ISO standard and under the same reference combustion conditions.

The LNG density is calculated in accordance with the revised KLOSEK MC KINLEY method (published in December 1980 in Technical note 1030 – National Bureau of Standards and described in the GIIGNL LNG custody transfer handbook, taking into account:

- LNG mean temperature before unloading,
- LNG mean composition determined during unloading,
- the molar mass of each component as defined in the current standard ISO 6976,
- the molar volume of each component and the correction factors K1 and K2 as described by the GIIGNL LNG custody transfer handbook (Technical note 1030 – National Bureau of Standards, published in December 1980)

4 UNITS AND ROUND OFFS; LOADING, QUANTITY AND UNLOADING CERTIFICATES

4.1 UNITS AND ROUND OFFS

The calculations are performed in International Units as defined in the standard ISO 1000, and the round offs in accordance with the standard ISO 31/2.

The calculation methods for transferred energy and the round offs rules are described in a technical note published on the operator's website.

The following table shows the round offs to be applied to the calculation results that are displayed (read-out only) in the certificates (cf. § 4.3):

Magnitude	Unit	Round off (read-out)
Volume (apart from gross and net unloaded LNG)	**m3 (cubic meter)**	**0,001**
Gross and net unloaded volume of LNG	**m3 (cubic meter)**	**0,1**
LNG and gas return temperatures	**°C (degree Celsius)**	**0,1**
Pressure in Vessel's tanks	**mbar (millibar)**	**1**
LNG and gas return composition	**Molecular %**	**0,001**
Mass GHV	**MJ/kg (Megajoule per kilogram) or kWh/kg (kilowatt-hour per kilogram)**	**0.01**
Volum GHV	**MJ/m3 (Megajoule per cubic meter) or kWh/m3 (kilowatt-hour per cubic meter)**	**0,01**

Wobbe Index	**MJ/m3 (Megajoule per cubic meter) or kWh/m3 (kilowatt-hour per cubic meter)**	**0,01**
Density	**kg/m3 (kilogram per cubic meter)**	**0,1**
Quantity of energy returned to the vessel Qr	**MJ (Megajoule) or kWh (kilowatt-hour)**	**1**
Quantity of energy unloaded	**MJ (Megajoule) or kWh (kilowatt-hour)**	**1**

Any quantity of energy expressed in MWh (Megawatt-hour) is round offs to three (3) meaningful decimals and any quantity of energy expressed in kWh (Kilowatt-hour) is round offs to zero (o) meaningful decimals, as per the following rule:

- a non-meaningful decimal which equals to zero (0), one (1), two (2), three (3) or four (4) does not raise the meaningful decimal ;
- a non-meaningful decimal which equals to five (5), six (6), seven (7), eight (8) or nine (9) raise the meaningful decimal.

In case of dispute, the quantity of energy expressed in MWh (Megawatt-hour) only is contractual.

4.2 UNIT CONVERSION

A quantity of energy expressed in kWh (Kilowatt-hour) at 25°C (GHV) is converted in a quantity of energy expressed in MWh (Megawatt-hour) at 0°C (GHV) by multiplying this quantity of energy by 1.0026, in accordance with the recommendations of the standard NF ISO 13443, and by dividing the result by one thousand (1000).

A quantity of energy expressed in MWh (Megawatt-hour) at 0°C (GHV) is converted in a quantity of energy expressed in kWh (Kilowatt-hour) à 25°C PCS by multiplying this quantity of energy by one thousand (1000), and by dividing the result by 1.0026, in accordance with the recommendations of the standard NF ISO 13443.

A quantity of energy expressed in Wh (Watt-hour) is converted in a quantity of energy expressed in J (joule) by multiplying this quantity of energy by one three thousand and 6 hundred (3600).

A quantity of energy expressed in Btu (British Thermal Unit) is converted in a quantity of energy expressed in J (joule) by multiplying this quantity of energy by 1055.056.

4.3 CERTIFICATES

4.3.1 LOADING CERTIFICATE

The Loading Certificate indicates:

- the Shipper's name;
- the Tanker's name;
- the journey number;
- the name of the Loading port (and the name of the wharf if necessary);
- the Loading date;
- the LNG destination;
- the Cargo reference number;
- mean content of loaded LNG as a molecular % and its impurity content:
  - the total sulphur in mg(S)/m3(n),
  - sulphur in the H2S in mg(S)/m3(n),
  - sulphur in H2S+COS in mg(S)/m3(n),

- mercaptans in mg(S)/m3(n),
- carbon dioxide in ppmm,
- mercury in ng/m3(n),
- the oxygen content in ppmv
- the hydrocarbon dew point temperature in degrees Celsius

o the total volume before and after Loading;

o mean temperature of loaded LNG;

o the tank pressure after Loading.

4.3.2 QUANTITY CERTIFICATE

During Cargo inspection, before unloading and after unloading, a Quantity Certificate shall be drawn up and signed by the Operator and the Shipper (cf. form provided in pages 7 and 8).

4.3.3 UNLOADING CERTIFICATE

After the unloading, an Unloading Certificate is drawn up by the Operator and sent to the Shipper (cf. form provided in page 9).

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CERTIFICAT DE QUANTITE / QUANTITY CERTIFICATE

NAVIRE / *VESSEL*	**CARGAISON N° / *CARGO N°***
PROVENANCE / *COMING FROM*	**DATE**

Nom de l'expéditeur - *Shipper name*						
Numéro de cuve avant déchargement *Tank number before unloading*	1	2	3	4	5	6
Valeur de l'assiette (en mètre) - *Trim value (in meter)*						
Valeur de la gîte (en degré) - *List value (in degree)*						
Hauteur (en millimètre) – *Height (in millimeter)*						
Correction due à l'assiette du navire (en millimètre) *Correction for tanker trim (in millimetre)*						
Correction due à la gîte du navire (en millimètre) *Correction for tanker list (in millimetre)*						
Cuves autoportantes : correction due à la température des cuves du navire (en millimètre) *Self supporting tank : correction for tank temperature (in millimetre)*						
Jauges à ruban : correction due à la température de la phase gaz des cuves du navire (en millimètre) *Float gauges : correction for tank vapour phase temperature (in millimetre)*						
Hauteur corrigée (en millimètre) *Corrected height (in millimetre)*						
Volume correspondant (arrondi à 0,001 m^3) *Corresponding volume (rounded to 0.001 m^3)*						
Volume total avant déchargement (arrondi à 0,001 m^3) *Total volume before unloading (rounded to 0.001 m^3)*						
Température du GNL (arrondie à 0,1 °C) *LNG temperature (rounded to 0.1 °C)*						
Température moyenne du GNL avant déchargement (arrondie à 0,1 °C) *LNG mean temperature before unloading (rounded to 0.1 °C)*						
Température de la phase vapeur (arrondie à 0,1 °C) *Vapour phase temperature (rounded to 0.1 °C)*						
Pression absolue avant déchargement (arrondie à 1 mbar) *Absolute pressure before unloading (rounded to 1 mbar)*						

Numéro de cuve après déchargement *Tank number after unloading*	1	2	3	4	5	6
Valeur de l'assiette (en mètre) - *Trim value (in meter)*						
Valeur de la gîte (en degré) - *List value (in degree)*						
Hauteur (en millimètre) - *Height (in millimeter)*						
Correction due à l'assiette du navire (en millimètre) *Correction for tanker trim (in millimeter)*						
Correction due à la gîte du navire (en millimètre) *Correction for tanker list (in millimeter)*						
Cuves autoportantes : correction due à la température des cuves du navire (en millimètre) *Self supporting tank : correction for tank temperature (in millimeter)*						
Jauges à ruban : correction due à la température de la phase gaz des cuves du navire (en millimètre) *Float gauges : correction for tank vapour phase temperature (in millimeter)*						
Hauteur corrigée (en millimètre) *Corrected height (in millimeter)*						
Volume correspondant (arrondi à 0,001 m^3) *Corresponding volume (rounded to 0.001 m^3)*						
Volume total après déchargement (arrondi à 0,001 m^3) *Total volume after unloading (rounded to 0.001 m^3)*						
Température du GNL (arrondie à 0,1 °C) *LNG temperature (rounded to 0.1 °C)*						
Température de la phase vapeur (arrondie à 0,1 °C) *Vapour phase temperature (rounded to 0.1 °C)*						
Température moyenne de la phase vapeur (arrondie à 0,1 °C) *Vapour phase mean temperature (rounded to 0.1 °C)*						
Pression absolue après déchargement (arrondie à 0,1 mbar) *Absolute pressure after unloading (rounded to 0.1 mbar)*						
Pression absolue moyenne après déchargement (arrondie à 1 mbar) *Mean absolute pressure after unloading (rounded to 1 mbar)*						
Volume total brut de GNL déchargé (arrondi à 0,1 m^3) *Unloaded LNG gross total volume (rounded to 0.1 m^3)*						
Gaz d'évaporation consommé à la machine durant le déchargement (MWh)/*Gas sent to engine room during unloading (MWh)* ➢ Selon lecture du compteur / *As per gas meter reading* ➢ Selon forfait / *lumpsum value*						
Gaz d'évaporation torché selon lecture du compteur (MWh) *Boil off gas to flare as per gas meter reading (MWh)*						

Signature
Signed

Pour le Navire
For Ship

Pour le Terminal
For Terminal

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NAVIRE/ *VESSEL* _____ **CONTRAT/ *CONTRACT*** _____

CERTIFICAT DE DECHARGEMENT / *UNLOADING CERTIFICATE*

CARGAISON N° / *CARGO Nr* :

DATE / *DATE* (JJ/MM/AA) : HEURE / *HOUR* (HH/MM) :

EMETTEUR / *FROM* :

DESTINATAIRE / *TO* :

COPIE / *COPY* :

Nom de l'Expéditeur / *Shipper name*							
Date et Heure de début des analyses / *Date and Time of the beginning of analysis*							
Date et Heure de fin des analyses / *Date and Time of the end of analysis*							
Date et Heure de l'échantillonnage en bouteilles / *Date and Time of the sampling in gas cylinders*							
Composition moyenne du GNL déchargé (% mol) / *Mean composition of unloaded LNG (% mol)*							
C1	C2	C3	i C4	n C4	i C5	n C5	N2
Teneur en impuretés / *Impurities content*							
Sulfure d'hydrogène de H_2S / *Hydrogen sulphide in H_2S* ($mg/m^3(n)$)							
Soufre de H_2S+COS / *Sulfur in H_2S+COS* ($mg(S)/m^3(n)$)							
Mercaptans / *Mercaptans* ($mg(S)/m^3(n)$)							
Soufre total / *Total sulfur* ($mg(S)/m^3(n)$)							
Mercure / *Mercury* ($ng/m^3(n)$)							
Volume de GNL brut déchargé (arrondi à 0,1 m^3) Unloading LNG gross Volume (rounded to 0,1m^3)							
Température moyenne du GNL déchargé (arrondie à 0,1°C) / *Mean temperature of unloaded LNG (rounded to 0.1°C)*							
Température moyenne du gaz retour (arrondie à 0,1°C) / *Mean temperature of return gas (rounded to 0.1°C)*							
Pression absolue moyenne des cuves après Déchargement (arrondie à 1 mbar) / *Tanks mean absolute pressure after Unloading (rounded to 1 mbar)*							
PCS massique du GNL déchargé / *Mass gross calorific value of unloaded LNG* (MJ/kg)							
Masse volumique de GNL déchargé / *Unloaded LNG density* ($kg/m^3(n)$)							
PCS volumique du GNL déchargé / *Volume gross calorific value of unloaded LNG* ($MJ/m^3(n)$)							
Indice de Wobbe du GNL déchargé / *Wobbe index of unloaded LNG* ($MJ/m^3(n)$)							
Quantité d'énergie renvoyée au Navire / *Quantity of energy returned back to the Ship* (MJ)							
Quantité d'énergie consommée par le navire pendant le déchargement							
Quantité brute d'énergie déchargée / *Unloaded energy quantity* (MJ)							
Quantité d'énergie déchargée (nette) / *Net energy quantity transferred* (MJ, kWh)						MJ	kWh (1 kWh = 3,6 MJ)