STUDY: CURRENT STATE AND PROSPECTS OF LNG IN THE UNECE REGION

CHAPTER 4: INTEROPERABILITY AND SAFETY

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CHAPTER 4: INTEROPERABILITY AND SAFETY –

1.- INTRODUCTION

Since the World first LNG tanker, the Methane Pioneer transported a cargo of Liquefied Natural Gas (LNG) in 1959 from Lake Charles, USA, to Canvey Island in the UK, the global LNG business has expanded to more than 370 LNG tankers, 95 LNG Liquefaction Trains and more than 90 LNG Regasification Terminals in operation.

The latest generation of Q-Max LNG tankers can transport almost 270.000 cubic meters of LNG in a single vessel. At the other end of the scale, LNG is starting to go “small scale” with LNG moving down the distribution chain to small scale-storage and Regasification Terminals.

The LNG industry, from gas producers and liquefiers, right through the transport chain to LNG Regasification Terminals, has managed to facilitate this enormous expansion in global trade in a multitude of countries without any significant safety or environmental issue, providing the technological, regulatory and operational framework to enable the production and safe delivery of more than 240 million tons of LNG per year.

The principal transport route of the majority of LNG transportation is maritime and a critical aspect of the LNG production-to delivery chain is the Ship to Terminal interface. Taking into account the enormous range of coastal and port environments, the differences in local operational and regulatory procedures from port to port, the variance in crews and operators, the tremendous variety of LNG tankers designs, and the added ingredient of ever-changing regulations and technology, ship to Terminal compatibility is a very important global issue.

The first part of the Chapter 4 is devoted to LNG Quality and Interchangeability, including the LNG and impurity Specifications, taking into account that individual nations have developed different Gas Specifications so an LNG supplier must match his product to different Market requirements and a Terminal Operator has to consider flexibility to receive LNG of different qualities from different sources. The actual Specifications in each market depend mainly on the history of its gas supply.

The Gas Quality Harmonization is an important effort in order to define Gas Quality standards for the European Union countries and the Association EASEE-gas is working in that way, trying to promote the physical transfer and the trading of gas across Europe.

The accurate analysis and measurement of LNG Quality is very important, mostly in the Receiving Terminals and the sampling techniques and the operational sampling are included in this Chapter and also the methods of adjusting Quality at the Liquefaction Plants and at the Receiving Terminals, which are the two ends of the LNG value chain.

Another section is devoted to the impact of the LNG Quality in the utilization on gas turbines used for power generation and also on the performance of domestic appliances in different countries of Europe and the USA.

The future challenges in the near-term and in the log-term perspective, are also included considering the great importance of the unconventional gas: shale gas, tight gas and coal-bed-methane which, in general, have very lean composition and that may increase the demand for rich LNG as a blending component.

In conclusion, we consider that global harmonization of traded LNG Quality is unlikely but some regional harmonization is feasible and likely in the USA, Europe and Asia Pacific.

The last Part of the Chapter 4 is devoted to LNG Facilities Compatibility (Interoperability), including information related to Operational Safety of LNG Facilities and LNG Carriers.

An important aspect of the LNG Liquefaction Plant to LNG Terminal chain is the Ship to Terminal interface. In other words the Ship to Terminal compatibility is a very important global issue. In addition the spot-trading cargoes are increasing and some ongoing projects will convert import Terminals to bi-directional capability and the issue of compatibility is also being re-defined for the proposed floating off-loading projects.

In summary, the Chapter 4 tries to identify the current issues, trends, requirements and challenges to allow the LNG industry to grow in safety and interoperability.

Traditionally LNG is delivered by Ship to a Receiving Terminal onshore or LNG is loaded on to a Ship, in the case of an LNG Export Terminal. A future operation alliance related to LNG Carrier/Terminal compatibility would make global LNG access safer and more viable. Therefore understanding specific design drivers and data linked to individual LNG Terminals is essential to understand compatibility challenges.

Another section is devoted to Operational safety of LNG Facilities and LNG Carriers. We must realize that the LNG industry has an excellent safety record and to maintain it, LNG Facilities undergo safety reviews during the engineering and before an LNG Facility can start the design phase, there is an extensive permitting process, that is explained in this section, including a reference to SIGTTO, an International Society established for the exchange of technical information and experience between members of the industry, to enhance the safety and operational reliability of LNG Carriers and Terminals.

Regarding Safety Operations and Procedures, the LNG Terminal must be provided with a Risk Assessment and Detection System designed for informing the operators of any incident and automatically activating the corresponding Emergency Shutdown System.

The Environmental issues section includes a list of the chemical products employed and the prevention measures to be considered in a Terminal. In addition a reference to the Best Practices is included.

Another section is devoted to the vessel approval and compatibility procedure that should be designed in line with the GLE LNG Ship Approval procedure, in order to check the compatibility of the ship and the shippers must send to the LNG Terminal a preparatory information to study the good match of the ships to berth, a ship-shore interface study to ensure they are compatible and the ship safety inspections are valid and finally the Unloading Test and Ship Approval.

2.- LNG QUALITY AND INTERCHANGEABILITY

2.1.- LNG SPECIFICATIONS

2.1.1.- GENERAL.-

The natural gas is a mixture of gases where the main component is the methane, and in natural conditions of pressure and temperature is in gas phase.

The composition of natural gas is not always the same as different gas fields have different compositions. The process to obtain LNG also has an influence on its quality.

LNG quality is one of the most important issues in the LNG business. Any gas which does not conform to the agreed specifications in the sale and purchase agreement is regarded as “off-specification” (off-spec) or “off-quality” gas or LNG. Each country (and sometimes each pipeline, as in the US) has different specifications.

Quality regulations serve three purposes:

1 - To ensure that the gas distributed is non-corrosive and non-toxic, below the upper limits for H_2S, total sulphur, CO_2 and Hg content;
2 - To guard against the formation of liquids or hydrates in the networks, through maximum water and hydrocarbon dew points;
3 - To allow interchangeability of the gases distributed, via limits on the variation range for parameters affecting combustion: calorific value and Wobbe Index. Out of specification gas can lead to incomplete combustion, and the production of carbon monoxide, or the lifting of the flame from the burner.

Gas Interchangeability is defined as the ability to substitute one gaseous fuel for another in a combustion application without materially changing operational safety, efficiency, performance or materially increasing air pollutant emissions.

Gas Interchangeability may be captured in specifications using a range of physical and chemical properties, and these specifications commonly refer to the High Heat Value

(HHV), a measure of its energy content per volume. The HHV is the number of heat units generated when a unit volume of product in the vapour phase at defined temperature and pressure (0ºC or 15ºC) is burnt completely in dry air. The gaseous products of combustion are brought to the same standard conditions of temperature and pressure, but the water produced is condensed to liquid in equilibrium with water vapour.

Most of the countries are using the HHV as defined in the ISO standard 13443:1996, i.e. metering and combustion of the gas at 15ºC and at a pressure of 1.01325 bar, using real gas conditions (expressed in MJ/cubic meter).

The importance of the HHV is obvious when looking at LNG sales contracts, which usually stipulate that the sales value is directly related to the amount of energy that is transferred to the customer. Hence, careful measurement of the HHV becomes a matter of economic priority. However a qualitative description of a specific cargo of LNG that is for sale requires more detail that just the HHV, if a potential buyer wants to determine if it is acceptable, because two gases of the same HHV can still be very different.

A final gas user will likely have concerns in two areas: combustion properties related to burner operation, best described by interchangeability parameters and the level of impurities of the gas, important for safety, environmental performance and certain chemical plants taking gas as feedstock.

With respect to combustion properties, a regasified LNG must be interchangeable with the gas the customer has received historically for which end use equipment is designed and adjusted in order to help ensure that it can burnt safely and efficiently. The single most important interchangeability parameter is the Wobbe Index (WI) that is a measure of the degree to which the combustion properties of one gas resemble those of another gas.

The Wobbe Index is used to compare the combustion energy output of different composition fuel gases and is frequently defined in the specifications of gas supply and transport utilities. The Wobbe Index, IW, is defined as:

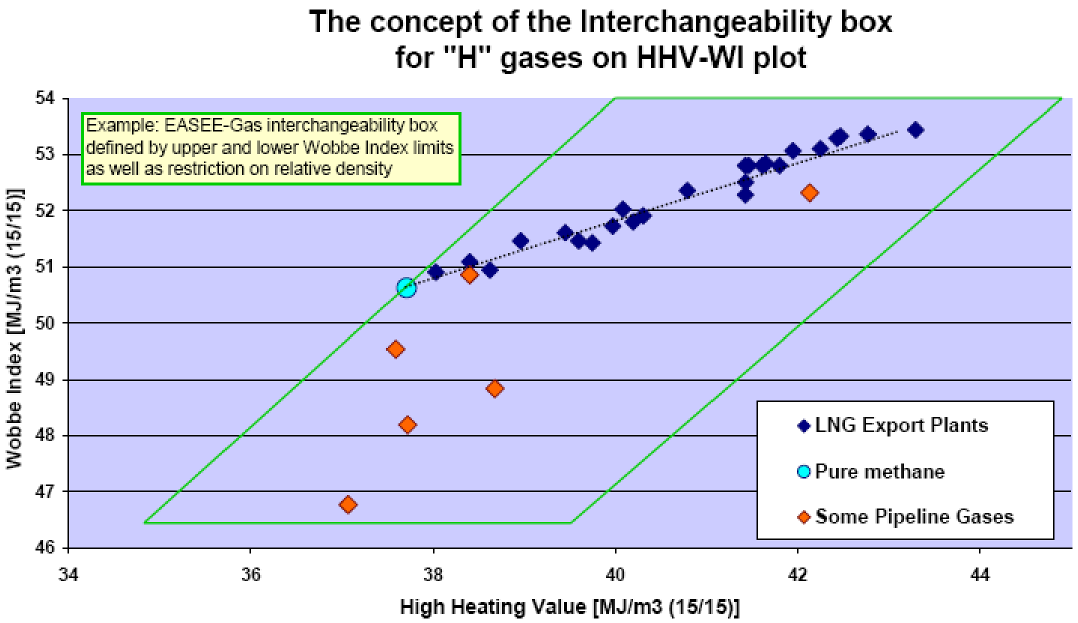
Wobbe Index = higher heating value/square root of gas specific gravity (density of gas relative to the density of air).

$$WI = HHV/ (Rd)^{0.5}$$

Where Rd is the density of gas relative to the density of air. If two gases have the same WI then the energy input to the flame of a burner is identical. The WI is expressed, like the HHV, in MJ/cubic meter, or some times in Btu/scf. By imposing an upper and lower bound on the WI, NOx and other emissions can be controlled, high efficiency of burners can be achieved, and most importantly, the safe operation of equipment can be assured. From upper and lower limits on any two of the three parameters HHV, WI and Rd, one can draw an “interchangeability box” on an HHV-WI plot. If the limits are chosen with respect to the requirements of gas turbines and gas appliances in a specific gas market, the interchangeability box defines which gases are acceptable to all users in that particular market and is a useful way of defining a range of gases that can be used in a gas market without materially affecting combustion or emissions performance.

In the case of off-spec LNG, the buyer can refuse to accept the LNG, and the seller has to pay liquidated damages for the respective off-spec gas volumes.

Graph 1 visualizes the concept, using the example of the interchangeability box for high-calorific value gases ("H" gases) proposed by EASEE-gas of the European Association for the Streamlining of Energy Exchange.



Graph 1: EASEE-gas Interchangeability Box, LNG and pipeline gas qualities[4]

Countries that import LNG represent the markets in which LNG and natural gas specifications may relate to gas interchangeability. While conventional definitions of gas interchangeability focus on combustion behaviour, in recent years the use of the concept of interchangeability has expanded to include other uses of regasified LNG such as reliquefaction of gas to LNG for natural gas peak shaving or as feedstock applications (e.g. chemicals production).

2.1.2.- GAS INTERCHANGEABILITY SPECIFICATIONS APPLYING TO IMPORTING AND EXPORTING COUNTRIES.-

Countries importing LNG as of the end of 2012 include the following:

Argentina	China	Italy	Puerto Rico	United Arab Emirates
Belgium	Dominican Republic	Japan	South Korea	United Kingdom
Brazil	France	Kuwait	Spain	United States
Canada	Greece	Mexico	Taiwan	Thailand
Chile	India	Portugal	Turkey	Netherlands

In addition other countries like Indonesia, Malaysia, Poland, Singapore and Sweden have new LNG Receiving Terminals under construction that will be in operation between 2013 and 2014.

Appendix A includes LNG Quality requirements in Europe, U.S.A. and Mexico LNG Terminals.

The following countries are LNG exporters to the world market as of the end of 2012:

Algeria	Equatorial Guinea	Nigeria	Qatar	United Arab Emirates
Australia	Indonesia	Norway	Russia	United States
Brunei	Oman	Trinidad&Tobago		
Egypt	Malaysia	Peru	Yemen	

Other countries that have under construction new LNG Liquefaction Plants are Angola and Papua New Guinea.

LNG Supply characteristics and specifications have not been documented for all exporting countries and in this Chapter we have summarized actual supply characteristics and specifications for gas quality obtained from a variety of sources (Appendix B). In addition to limits on gas quality attributes, average supply properties are shown where available.

Rich LNG sources naturally have served historically strong portions of the market that had rich natural gas market requirements. With the development of increasing regasification capacity in markets requiring leaner compositions, the role of suppliers with leaner LNG has shifted in favour of serving these markets.

The most important gas quality concerns involve the sulphur and mercury content and the calorific value. Due to the sensitivity of liquefaction facilities to sulfur and mercury elements, the gas being sent to the liquefaction process shall be accurately refined and tested in order to assure the minimum possible concentration of these two elements before entering the liquefaction plant, hence there is not much concern about them.

2.1.3.- GAS QUALITY HARMONIZATION EFFORTS: EASEE-gas.-

EASEE-gas is the gas arm of the European Association for the Streamlining of Energy Exchange and was set up in 2002 to develop and promote the simplification and streamlining of both: the physical transfer and the trading of gas across Europe. The creation of EASEE-gas is a project that is fully supported by the European Commission and by the European Regulators through the so-called Madrid Forum. There are currently 82 full members and 23 Associate members of EASEE-gas representing the following segments of the European Gas Industry:

- Producers

- Transporters
- Distribution Network Operators
- Traders & Shippers
- Suppliers
- Retail suppliers
- LNG Terminal and Storage Operators
- Associate Members

EASEE-gas develops terms of trade referred to as Common Business Practices (CBPs). CBPs are standards, procedures and/or protocols commonly used in the gas industry in Europe and recommended by EASEE-gas for adoption by all relevant industry players to simplify and streamline business processes across Europe.

Madrid Forum VII (2002) identified the need for removing technical obstacles for interoperability of different natural gas qualities, recognizing that different requirements are in effect throughout Europe regarding natural gas quality and that these differences represent a potential and real barrier for the creation of an efficient European gas market. Madrid Forum invited EASEE-gas to take the lead in discussions among stakeholders with the aim of streamlining interoperability for high calorific gases.

Specific areas of application of EASEE-gas specifications include:

- European Cross Border points
- EU entry points
- LNG Import Terminals

Specifications would also apply to high calorific gas without odorants, but would exclude areas of production and isolated systems where production, transportation and utilisation are combined.

The Common Business Practice on gas quality (CBP 2005-1), was approved by the EASEE-gas Executive Committee on 3 February 2005. This CBP recommends natural gas quality specifications at cross border points in Europe and describes recommended gas quality parameters, parameter ranges and an implementation plan. Natural gas arriving at cross border points in line with these proposed quality specifications cannot be refused for quality reasons. The CBP does not in any way restrict parties at a cross border point in agreeing other specifications.

Parameters and values in CBP 2005-01 were based on expert opinion of participating companies/organisations. It was recognized that increased ranges within these specifications was necessary to achieve their primary objective: increased interoperability in Europe. Based on standard project lead times, EASEE-gas was of the opinion that the earliest implementation date of any parameter and associated value is 1st October 2006 for all EU Member States that have been asked to analyse the impact of adopting the EASEE-gas specifications. The methodology applied by each country to accommodate the EASEE-gas specification at cross border points will depend on the historic and future development of the national gas market.

The EASEE-gas Quality Specifications are currently as follows:

Parameter	Units	EASEE-gas
WI max	kWh/m	15,81
WI min	kWh/m	13,6
d max	m^3/ m^3	0,7
d min	m^3/ m^3	0.555
Total S	mg/ m^3	30
H_2S + COS (as S)	mg/ m^3	5
RSH (as S)	mg/ m^3	6
O_2	mol %	0.001
CO_2	mol %	2,5
HC DP (*)	ºC at 70 bar (a)	-2
H_2O DP (*)	ºC at 70 bar (a)	-8

2.1.4.- WEATHERING/AGING ISSUES IN LNG TRANSPORT AND STORAGE.-

Aging of LNG or "weathering" is the physical process of boiling off low boiling point fractions within LNG in storage as heat is gained by a storage vessel. Historically, LNG weathering in LNG traded on the world market has been an issue associated with marine transport and LNG carrier technology.

The LNG delivered at the LNG terminal will in most instances have a slightly higher heating value than when it was initially loaded at the LNG Liquefaction Plant, due to the fact that lower Btu content components, such as nitrogen and methane, flash or boil-off during loading, transportation, delivery, storage and send-out at a higher rate than the heavier, higher Btu content components such as ethane, propane and butane.

Weathering may be a more important issue with the growth of an LNG spot market where exporter and importer specifications may be relatively inconsistent to begin with, where older carriers are involved, and where carrier routes and hold times may be more conducive to significant compositional changes due to weathering.

With respect to gas interchangeability, significant weathering of LNG may result in inconsistencies between exporter and importer product specifications. Better understanding of weathering processes and potentials is of active interest within the LNG industry through projects such as the Enagas project MOLAS that has been developed with the support of other members of GERG (Groupe Europeen de Recherches Gazieres). Improved carrier designs and technology, including insulation systems and boil off management, should mitigate concerns associated with normal weathering over time.

Weathering also plays a role in LNG peak shaving operations where regasified imported LNG serves as a feedstock to production of LNG at the peak shaving Facility. Many of these facilities designed in the mid to late 1960s have bottom-fill tanks only since mixing of LNG from various compositional feed gases was not a design consideration.

In addition, heavier constituents (ethane and higher) possible from weathered imported LNG were not considered significant in plant design, and no processing for removal of these heavier constituents were included. As a result, liquefaction of gases from rich LNG can result in the addition of heavier stored LNG at the bottom of the tank and unmixed with the rest of the tank stored volume. Two concerns arise from this situation. First, withdrawals from the bottom of these tanks will produce richer send out that the average makeup of the tank and may not be interchangeable for customer use. Second, the stratification that is introduced by such filling may increase the likelihood of stratification and, over long hold times, the potential for rollover.

An additional concern may arise from liquefaction of previously nitrogen-ballasted LNG send-out from import Terminals. Increased nitrogen reduces process efficiency of peak shaving liquefaction, usually increasing energy demand and stream days required for liquefaction.

Modern plants and modernized older bottom fill-only plants has alleviated these problems for many peak shavers. Top and bottom fill capabilities and storage mixing are often included in major upgrades of older tanks and tend to be standard in new plants. Upgrade of liquefaction and additional nitrogen management strategies (both to flash nitrogen in liquefaction and management of nitrogen in the headspace of the tank) are increasingly used.

2.2.- IMPURITY SPECIFICATIONS.-

2.2.1.- ORIGIN OF IMPURITY SPECIFICATIONS.-

The origin of impurity specifications in gas stems from two fronts: the change in gas supply and end-uses throughout the years. Prior to 1945, for the most part, gas was manufactured and distributed in regional areas. Utility companies in large metropolitan areas controlled the quality of the gas they made for local distribution, and were often able to have equipment and appliances tailored to their needs.

Whilst the rate of change in the characteristics of gas supply will vary from country to country, we have observed, certainly more prominently in Europe than any other regions, a change from manufactured gas to natural gas on an enormous scale in the 1970´s and 1980´s. As natural gas displaced manufactured gas, the industry became national in scope and the control of supply quality passed from the local manufacturing utility to the production, transmission and distribution segments.

The energy crisis and particularly the “natural gas shortage” of the 1970´s upset the traditional supply patterns. Every country was seeking alternate sources of supply and many of the alternates varied significantly from the historic supply compositions. Liquefied natural gas (LNG), Synthetic natural gas (SNG), ethane enrichment, coal seam gas, landfill gas, coal gasification gas, etc…were all discussed and/or sought after. Gas quality and interchangeability became important matters for a time, and stimulated a spate of activity. Since the energy crisis has passed, natural gas supplies again seem adequate for demand and growth, the industry has slipped back into the prior pattern, and gas quality is no longer seen as a priority matter.

Then, in the late 1990´s and early 2000´s, energy demand growth around the world started to outpace the supply, and clean environment has become more a society mandate than an option and all kinds of gas are sought after as a clean fuel and alternate feedstock to oil. The gas that is delivered to a national or local transmission network will not only be used for heat or power generation, it will often be chemically converted into other products such as fertilizer. These end-uses tend to be more sensitive to the presence of impurities than to density or heating value. In consequence, market requirements are expressed in terms of more than just heating value; there will be limits on impurities as well. And the sensitivity of each regional market to specific impurities will depend on the nature of the predominant users. Once again, gas quality debate has entered centre stage.

Typically, non-hydrocarbon impurities of concern to the end-users are: sulphur compounds (i.e., H_2S, total sulphur), water vapour, inert compounds (i.e., CO_2, nitrogen), oxygen and heavy metals (e.g., mercury).

2.2.2.- REVIEW OF IMPURITY SPECIFICATIONS IN EUROPE AND THE REST OF THE WORLD.-

A review of the governmental regulations on gas quality specifications and industry code and standards shows that there is no consensus on uniform impurity specifications around the world. The U.S. probably has the largest and most matured pipeline infrastructure in the world. Table 2.1 contains impurity specifications for several transmission pipelines.

Table 2.2 and Table 2.3 show some of the selected impurity specifications in Europe and rest of the world respectively. EASEE-gas 2006 was an attempt by the European gas industry, under the guidance of the Commission to try to harmonise the gas quality specifications of all the countries within the European Union in order to promote better trade across borders. Comparing the EASEE-gas impurity specifications with specifications from each individual country, one can conclude that safety probably takes precedence over any other criteria, resulting in much lower H2S, total sulphur and oxygen limits.

Table 2.4 shows the typical LNG contractual limits for impurities. They vary from contract to contract and from region to region.

In a nutshell upon review of the governmental and industry standards as well as LNG contracts, we can conclude as follows:

- Units are not always the same.
- Reference conditions are not always the same (e.g., EU uses 15ºC, 101.325 kPA, U.S. uses 60º F, 14.73 psia, China uses 20ºC, 101.325 kPA, Spain uses 25ºC, 101.325 kPA).
- LNG Contracts mix different units and reference conditions liberally.
- Different end-users have different quality requirements (e.g., gas turbines, CNG, etc…).

- Government quality specifications are different than those of the industry standards and specifications.

2.2.3.- PROPOSED NEW IMPURITY SPECIFICATIONS.-

In the light of the ever increasing emphasis on clean environment (e.g., curbing greenhouse gas emission, reducing SO_2 and ozone emission) and promotion of global LNG trade, it is prudent for all LNG producers to have an uniform LNG impurity specification that will meet the stringent market requirements and allow LNG to not only trade freely around the world, but also be considered a clean fuel of choice. As a result, the following set of impurity specifications is proposed:

- Hydrogen sulphide < 0.25 grains/100 scf
- Total sulphur < 0.5 grains/100 scf
- Mercaptan sulphur < 0.3 grains/100 scf
- Oxygen < 0.01 %
- Nitrogen < 1 %
- Carbon dioxide < 0.05 %
- Mercury – traces or < 5 nanograms/cubic meter
- Water vapour < 1 ppm

Table 2.1 - Natural Gas Pipeline Impurity Requirements in the U.S.A.

H_2S limit # of Pipelines Grains/100 ft3	 9 1.0	 2 0.5	 25 0.25	
Total sulphur # of Pipelines Grains/100 ft3	 16 20	 10 10	 5 5	 5 2
Mercaptan sulphur # of Pipelines Grains/100 ft3	 7 0.25 - 1			
CO_2 Limit # of Pipelines Volume%	 15 3	 15 2		
Nitrogen Limit # of Pipelines Volume %	 7 3			
Oxygen Limit # of Pipelines Volume %	 3 1	 3 0.4	 14 0.2	 15 <0.1
Water Limit # of Pipelines Lbs/MMft3	 27 7	 9 5		

Table 2.2 - Impurity specifications for selected European countries

	EASEE-gas 2006	France Regulations via Bylaws/Arreles Ministeriels	UK Gas Safety Regulations (1996)	Germany DVGW Code of Practice G260	Italy Transmission system spec	Belgium Royal decree 1984	Holland Entry gas spec	Spain BOE April 4 2006
H2S Limit Mg/m3 (grains/100 scf)	5 (0.23)	7.00 (0.31)	5. (0.23)	5.00 (0.23)	6.6 (0.31)	5.50 (0.24)	5. (0.23)	1.5 (0.07)
Total sulphur Mg/m3 (grains/100 scf)	30 (1.38)	150 (6.55)	50 (2.29)	30 (1.31)	150 (6.87)	150 (6.55)	20 (0.92)	150 (6.55)
Mercaptan sulphur Mg/m3	6 (0.28)				15 (0.66)		8 (0.35)	
CO2 Limit Mol%	2.5					2		3
Nitrogen Limit Mol%				6% Total inerts (biogas injection)	3% total inerts		1.5 -8 total inerts	2.5% total inerts
Oxygen Limit Mol%	0.01		0.2	3	0.6		0.0005-0.5	0.01
Water vapour Limit dewpoint	-8°C at 70 bar	-5°C @ operating pressure	such that liquids do not interfere with integrity of networks or appliances	Ground temp at operating pressure		-8°C @ 6.9 MPA	-8°C at 7 MPA	-7°C @ 4 MPA
Reference temp & pressure	0°C metering, 25°C combustion, 1.01325 bar	0°C, metering, 0°C combustion101.325 kPa	15°C, metering, 15°C combustion 1.01325 bar	0°C metering, 25°C combustion, 101.325 kPa	0°C metering, 25°C combustion, 101.325 kPa	0°C metering, 25°C combustion, 101.325 kPa	0°C metering, 25°C combustion, 101.325 kPa	0°C, metering, 0°C combustion101.325 kPa

Table 2.3 – Selected Impurity specifications for the rest of the world

	Canada Pipeline traiffs	New Zealand NZS 5442	Mexico NOM-001-SECRE-2003	Japan Utilities	China (GB 17820-1999)
H2S Limit Mg/m3 (grains/100 scf)	6 - 23	5 (0.23)	6.1 (0.28)	0 - 1	I < 6 II < 20 III < 460
Total sulphur Mg/m3 (grains/100 scf)	23 - 230	50 (2.29)	150 (6.9)	0 - 5	I < 100 II < 200 III < 460
Mercaptan sulphur Mg/m3	5 - 6				
CO2 Limit Mol%	2		3	0 – 0.5	I < 3 II < 3 III < 3
Nitrogen Limit Mol%			5	0 - 1	
Oxygen Limit Mol%	0.4	0.1	0.2	0 – 0.01	
Water vapour Limit dewpoint	-10°C@operating pressure	< 100 mg/m3	< 112 mg/m3		
Reference temperature and pressure	60°F, 14.73 psia	15°C, 101.325 kPa	20°C, 98.07 kPa	0°C, 101.325 kPa	20°C, 101.325 kPa

Table 2.4 – Typical LNG Contractual Limits for impurities

	Typical Indonesian-Taiwan/Korean Contracts	Typical Indonesian-Japanese Contracts	Typical Middle East Contracts	Typical Pacific LNG Contracts (non-Indonesian)	Typical Atlantic LNG Contracts
H2S Limit Mg/m3	5.73	5.73	5 - 7	5	0.7 – 5.7
Total sulphur Mg/m3	30	30	30 – 45.8	30	30 - 150
Mercaptan sulphur Mg/m3					2 – 2.3
CO2 Limit Mol%			0.01 – 0.1		0.01
Nitrogen Limit Mol%	1	1	1	0.1 - 1	0.2 – 1.4

2.3.- SAMPLING, ANALYSIS AND MEASUREMENT OF LNG QUALITY.-

The accurate analysis and measurement of LNG quality is important for two reasons. These are firstly in order to calculate custody transfer accurately in order to satisfy contractual and commercial agreements and secondly to be able to control the inventory and operation of the LNG Facility.

Because of the liberalization of the European gas market, a lot of attention is given to methods for LNG sampling and analysis due to the role that these have to play in satisfying contractual agreements between parties. But also because the imports of LNG to a receiving Terminal can be of significantly varying quality, interchangeability is also becoming an important issue within the operations of the Terminal. Blending, ballasting and other operational methods all require specific measurements, which must satisfy the requirements of the operational intent.

2.3.1.- SAMPLING TECHNIQUES.-

For offloading, the type of contract (DES, FOB, etc…) can dictate the manner of taking samples. In the case of DES for instance, the measurement procedures, such as sampling methods and the conditions to calculate the unloaded energy must be performed with high accuracy. Therefore it is recommended to install at least two different methods of sampling: a continuous system and a discontinuous system. For both systems a few methods exist: dome sampling, off line sampling, piston sampling and intermittent sampling. Multiple standards such as ISO 8943, ISO 6974, NF EN 12838, ISO 10715, and ISO 6143 are all related to sampling methods. Furthermore, other standards such as ISO 6976 are applied to the calculations of LNG characteristics (calorific value, density, Wobbe Index, etc…)

The sampling systems as described in GIIGNL´s “Custody Transfer Handbook”, can be applied in general. For this the position of the sampling tube or probe in the LNG pipeline is very important. Because of the high flow in those pipes, it is also recommended to reinforce this tube, to avoid bending resulting and breakage. At the outlet of the probe, vacuum insulation is installed. It is recommended to check this vacuum periodically.

For operational reliability and accuracy some alarm settings applicable to the sampling process can be very useful. Examples include a pressure alarm in the unloading lines, because low LNG pressure in the unloading line can give serious disturbances to the analysis. For sampling systems equipped with a drum, a level alarm must be installed. It is even recommended to install a continuous level reading on the drum.

In addition, redundancy in components of the system is needed. If sample bottles are used for sampling, it is recommended to connect at least two or three. One bottle will be assigned for the Operator, another for the seller and a third bottle can be held as a spare or backup for a defined period. A spare gas chromatograph is also recommended as well as a spare vaporizer.

In the case of failure of the sampling system, a special clause is required in the contract, explaining how to deal with the calculation via an alternative method. One alternative approach to the calculation can be set-up by using, for instance, the analysis which was taken during the loading, and then calculating the estimated composition on arrival by taking into account the boil-off rate from the cargo tanks of the ship and the duration of the voyage (e.g. the MOLAS Program).

2.3.2.- OPERATIONAL SAMPLING FOR LNG QUALITY AND INTERCHANGEABILITY.-

The variation in imported LNG quality, HHV, Wobbe Index, etc.. can be significant, depending on the source procedure. Therefore as "LNG storage tank management procedure" is needed to instruct the operator on how to deal with different types of LNG for the management of the interchangeability. Because the quality of send-out gas must be within strict limits, it is necessary to install chromatographs at various important locations throughout the process.

Software programs can be set up to calculate the daily stock and to construct a daily inventory of the LNG which is coming in and the gas being sent out. The daily boil-off due to heat input, the variation of stock due to send out, the gas in kind and other losses will have an important influence on the composition of the LNG which is in storage. This results in a continuous change of energy and quality figures. To control or monitor the composition of the LNG which is in circulation in the process, it is recommended to put chromatographs in several locations.

To monitor the composition of the LNG tanks, sampling points can be put in place at the outlet of the low pressure pumps of each tank. To monitor the quality of LNG following blending of LNG from different storage tanks, an additional sampling point can be placed in the low pressure send out line, just before the recondenser. A sample point on the gas send out is of course necessary. Other sample points in the boil off system, for example, and at the inlet to the recondenser and in the fuel gas system can be valuable.

If a nitrogen installation is installed to inject nitrogen into the natural gas lines for Wobbe corrections, more control systems (Wobbe-measurement or chromatographs) may be needed. Because of the nature of the installation in a process area, this equipment needs particular features as rapidity of measurement, rapidity of sampling, dedicated maintenance program, spare parts, fast diagnostics, auto-calibration and accuracy. If chromatographs are used for contractual calculations, the accuracy can be very important, including the analysis of C6+ and oxygen.

Due to this extra sampling equipment, a more extended maintenance program has to be set up. Special training shall be given to the maintenance and instrumentation department, who will be responsible for the reliability of this equipment. Training of the operators to have a better understanding of the intricacies of sampling will also be necessary. The training will explain the monitoring and control LNG quality and interchangeability, taking into account the particular LNG storage tank strategy.

The instruments should be evaluated for performance before installation in accordance with ISO 10723. Regular calibration and inspections will be performed with reference gas in accordance with contractual specifications. Inspection can be done by operators on site, while calibration and maintenance will be performed by qualified technicians. Alarms which are generated by the sampling equipment must be well described and understood by the operators and technicians.

2.3.3.- CONCLUSION.-

LNG interchangeability and quality control in a process environment, requires special attention and a different approach. Because of variations in LNG quality which must be treated in receiving Terminals, analysis for interchangeability has become very important. Blending, mixing of LNG during offloading, mixing of LNG during send out and ballasting are all methods of controlling the quality of LNG so that it conforms to contractual conditions. Other features necessary for process control will have an impact on the selection of state of the art chromatographs and sampling equipment. Speed of analysis, faster interaction, reaction to an impact on the process can be more important than accuracy.

2.4.- QUALITY ADJUSTMENT AT LNG IMPORT TERMINALS AND LIQUEFACTION PLANTS.-

If the LNG does not meet the market requirements, is adjusting the product quality at the liquefaction plant the best solution? In general, this will not be economic unless very large quantities of product are destined for the same market, and it will always be expensive and operationally inconvenient to have to segregate your storage for different product grades. Accordingly, the focus has so far been on import Terminals, where a variety of solutions have been adopted for quality adjustment – either richer or leaner – where necessary.

The simplest method of reducing the heating value is to inject nitrogen, commonly known as ballasting. It is not cheap, as, surprisingly, nitrogen is generally more expensive per tonne than LNG.

The other principal method is to extract the heavier components such as ethane and propane, condensing them into a liquid phase. This may be economic if there is a local market for the liquids.

When the gas needs to be enriched, the usual method is to inject propane and butane. This may even be imported from the places where it was extracted from the LNG in the first place.

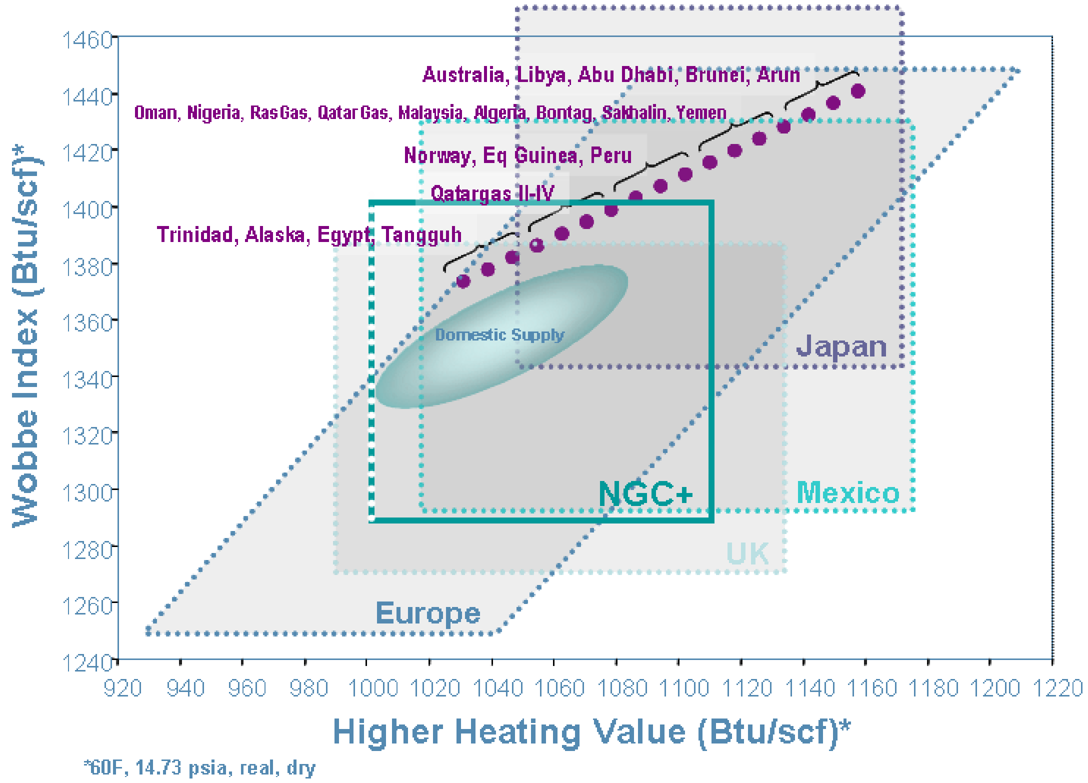
At LNG Import Terminals, measures to adjust quality are mostly inert gas injection (air or nitrogen) or LPG extraction or injection.

The higher content in methane, the leaner LNG, as higher hydrocarbons are heavier which means they have a greater calorific value on a volume basis.

	BTU/scf
Methane (CH_4)	1010
Ethane (C_2H_6)	1770
Propane (C_3H_8)	2520
Butane (C_4H_{10})	3260

2.4.1.- MARKET SPECIFICATIONS AND LNG QUALITIES.-

Graph 2 shows the quality of various LNG supplies versus market specifications. The market specifications in this figure include the envelopes of the Natural Gas Council (NGC+) (USA) guidelines and EASEE-gas.



Source: TOTAL and Shell Trading

Graph 2

LNG interchangeability issues are mainly present in the Atlantic Basin, with lean markets in the United States and in the United Kingdom. More LNG supplies fall into the Asia Pacific region (mainly in Japan) and by injection of LPG it is easier for these countries to adjust to a higher Wobbe Index.

The majority of new LNG supplies (recently started production, being constructed or planned) have adjusted their quality towards a leaner market. This is for example Qatar, Tangguh, Snohvit or Nigeria LNG Train 7.

The commercial drivers for lean LNG production, apart from entering a new market, are different from project to project, and include leaner (non-associated) feed gas supply, the development of a local petrochemical industry which uses ethane or LPG as feedstock (e.g. Qatar), or reaping benefits by establishing a separate LPG value chain.

It is also recognized that in the Asia Pacific, where rich markets dominate demand, a lean supplier could be penalized against a reach supplier for the requirement of injecting LPG.

2.4.2.- NATURAL GAS LIQUIDS EXTRACTION AT LIQUEFACTION PLANTS AND AT IMPORT TERMINALS.-

Natural Gas Liquids (NGL) include ethane, propane, butane, pentane and heavier hydrocarbons and higher NGL recoveries in a Liquefaction Plant can be achieved when the main distillation occurs at about a pressure of 20 to 30 bar. The NGL extraction can increase selling flexibility significantly and improved NGL recovery will result in higher selling flexibility.

However the disadvantages with any NGL extraction at a Liquefaction Plant are:

- The mass flow of LNG is reduced due to extraction of NGL
- Power is required to recompress the gas after extraction leaving less power for liquefaction
- Liquefaction of leaner LNG costs more power as the amount of heavier hydrocarbons with a higher boiling point than methane is lower
- Unit shipping cost increases, as the energy content per unit volume is reduced

Hence, the benefit of improved NGL recovery from producing more NGL needs to be balanced with the disadvantages of reduced LNG production and higher fuel gas costs.

Regarding LNG Import Terminals, usually handle LNG of different qualities, not all meeting the end-user specification. Options for gas quality adjustment to end-market specifications at an import Terminal are:

- Blending LNG of different composition
- Injection of nitrogen or other inert gases
- Extraction / injection of NGL /LPG

Nitrogen injection is the most common way of lowering the Wobbe Index at LNG Import Terminals. This is because of operational flexibility and ease of implementation. However, in some cases this concept is limited by the amount of inert gases allowed in gas sent to the grid. A typical maximum amount is 3 mol %. The effect of nitrogen injection is therefore limited to a drop in HHV and WI of respectively, around 30 Btu /scf and 55 Btu / scf.

In case gas grid specifications require a leaner composition and blending and nitrogen injection are not possible or allowed to be used, extraction of ethane and/or heavier is the only option for meeting a specification. By extracting ethane and/or heavier hydrocarbons the gas can meet this specification.

Propane and butanes can be sold but need separate storage and possibly also loading facilities. Ethane is uneconomical to store and must either be sold directly to a local customer or reinjected into the gas if the specification allows it.

LPG extraction has only been implemented for a small number of LNG Terminals, mainly in the Gulf of Mexico (e.g. Lake Charles). It is economically difficult to justify unless there is a dedicated supplier to the Terminal, as the extraction plant is otherwise only likely to be used for a small proportion of the time. Note that NGL extraction at the Barcelona Terminal was discontinued some time ago.

2.4.3.- HEATING VALUE ADJUSTMENT BY LPG INJECTION IN IMPORT TERMINALS.-

In Japan, LNG is imported and stored in LNG storage tanks at 28 LNG receiving Terminals. In the case of city gas supply, the stored LNG is vaporized in accordance with demand, and LPG (propane or butane) is injected so that the heating value is almost constant at a figure which is called the “standard heating value”. Then the city gas is supplied to the customers via pipeline network.

Butane is cheaper than propane. However butane injection leads to knocking of gas engines when the mixing ratio of butane to natural gas is too high. Also gas hydrocarbon dew-point limits butane injection above a certain operating pressure. Hence, propane is generally favoured for heating value enhancement.

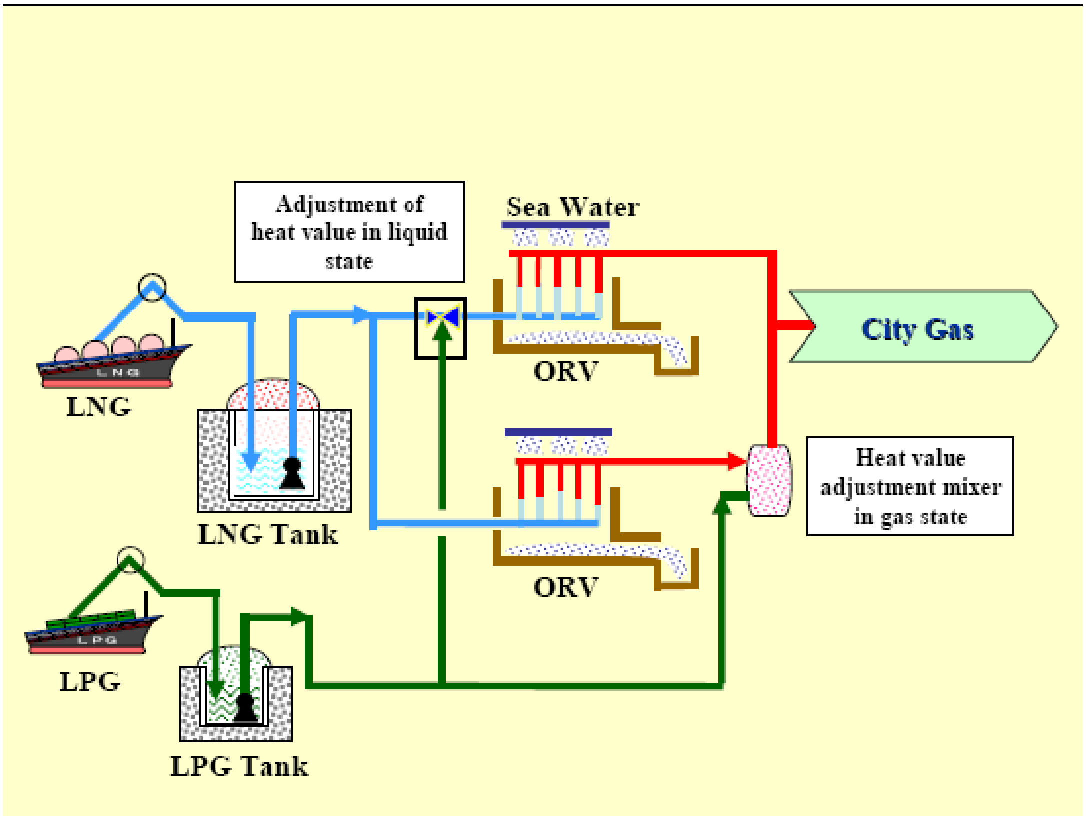
When the heating value is adjusted to a standard heating value and the cost of LPG is moderate, the cost of increasing the heating value can be lower that the cost of ballasting and higher heating values can be achieved throughout the pipeline network. However, the adjustment level needs to be reduced when the cost of LPG per unit heating value is higher than that of LNG. To reduce the cost of LPG, a smaller range of LNG heating value is preferable.

One of the reasons for the heating value adjustment is that gas consumers wish to use the energy at a high efficiency and with low environmental impact. Industrial and commercial gas appliances including gas engines and turbines are adjusted to achieve high efficiency at the stable heating value.

Another reason for the use of a standard heating value is to avoid the additional cost involved in the assessment of the impact on existing gas appliances, and the cost of plant-by-plant adjustment or installation of heating value controllers at customer sites for a wide-range heating value. In controlled atmospheric furnaces and industrial processes such as glass manufacturing, combustion properties have a major impact on the production process. A standard heating value also reduces the number and cost of instruments required by the billing regime and ensures fair treatment of customers.

If the standard heating value was used without LPG injection at the LNG import Terminal this would limit the LNG supplies available for import. On the other hand, heating value adjustment does have some disadvantages, mainly the additional cost of LPG and LPG injection facilities including equipment for LPG unloading, storage and heating value adjustment.

Graph 3 shows the heating value adjustment by LPG injection in LNG import Terminals.



Graph 3: Heating Value Adjustment Equipment

2.5.- IMPACT OF LNG QUALITY ON GAS TURBINE OPERATION.-

This section discusses the impact of increasing LNG imports on gas turbines used for power generation. Modern gas turbines can be sensitive to gas quality due to the complexity of the low emission combustors installed to give improved environmental performance. We provide background on the development of these combustors, look at typical fuel gas quality specifications and discuss particular potential problems posed by LNG.

In the UK, Europe and the US most power generating capacity that has been constructed in recent years consists of natural gas-fired turbines. These power generators will in future see as fuel an increasing proportion of LNG. The composition and qualities of imported LNG typically differ from the incumbent natural gas. Due to the highly complex design of modern gas turbines, aimed at maximising efficiency and minimising emissions, they can be sensitive to gas quality changes. This section considers the potential impact of the increasing use of LNG as fuel on power generating plants. It will consider typical turbine fuel specifications and discuss the potential problems that LNG may pose to power plants currently operating on pipeline gas and will examine how different national or regional quality specifications may help or exacerbate potential problems. Finally potential methods of overcoming the challenges posed by LNG – both at the power generating plant and at the LNG receiving Terminal – are presented.

2.5.1.- GAS TURBINE DESIGN AND FUEL SPECIFICATIONS.-

For a gas turbine power output and thermodynamic efficiency to be maximised the following have to be achieved:

- The fuel must be burnt at as high pressure as possible. This demands high pressure ratios of the air compressor and high pressure combustors.
- The temperature entering the power turbine must be maximised.

Given the high air/fuel ratio required and narrow operating band that modern Dry Low Emission (DLE) and Dry Low NOx (DLN) combustors aim to operate in, it follows that they can be sensitive to fuel gas quality.

Gas turbine manufacturers typically limit fuel gas Wobbe Index variability to within a ±2-5% range for Low NOx combustors, as opposed to 15% for diffusion type combustors. Within this range performance will be satisfactory with respect to emissions and dynamics, but optimum performance will be achieved on the fuel gas the combustor was designed and tuned for. Performance towards the extreme limits can be improved via manually re-tuning on-line.

2.5.2.- EFFECT OF GAS QUALITY ON GAS TURBINE OPERATION.-

The modern DLE and DLN combustor design can be sensitive to fuel gas quality. When assessing the impact that a change of gas quality may have on the power generator, whether due to a change to another indigenous gas supply or LNG, the turbine manufacturer should be consulted. One example where LNG may potentially be problematic if not assessed correctly is due to LNG typically being richer than indigenous gas, particularly in the US and UK.

Significant amounts of Atlantic Basin LNG supply are too rich for US and UK gas transmission systems. The LNGs must be ballasted with nitrogen to bring them into compliance. With between 2% & 4% nitrogen dilution all Atlantic Basin LNG can be brought into specification. This raises two points favourable to stable gas turbine performance. Firstly the lean, narrow Wobbe ranges of the UK and US afford some protection as once the LNGs are ballasted to achieve compliance, other network compliant gas in unlikely to cause an excursion of greater than +/-5% Wobbe on mixing. Secondly, the nitrogen required for ballasting will also have the effect of reducing the concentration of the higher hydrocarbons thus further reducing the propensity for flashback.

Conversely, the EASEE-gas specifications require no Atlantic Basin LNG supply to be ballasted and allow a wide range of Wobbe Index, although the limit on specific gravity of 0.7 does offer some protection particularly at higher Wobbe Index. Therefore more careful consideration and assessment is required here by LNG importers and power generators.

In addition to how gas quality specifications can be used to afford some protection to gas turbines, other strategies can be applied at the LNG import Terminal or power plant.

Historically, LNG import Terminals would be one part of the overall LNG project value chain, and would receive one relatively fixed LNG composition from the projects liquefaction plant. Therefore the gas quality of the Terminal send-out would also be relatively constant. Terminals operators are now increasingly looking to take advantage of arbitrage possibilities by becoming active short term and spot traders to fulfil at least part of their sales obligations. This in turn makes managing send-out gas quality more challenging as it is then intimately linked with tank inventory management as well as shipping and unloading operations.

At the power plant itself a couple of options exist for adjusting the fuel gas quality in addition to the usual methods of on and off-line tuning. The first of these is fuel gas temperature adjustment which in effect adjusts the Wobbe Index of a gas via changing its temperature and hence relative density. A disadvantage of this is also that the dynamics of the system are not fast enough to be able to control a rapid change in fuel gas composition. The gas turbine manufacturers have recognised the potential problems of gas quality changes and are rapidly developing multivariable control solutions which constantly monitor turbine operating conditions such as temperatures, dynamics, etc… and feedback to the fuel staging controls.

In conclusion, the reduction in indigenous supplies of natural gas and increased in demand for combined cycle gas turbine power generation, particularly in the Atlantic Basin, has until recently led to an increase in demand for LNG imports. Due to the complex nature of modern gas turbine technology they can be sensitive to changes in gas quality. These two factors are not as conflicting as at first they may appear as long as the correct assessments are made and suitable strategies, be that gas quality specifications, import Terminal operations or choice of technology, are used.

For example, the power station linked to the Bilbao import Terminal in Spain has automatic burner adjustment to allow for differing quality in the gas received by the Terminal.

2.6.- IMPACT OF LNG QUALITY ON CONSUMERS: APPLIANCE TESTING.-

The impact of the different qualities of gas on the performance of domestic appliances has been and continues to be, studied by numerous organisations and bodies around the world. The general objective of these tests is to assess the impact of a wider range of HHV and Wobbe Index on the safety, operation and efficiency of domestic appliances. This is in preparation for either change to region gas specifications that are envisaged due to a change in fuel supply, e.g. pipeline gas to LNG or harmonisation efforts, such as the proposed introduction of the EASEE-gas specification across Europe. This section reviews the current position of these tests and some of their findings.

2.6.1.- UK AND SPAIN TEST WORK.-

In the UK during 2005/2006 the UK Government Department of Trade and Industry (DTI) held a public consultation on the "Future Arrangements for Great Britain's Gas Quality Specifications". This consultation addressed the issue of gas quality in light of the UK becoming a net importer of natural gas, from additional pipeline interconnectors with mainland Europe and new LNG importation Terminals. The background to the work also took account of the proposed EASEE-gas specification for a harmonised European gas quality specification with a Wobbe Index range of 47.0 MJ/cubic meter to 54.0 MJ/cubic meter. This compares with the current UK Gas Safety

(Management) Regulations (GSMR) with Wobbe range 47.20 MJ/cubic meter to 51.41 MJ/cubic meter.

The DTI Gas Quality Programme included an appliance survey of UK domestic gas equipment. A classification of appliances was developed based on appliance application, burner, installation and flue type. From this, a representative sample of 25 appliances was selected for testing by Advantica and BSRIA laboratories. These 25 appliances represented some two-thirds (67%) of the total UK domestic gas appliance population, including central heating boilers, domestic heating boilers, hot water boilers, single-point water heaters, fires and cookers.

The appliances were selected to cover testing of different:

- flue types
- burner designs
- burner construction
- boiler types
- safety devices

The test showed that generally the test gases within the GS(M)R range of Wobbe Numbers from 47.2 to 51.4 MJ/cubic meter resulted in acceptable appliance operability. Overall:

- Ignition OK for all test gases
- Flame lifts not generally a problem
- Soot – little or no soot measurements in the flue gas
- NOx substantial increase in predominantly NO from many appliances as the Wobbe Number increases.
- Efficiency - relatively little change with Wobbe number
- CO emission increases with Wobbe Number

The tests showed that increasing the Wobbe Number of the gas used will almost certainly increase the emission level of carbon monoxide from typical UK appliances. Whilst the levels produced from the appliances tested were on the whole modest, except for Wobbe Number gases >53 MJ/cubic meter, where exponential increases in CO emissions were seen, there is the potential for badly maintained or installed appliances to produce CO levels that may cause an increasing overall risk to consumer safety. The UK Government intends to adopt the “no change” option and retain the current Gas Safety (Management) Regulations limits for combustion parameters for the foreseeable future.

In the Spanish gas network, some natural gases may have Wobbe Index in the upper limit range of EN 437.

During the years 2005 and 2006, eight old boilers were tested in the Repsol Technology Center (CTR) in order to get data of the behaviour of old boilers that have been working for many years with natural gas of the Spanish network (75% received as LNG and 25% received by pipeline) and also to assess this behaviour in terms of safety of operation and using the incomplete combustion limit gas (G21).

The eight boilers were constructed before 1995 and were using natural gas from the Spanish network for more than 8 years. These boilers were replaced in 2005 for new, more efficient boilers according to a special renovation plan of the Spanish Administration.

Three gases were used for the test:
- G20 (pure CH4) (Wobbe 50.7 MJ/cubic meter).
- Natural gas from the Spanish network as normal H-type operation gas in houses.
- G21 (87% CH4 + 13% C3H8) (Wobbe 54.7 MJ/cubic meter) as gas limit for incomplete combustion gas and soot formation.

The results deduced from combustion test of as-received boilers fulfil EN 297 criteria for safety even using G21.

The combustion tests after burning cleaning show that CO emissions generally decrease and the operation is remarkably safe even with G21.

Conclusions:

- Boiler combustion is safe according to the current standards of testing, even using old boilers.
- It has been demonstrated that then use of Spanish natural gas (H-type) is safe, even after 10 years of the utilization of the boiler.
- There is no need for reduction of Wobbe Index limits as given in EN-437.

2.6.2.- MARCOGAZ ACTIVITY IN GAS INTERCHANGEABILITY IN EUROPE.-

The European Union is constructing a common European gas market including common rules related to the functioning of the natural gas market.

EASEE-gas, an association of industry representatives of the natural gas value chain, has been asked by the European Union to develop a series of Common Business Practices including a European gas quality specification that could be accepted for trading gas across any EU border and at any LNG Terminal exit.

Marcogaz – the Technical Association of the European Gas Industry – is assisting in recommending suitable parameters and values that might be employed to define gas interchangeability.

Marcogaz, in developing its proposed Wobbe range, took account of two key considerations regarding the performance of appliances – compliance with the Gas Appliance Directive (GAD) on installation, and performance with time through field maintenance. These two key considerations were discussed with other stakeholders at a Workshop organised by Marcogaz, held on 13th December 2005 in Paris and previous appliance test results from UK and Spain were presented.

Marcogaz recognised that appliances are generally factory set for operation with the reference test gas G20 (pure methane). Furthermore, testing of appliances with the high and low Wobbe test gases (EN437) is generally performed for only a relative short period of time.

In general Marcogaz has concluded that use of a wider Wobbe range such as suggested in the EASEE-gas CBP could not be implemented across all European countries, without addressing a number of issues.

Consequently, Marcogaz has proposed a test programme, across 27 European countries, to produce evidence that will aid in the development of a harmonised European standard of gas quality. This programme has been given direction in a mandate by the European Commission to CEN, the European standards body and this will include:

- Market study
- Existing certification practices study
- Installation and inspection rules and practices study
- Selection of appliances and definition of testing programme
- Testing between 80 and 100 appliances

The results from this test programme will steer the development by CEN of a harmonised European gas quality standard.

2.6.3.- U.S. APPLIANCE TESTING ADDRESSING GAS INTERCHANGEABILITY

Recent US appliance testing can be characterized in terms of general studies of current appliance response to limit gases, some of which are directly associated with imported LNG, and regulatory-related studies focused on gaining acceptance of gases, including imported LNG, through U. S. federal or state regulatory proceedings. In addition, these studies can be characterized by more generally applicable categories as they apply to questions, about imported LNG, depending upon the nature and state of the appliances tested.

The following are major examples of testing programs in the U. S.:

- Basic Performance Testing: National Energy Technology Laboratory (NETL) Database and Gap Analysis.

The NETL of the U. S. Department of Energy published in December 2007 a review of gas interchangeability testing programs and data that covers publicly available information on gas composition and effects on appliances and equipment and recommendations on additional testing needs.

NETL reviewed publicly available studies and data covering basic performance in response to projected LNG import compositions. NETL found that: "Those studies show that properly tuned and maintained appliances can handle a broad range of fuel variability without any material impact."

Gas interchangeability test results on appliances include the tests sponsored by the Southern California Gas Company and the Gas Technology Institute (GTI). These are the only gas interchangeability test programs documented in the database and the NETL database serves as a common record of these test programmes. The results of these programs can be obtained from the sponsoring organizations through the websites: http://www.socalgas.com and http://www.gastechnology.org

NETL did not identify specific data gaps in the published appliance studies, but the limited number of published U.S. studies suggests a fairly narrow basis for assessing gaps.

- Design Certification Conditions Testing.

Recently completed testing sponsored by the U.S. Air-Conditioning, Heating and Refrigeration Institute (AHRI) is summarized in a 2009 World Gas Conference paper from the American Gas Association (AGA), a cosponsoring organization for the testing. The purpose of these tests was to characterize performance of currently manufactured appliances under the design certification test conditions but using gas compositions representing high Wobbe imported LNGs and low Wobbe domestically produced gas.

The test results are of great interest to manufacturers since retaining acceptable performance under these conditions addresses specific business risks faced by manufacturers when new, non-traditional gas supplies are introduced into the U. S. system.

- Installed Appliance In-Service Testing.

Appliance testing in support of U. S. regulatory activities involving importing LNG into the U.S., with the notable exception of the Southern California Gas Company testing mentioned above, is being done on a proprietary basis. These studies have come to be applied in tariff proceedings involving LNG import Terminal and downstream interstate pipelines and pipeline customers. These proceedings are administered by the Federal Energy Regulatory Commission (FERC).

Removal of the appliances, and replacement with new appliances, is required for more detailed testing to limit gases in the laboratory for a battery of gas interchangeability tests. In most cases, appliances are selected for laboratory testing based on their statistical representativeness of a given appliance population, appropriately defined as the service territory in which imported LNG is expected to be introduced. Acceptability of performance is typically defined based on conventional qualitative gas interchangeability combustion performance and quantitative carbon monoxide emissions.

While FERC proceedings have accepted testimony based on gas interchangeability tests on appliances, to date, most proceedings have hinged upon arguments associated with gas interchangeability issues of large power turbines. To date, it appears that owners and operators of large power turbines have demanded tighter gas interchangeability specifications than are suggested by appliance studies. One important exception is the Cove Point LNG Terminal proceeding in the early years of the 2000´s in which appliance testing sponsored by Washington Gas Light Company and following the installed appliance in service testing model resulted in specific tariff limits based on appliance interchangeability criteria.

In conclusion we can say that a common approach is being undertaken to testing new and installed domestic gas appliances across a wide range of gas quality. This is to ensure the safe and efficient operation of gas-fired domestic equipment now and in the future. Test results are being used to set limits on combustion interchangeability parameters within gas quality specifications, particularly in the U. S. and in Europe.

2.7.- FUTURE CHALLENGES.-

The issues of LNG quality and interchangeability continue to be of major interest to the producers and purchasers of LNG due to increased liquidity in the LNG market. The prevailing view at the moment is that the world is split into the areas where different specifications predominate. The traditional Far East market with its requirement for rich (high calorific value, high Wobbe number) regasified LNG, the Atlantic Basin with its preference for lean (lower calorific value, lower Wobbe number) regasified LNG and then growing markets such as the European Union (EU) with its attempts to harmonise the quality specifications of its member states into a wide ranging specification that can accept both lean and rich LNGs.

2.7.1.- THE NEAR-TERM PERSPECTIVE.-

Current and developing national and multi-national market requirements for natural gas will continue to have a strong influence on development of LNG trade specifications, at least in the foreseeable future. Some of these markets are strongly driven by short-run economic limitations, specifically determined by end use technology requirements, implemented by standards or developed as common practice, which result in relatively inflexible gas supply requirements. LNG markets based upon such requirements are likely to be price takers in the short run because of fixed supply and generally fixed export compositions.

The trend towards global trading will continue as LNG sources and import Terminals multiply and diversify, and as exporters seek to use flexibility in their supply contracts to benefit from intra-regional price variations. The quality of LNG arriving at any given Terminal will vary and will be even less predictable as a result of spot cargo trading. The key parameter probably will be the relative volumes imported by the major consumers, the Far East, Europe and USA, with their different quality requirements.

With respect to current and near-term gas sources, the sources of gas which ends up as LNG are changing, as old fields decline and new ones, including unconventional gas fields are brought on stream.

Quality problems occur when for example rich LNG cargoes go to the UK, where the maximum higher heating value and Wobbe numbers that this country can accept are limited, or when lean cargoes go to Asia Pacific, where there is a relatively high minimum heating value requirement.

2.7.2.- THE LONG-RUN PERSPECTIVE.-

Long-run economics (i.e., specifically where technology change is not a constraint) will provide importing markets opportunity to adapt end uses to more supplies and sources. Intensive programmes of appliance testing are ongoing in the USA, UK and other parts of Europe. EASEE-gas in the EU has proposed a very wide range of gas quality for cross-border trades. However, it is currently difficult to design an individual burner to avoid combustion burners at the far ends of the range, without potential health, safety and environmental consequences.

In the long run (over 20 years), it should be possible for national governments to anticipate the desired range of quality in advance, mandate it for new appliance installations and allow for the stock of appliances to be completely turned over.

Response of exporting countries in developing projects for national and multi-national market requirements will determine infrastructural capability to produce various grades of LNG. Indeed this is already occurring where new liquefaction trains are being brought on stream that have either greater flexibility to produce various grades of LNG or processing commitments to address specific markets. Natural Gas Liquids (NGL)(C3+ or even C2+) extraction, whether at the export or import Terminal, will continue as long as there is a premium price for the gas molecules as NGL (or refined LPGs, etc..) rather than in the LNG. This is likely to increase rather than decrease because of the relationship of NGL pricing to oil.

For the foreseeable future, electric power demand is expected to drive marginal demands for world LNG and relative specifications. The adaptation of generation capacity for broader compositional requirements is going to help relieve pressure on exporters to meet a wide variety of LNG specifications.

In terms of technology, we can expect to see an increase in the capability of micro-chip based self-adjustment devices on burners to accommodate gas quality changes, not only in gas turbines, but also on domestic appliances as being trialled in Japan.

In terms of supply, the long-term trend is toward development of non-associated gas in remote or environmentally and politically challenging parts of the world. A long-term issue in the US and Canada that may alter forecasts of world LNG demand and compositions is the development of unconventional natural gas resource, specifically tight and shale gases. Significant contribution of these unconventional natural gases may alter exporter expectations and allow a refocusing of the export market to more traditional target compositions. At present, there is no strong consensus on this impact, and in particular its effect on the Atlantic Basin trade. One significant quality impact may be increased demand for rich LNG as a blending component to counteract the extremely lean composition of coal-bed methane. Some shale gas is also very lean, although its composition can vary widely even within one producing basin.

2.8.- CONCLUSIONS.-

The global harmonization of traded LNG quality is unlikely, even considering the 2030 timeline, because of the different economic and political forces on different consuming nations. However, some harmonisation is both feasible and likely, along the lines of the regional characteristics of USA, Europe and Asia Pacific and some degree of harmonization should be enough to improve the growing world development of the LNG market.

Therefore, because of global trading and continuing diversity of gas sources, it will probably become the norm for import Terminals to be built with quality adjustment facilities.

It is possible that for economic reasons the regional specifications will converge towards those of Europe. On the other hand, because of its geographical position and its unconventional gas production, the USA will have less incentive for internal change and probably it will adjust off-specification cargoes as necessary at import Terminals. Within Europe, the UK may agree to accept the EASEE-gas proposed quality range by 2030. However, occasional internal quality adjustments will still have to be made in most EU states (as they are for example within Spain), as this range is very wide for any one given set of appliances to accommodate without burner adjustment.

Natural gas remains one of the safest, cleanest, most convenient and efficient base-load fuels available to mankind. This is a huge incentive for technological evolution to meet the challenges of its increasingly global availability, which can be expected to continue drawing new talent into the natural gas industry. In the opinion of the LNG Committee of the International Gas Union this will also drive importing countries to develop a legislative framework that ensures secure and competitive access to gas, notably in the form of LNG.

3.- LNG FACILITIES COMPATIBILITY.-

3.1.- EXECUTIVE SUMMARY.-

During the last years, many new Terminals and ports have come into service and this section devoted to LNG Facilities compatibility provides an insight into the issue of Terminal compatibility at the global level and identifies current issues, trends, requirements, and challenges to allow the industry to continue to grow enhancing safety and efficiencies.

This section addresses in detail the key aspects to LNG Facility compatibility, providing insight and resources for further investigation. It also leads to a limited set of over-riding conclusions regarding the way forward as the LNG industry continues to grow, continues to involve more players, and continues to change.

Forefront in the overall conclusions is that safety and environmental considerations remain and will remain the driver for growth and technological and operational advancement. The industry has to date an impeccable safety record and driving technological development by the rigorous collaboration of the different regulatory, operational and commercial bodies focussed on the over-riding issue of safe and clean operations will allow this record to continue.

Considering the number of different components in the global LNG loading-transportation-offloading network, the amount of information available and used on a day-to-day basis is not only enormous but is growing fast.

Relatively “constant” information such as ship specifications, Terminal specifications, cargo specifications, etc…coupled with variable information such as delivery schedules, weather information, etc…on a global industry level implies a severely complex information pool. Today this information resides in a multitude of different places.

For a global industry, two issues regarding the management of this information will be key in the future. Firstly the storing, updating, publication, reliability and accessibility of the information and secondly the standardization both of the information itself and the way it is shared in the industry. It will be a balance between the reliability, confidentiality and standardization using the internet and global communication networks overseen by capable and globally acceptable entities such as SIGTTO and SIRE.

A severe challenge in the future to the Ship-Terminal compatibility is the speed at which the LNG business is expected to change. Moving from the very steady-state, large scale LNG plants and long-term fixed delivery long term contracts to smaller scale projects, spot cargoes, diversification of regasification facilities (e.g. FSRU) and new markets means that compatibility management at the global level needs to be flexible and above all predictive and able to accommodate new concepts of offloading and delivery.

Finally, it is essential that a decisive, collaborative and continuous dialogue is encouraged at the global level between industry (producers, receivers and shippers), regulatory bodies and commercial organizations to ensure as much standardization as possible to ensure the continued safety record, seek added efficiencies in the value chain and allow the LNG industry to prosper.

3.2.- THE CHARACTERISTICS OF THE LNG FACILITIES AND THE IMPACT ON THE COMPATIBILITY.-

The objective of this section is to describe characteristics of onshore LNG facilities and highlight similarities and differences in design, lay-out and waterfront that impact Terminal logistics and therefore compatibility of ship/shore interface systems that must align to enable transfer of LNG cargo. The intent is to provide a high level overview of LNG facilities describing basic functionality of major components with focus on the compatibility of ship/shore interface systems.

3.2.1.- INTRODUCTION.-

Traditionally, LNG is delivered by ship and off-loaded to a receiving Facility in the case of an onshore LNG re-gasification Terminal, or conversely LNG is loaded onto a ship in the case of an LNG export Terminal. In both cases, the ship/shore interface facilities include a berthing jetty or dock for the ship, safety and communications systems, cryogenics connections to transfer the LNG cargo, and transport piping connecting one or more LNG storage tanks. Each of these components are critical to compatibility, but not priority to any one component.

Shored- based LNG export Facility concepts have remained fairly consistent. However, LNG receiving Terminal concepts are adapting to new ideas driven largely by commercial opportunities and technological advances. LNG receiving facilities now include fit-for-purpose Floating Storage and Regasification Units (FSRU) and LNG Liquefaction Plants now include Floating Liquefaction Natural Gas (FLNG), which offer, among other benefits, reduction or elimination of large onshore land assignments and potentially faster project implementation time, which impact project economics.

Several existing onshore LNG receiving Terminals are also experiencing conceptual adaptation, driven by increased global LNG market volatility and more frequent opportunities to trade LNG as a commodity. The first adaptation is that LNG is being received, stored and than re-exported as LNG via ship rather than being vaporized and send-out as natural gas through a pipeline. Apart from any commercial and / or regulatory issues, this re-export adaptation requires minimal modification to the original LNG receiving Terminal design to accommodate bi-directional flow and modify the Emergency Shutdown System to function for the reverse direction. The second more significant change is the addition of liquefaction process equipment to the original LNG receiving (unidirectional) and re-gasification Terminal thereby creating bi-directional capability. This change requires significant capital expenditure with associated regulatory compliance and supporting commercial arrangements, including the supply of natural gas as feedstock for the liquefaction process to make LNG.

Common to all onshore, Terminals for receiving or exporting LNG are the berth mooring / docking facilities, the cryogenic transfer system, the pipeline transport system between jetty/dock and storage system, and the storage tanks.

3.2.2.- TERMINAL / LNG CARRIER COMPATIBILITY.-

LNG carrier ((LNGC) compatibility encompasses a suite of characteristics about the physical and operational attributes associated with a Terminal that need to align with the corresponding attributes and capabilities of a ship. These characteristics are associated with the storage capacity of each, the waterfront interface systems physically connecting the ship to shore, the operational limits of the Facility to complete a cargo transfer within constraints, the marine operational limits impacting the ships ability to manoeuvre, regulatory requirements and LNG quality management.

In the gathering and interpretation of SIGTTO (Society of International Gas Tankers and Terminal Operators) data, it became clear that Terminal design and tanker selection have historically been driven by business and commercial requirements centered around traditional point to point trade. Export Terminal capacity is largely based on the production rate and size of recoverable natural gas resources combined with the latest cost effective liquefaction technology and power turbines. These factors are in turn matched with targeted market routes, ship sizes and receiving Terminal LNG storage tank capacities coupled with evaluation of weather uncertainties and the desired level of reliability owners and buyers require. All the information is evaluated to determine optimal economic LNG storage tank capacity and fleet size for the new export Terminal design.

At the receiving Terminal, the ability to manage LNG offloading is determined by the number of berths, transfer arms and rates, LNG storage tank capacity, return gas system capacity and boil off gas recovery system capacity, as well as delivery frequency, vaporization capacity, system bottlenecks and pipeline send out rates. The integration and modelling of all these parameters is highly complex. Business decisions are made that best suit the long term objectives of the project owners, both LNG suppliers and LNG buyers.

The introduction of larger LNG carriers has created the opportunity to economically deliver LNG cargos at lower cost per volume to markets at significantly increased distances from the source of supply. Additionally, the licensing of existing LNG Terminals to allow re-export of LNG has leveraged the business potential of these larger vessels. Existing Terminal owners and operators may consider participation in this growth market area and may choose to adapt Terminal installations to accommodate the larger LNG carriers. Obviously, owners of some Terminals may not be receptive to accepting larger LNG carriers. Those who are interested must first consider any physical or commercial constraints.

Some Terminal locations have physical constraints. For example, restricted land availability may limit jetty space making it unsafe to moor larger vessels or may prohibit construction of additional LNG storage capacity. Restricted water depth may limit draft thereby limiting the ability of large ships to access certain ports and restricted turning basin and / or channel depth may limit the ability to manoeuvre larger vessels.

As business drivers change and Terminals expand, the possibility that larger LNG carriers may be incorporated into the design would encourage Terminal designers to standardize certain base parameters thereby providing the flexibility to accommodate a wider range of carriers if warranted in the future.

Enagas is the Technical Manager of the Spanish Gas System and the Enagas web page includes a list of all the LNG tankers compatible with the 6 LNG Terminals that are currently in operation in Spain. The access to this information is:
www.enagas.es > English > Technical Management of the System > Gas System Infrastructures > Tanker Compatibility Relationship. This is a good example and in that page, which is updated very frequently, it is possible to consult which LNG tankers are compatible with each one of the LNG Terminals in Spain.

3.2.3.- STORAGE CAPACITY.-

Storage capacity for an export Terminal has two primary requirements: first, do not impact upstream gas production, and second, ensure uninterrupted schedule LNG deliveries to customers. Considerations for determining adequate storage capacity include the following:

- Daily gas production volume
- Number, size and length of cryogenics lines from the storage tanks to the jetty
- Number of berths
- Loading rate and capacity of the vapour return system
- LNG carriers size
- LNG carriers arrival conditions (e.g. cold vs. warm)
- Occurrence of significant weather events (cyclones, hurricanes, tsunamis)
- Possible daylight operating restrictions
- Scheduling
- LNG quality

The export Terminals ability to satisfy requirements may be compromised if the LNG storage capacity is insufficient for the size of LNG carriers calling at that Terminal. For example, if Terminal storage design capacity is for a conventional size LNG carrier (160.000 LNG cubic meters), and a Q-Max ship (260.000 LNG cubic meters) arrives to load a cargo, additional time would be required to complete LNG production and loading of the ship. The extended loading of the Q-Max LNG carrier would result in a reduction in overall efficiency and cause a delay that would impact the specific delivery schedule (SDS).

Historically, an export Terminal would have been designed for specific field development project using a dedicated fleet of ships to transport the LNG to the market. However, considering the evolving spot trading business of the global LNG industry, it is reasonable that the planning basis for future LNG projects may assume third party (non-dedicated) LNG carriers, or some combination of dedicated and third party ships. This subject is mentioned to highlight the importance of addressing adequate storage capacity to ensure the ability to meet primary requirements considering the full range of ships that may call at the export Terminal.

Regarding import facilities, the need for storage capacity at a LNG import Terminal is premised on the primary function of the Terminal, i.e. whether LNG is to be stored and remain available for periods of significant peak demand, or whether the LNG is to be continuously vaporized for gas send out through a pipeline system with limited LNG storage capacity. Japan and the USA are examples, respectively, of these alternative functions.

In Japan, natural gas is used mainly for power generation and for city gas. Japan does not have natural gas underground storage reservoirs, and the national pipeline grid has limited system capacity to stop send out gas volumes. Therefore, Japan has constructed extensive LNG storage capacity to absorb seasonal fluctuations in gas demand, ensure volume availability for extended periods of time, and provide security of supply.

The United States has significant underground gas storage reservoirs. Additionally, the U.S. has an extensive integrated pipeline delivery system tied into these natural gas storage facilities. The original intent was lo leverage gas storage capabilities thereby limiting capital expenditures and providing a means to store gas during low demand seasons and move gas directly into the pipeline grid during high demand seasons. Therefore, LNG storage tank capacity at U.S. LNG Terminals is generally sized for operational purposes only.

Another significant criteria is the ability to import varied LNG qualities, and hence the ability of facilities to segregate cargoes. This is considered a valuable compatibility performance issue, primarily in Japan, where LNG cargoes arrive from a multitude of export facilities. The added ability to mix LNG in tanks can eliminate the need for segregation, but again this is a business / economic decision made by the Facility developer and operator.

Another consideration in determining use of the LNG storage capacity is the expected frequency of deliveries at the Terminal and the need to manage tank levels for short or long periods. The Terminal operator and capacity-holders work together to manage inventory by balancing retained LNG needed to keep the tanks cold, vaporize for gas send out to meet pipeline obligations, or re-export for commodity trading.

3.2.4.- SHIP SHORE INTERFACE.-

The ship shore interface begins with the LNG carrier arrival offshore from the Terminal. The ship will be met by a trained pilot and tugs of sufficient power to manoeuvre the largest LNG carrier that the Terminal is designed to accept. Navigational aids will mark the entrance channel and assist the ship during its approach to the jetty. Instrumentation devices to assist the LNG carriers approach to the berth may include approach speed indicator, tide and current indicator, wave height and water depth indicator. The pilot will have a Portable Pilot Unit (PPU) which will allow him to access information from these instruments prior to the vessels arrival on the berth.

Jetties are designed for a range of LNG carrier sizes based on the fleets operated or considered by both the LNG suppliers and buyers. Some Terminals are unable to receive ships larger than a specific size due to strength limitations of the jetty structure. Variations in LNG jetty configuration include number of berths, berth layout, fender arrangement and strength, number of dolphins, and number of Quick Release Hooks.
SIGTTO has published a Compatibility Worksheet which includes an aide for calculation of mooring forces using Terminal design jetty dimensions, ship characteristics and weather criteria.

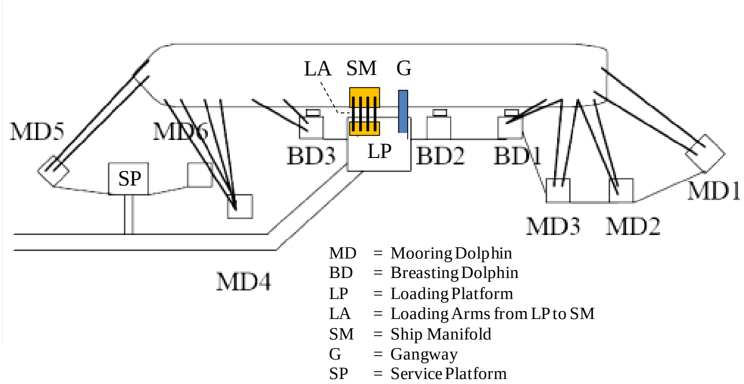
Industry guidelines recommend that the LNG carrier mooring arrangement be analyzed in an omni-directional 60 knot static wind condition. The mooring calculation determines the best mooring arrangement, individual line loads and ship motions at the berth. Line loads must remain below specific limits in order to achieve a satisfactory mooring arrangement. Once on the berth, LNG carrier line loads are monitored and recorded by a Mooring Load Monitoring (MLM) System which will have a display in the shore control room. MLM data will be provided to the ship either by the communications link or via a carry on board computer which can display the data.

Finally the ship and shore Facility will be joined by a linked Emergency Shutdown (ESD) system designed to stop cargo liquid and vapour flow in the event of an emergency and to bring the cargo handling system to a safe, static condition.

The principal areas of direct ship shore compatibility are:

- Mooring Arrangement
- Breasting Dolphins and Fender Contact
- Gangway
- Loading Platform and Loading Arms
- LNG Cargo Pumps and Transfer Rates
- Communications Link / Emergency Shutdown System

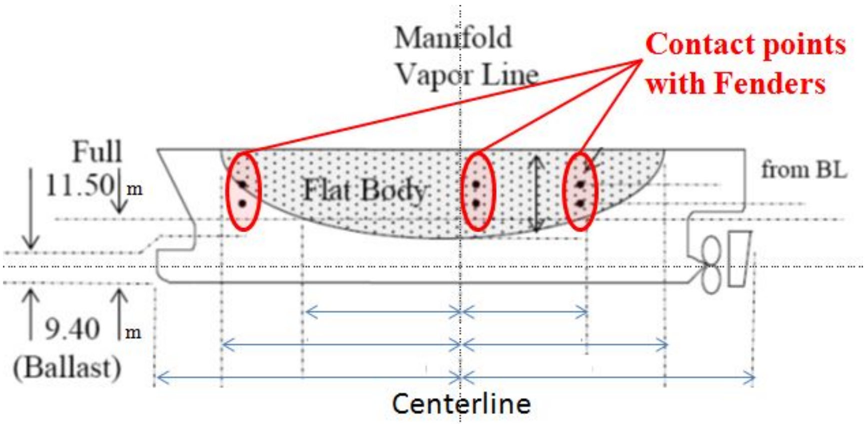
Regarding ship mooring arrangement (Graph 4), the purpose of mooring dolphins is to secure the ship to the berth. The objective of a satisfactory mooring arrangement is to hold the ship alongside the fenders and to maintain alignment of the ship with the platform in all conditions up to the stated maximum weather limits for the Terminal. Alignment of the ship with the platform is critical to ensure that the loading arms and gangway always remain within their operating envelope limits. At berth the ship is still subject to motion such as surge along berth, sway away from platform and heave, yaw and roll of the vessel due to wind, wave and current influence.



Graph 4: LNG Ship Mooring Arrangement

The mooring line monitoring system (Graph 4), utilizes load cells at each mooring hook to measure line tension. Monitors in both the ship and the shore control rooms provide operators with real time information on the status of the mooring lines.

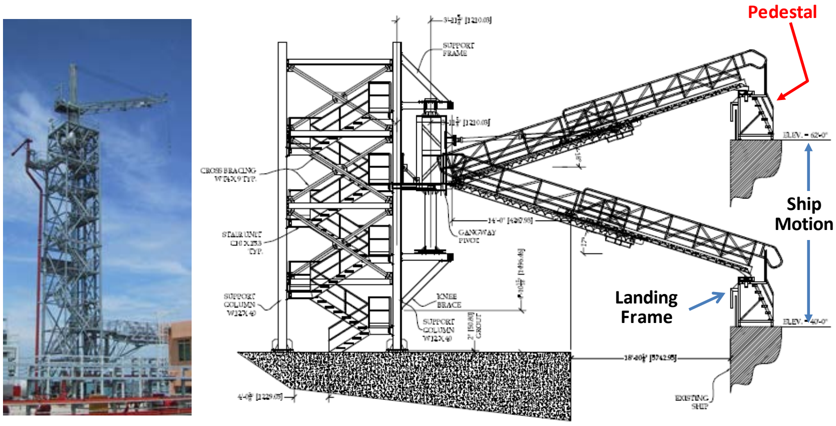
Parallel Mid Body Analysis is performed in design of Terminals to locate the breasting dolphins and fenders at optimal positions for the range of vessels calling at the Terminal. Fender contact with the ship at strategic locations in the flat body area (Graph 5), provides stability for offloading operations. Fender contact pressure, berthing energy limits and manifold offset for alignment with the fenders are compatibility factors to consider when a Terminal opens business to non-dedicated ships.



Graph 5: Fender Contact and Flat Body Diagram

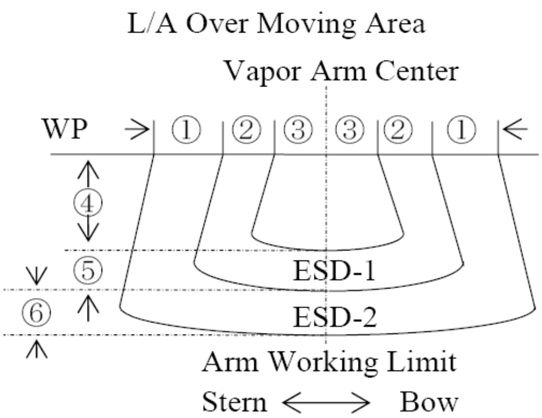
Safe access between ship and shore is achieved by means of the gangway extended or lowered from the loading platform. The location of the shore gangway is one of the most troublesome areas affecting the ship shore interface. Due to the cargo tank configuration on LNG carriers, the ships have very limited clear deck space in which to land a gangway. Careful study of the range of LNG carrier sizes anticipated to call at the Terminal will be required in order to determine the best location for the shore gangway tower. For existing facilities, the height of the ship deck in both loaded and ballast condition and at all heights of tide must be compared to the maximum and minimum elevation of the shore gangway. Alignment relative to the spotting line between the loading platform and the ship is essential to ensure the gangway remains within its operating envelope and is available for safe egress.

Graph 6 shows the Pedestal type Gangway, that can be elevated to the appropriate height on the gangway tower and lowered to a landing area on the manifold of the ship.



Graph 6: Pedestal Gangway and Tower

Determination of compatibility of the loading platform and arms begins similar to the gangway. The height of the LNG carrier manifold in both loaded and ballast condition and at all heights of tide must be compared to the maximum and minimum elevation of the shore arms to ensure they can remain within their operating envelope. In addition the range of ship motions at berth as determined in the mooring analysis must be measured against the maximum allowable motions of the loading arms. The ship manifold line spacing, the distance from the ship's rail to flange face and the flange size, including use of Short Distance Pieces (SDP) if required, must be compared to the shore arm specifications to ensure the arms can be safely connected for cargo transfer. Flange size, thickness and face finish of the ship connections must be compared to the shore Quick Connect Disconnect Coupling (QCDC) to ensure they can mate correctly.



(Unit:m)

	Bow	Stern
①	2.400	2.400
②	1.899	2.916
③	1.700	1.700
④	1.710	
⑤	1.458	
⑥	2.400	

at LWL + 18.25

Graph 7: Operating Envelope Diagram for the Loading Arms

Emergency Shutdown stages (ESD-1 and ESD-2) go into effect when excessive vessel motion causes arm movement to exceed safe boundaries as defined by the operating envelope. ESD can be activated by distance of movement as well as speed of movement. If activated, Powered Emergency Release Couplings (PERC) decouple the ship to prevent damage to the arms.

The manifold of LNG carriers will have five lines with the vapour return line in the middle and two liquid lines on either side. The lines are generally spaced three meters apart. Larger ships will have a manifold with larger lines and greater spacing between lines, up to four meters.

The shore based loading platform will generally have four larger diameter loading arms, i.e. one vapour return line, two liquid lines and one bi-directional liquid or vapour return line, to be used as needed.

Compatibility is impacted by the ability to transfer LNG cargo between ship and shore within a specified time window. Ship and Terminal piping systems will be designed for specific maximum flow rates and pumps will be sized accordingly. Modern large LNG carriers are capable of very high transfer rates which may exceed a receiving Terminal's maximum and require the ship to not use all cargo pumps to discharge its load. Normal discharge pressures at the ship rail are about 100 m of liquid or 60 psi. The liquid and vapour transfer rates must be balanced to ensure tank pressures are controlled and upper limits are not exceeded.

Receiving Terminals that have been modified to re-export LNG may have a limited number of the liquid arms converted for export and maximum transfer rates would be impacted accordingly. In addition, the maximum flow for the Terminal through a single arm may exceed the maximum flow for the ship through a single manifold. Communication and close coordination between the ship and Terminal is essential in these circumstances.

There are three types of ship shore communication links, also known as an Emergency Shutdown (ESD) system connection: Fibre Optic, Electric and Pneumatic. The functions of the cargo Emergency Shutdown (ESD) system are to stop cargo liquid and vapour flows in the event of an emergency and to bring the cargo handling system to a safe, static condition. Terminals will typically have a primary and a secondary ESD system. Most modern LNG carriers will carry all three systems and will be able to adjust settings and connections to match whatever system is used at the Terminal were they are calling. Older LNG carriers may only have one or two systems. If there is no common ESD system between ship and shore they are not compatible and the ship would be rejected. Approximately 30% of LNG ships in service today are older vintage, so this is a common compatibility issue.

3.2.5.- CONCLUSIONS.-

Global compatibility of LNG tankers, Liquefaction Plants and Terminals would seem a long way off, within the current LNG community. Incompatibility in design appears to be directly associated with individual Terminal commercial / business drivers. The added expense to modify existing Terminals to bring them into alignment with newer LNG Terminal design would seem impractical. However, as business opportunities and contracts change, there may be a chance for Terminals to come into design alignment over time, on a Terminal by Terminal basis.

LNG Terminal design globally utilise recognized industry guidelines such as the Permanent International Association of Navigation Congress (PIANC) which by its application will assist for future Terminal compatibility studies. Consideration of recommendations such as the Optimal Lay-Out and Dimensions for the adjustments to large ships of maritime fairways, shallow areas, sea straits and maritime waterways, would assist the LNG industry in moving toward increased ship-shore compatibility.

However while PIANC may be referred to these guidelines on Terminal design, must still accommodate considerations as to the Geographical location, prevailing conditions such as: weather, current, tidal & river experiences (over 100´s of years), the commercial drivers as to the size of the Terminal and the type of vessels they want to attract, planning permissions, local Laws / Legislation and whether the Terminal is expanding an existing installation or a complete new Terminal.

As can be appreciated with these variances applied to every project it will be difficult to standardise all aspects for compatibility, however industry has evolved sufficiently to standardise many aspects of the Terminal design.

Terminal Emergency Shutdown (ESD) systems is an example of such a standardisation (reliance on Fibre-Optic, Electric or Pneumatic), with Fibre-Optic being predominately the industry preferred option and electric the backup system, resulting in the majority of LNG vessels globally being fitted with these two systems and therefore ensure Terminal to vessel compatible in this area.

With service providers like Lloyd Register and Clarkson Register providing daily ship and Terminal information, it would seem doubtful that the current LNG operators would be willing to put any further efforts into inputting or maintaining SIGTTO web data base.

3.3.- OPERATIONAL SAFETY OF LNG FACILITIES AND LNG CARRIERS.-

3.3.1.- INTRODUCTION.-

The LNG industry has an excellent safety record. This strong safety record is a result of several factors. Firstly, the industry has technically and operationally evolved to ensure safe and secure operations. Technical and operational advances include everything from engineering that underlies LNG facilities to operational procedures and technical competency of personnel. Second, the physical and chemical properties of LNG are such that risks and hazards are well understood and incorporated into technology and operations. Third, the standards, codes and regulations that apply to the LNG industry further ensure safety.

To maintain this excellent safety record, LNG facilities undergo safety reviews during the engineering and design phase like Hazard and Operability (HAZOP) studies, Safety Integrity Level (SIL) classifications and reviews, and third party reviews by Peers.

There is a need to identify at the earliest opportunity the strengths and weakness of any contracted party. If a pre-qualification has been implemented then there should be a clear indication where the efforts can be focussed on improvements. Then an audit schedule can be derived and made specific to the scope with both management systems audits and specific technical audits at planned intervals.

Last but not least there are the reviews by the Notified Body and the authority body that will grant the operational license. No LNG Facility will be started up without satisfactorily pass the above reviews and approval processes. As a prerequisite to go through all of the above there is the permitting process which runs through the complete project life-cycle of an LNG Facility from its initial conception throughout its operational life.

Furthermore, the potential risks are identified in a Quantitative Risk Analysis (QRA) and a Fire Hazardous Analysis (FHA) report prepared for third party during engineering and design stage, and as a result, detection system and fire fighting Facility is appropriately installed to immediately detect a hazardous incident and take an adjustable action not to expand the damage such as LNG spillage and fire.

3.3.2.- SAFETY IN OPERATIONS.-

In the LNG industry there is no official certification levels but operators can take established courses. In addition via the GIIGNL contacts cross-fertilization takes place between operators of different Terminals. As an example during the commissioning and start-up phase, operators of operational Terminals frequently assist the operators of the Terminal that goes through the start-up.

For instance, Japan establishes no certification system by authority or third party that operators are well-trained and qualified. Needless to say, the gas or electric companies owning LNG Terminals, developed the original system that evaluates operator’s skill for an example, which kinds of actions in stable situation or emergency must be taken.

In the USA, the Gas Technology Institute (GTI) has been training LNG plant operators and ensuring their compliance with Department of Transportation regulations for decades. GTI certification provides documentation that the operators have been trained and have passed the final exam.

3.3.3.- SAFETY PROCEDURES.-

Active safety is founded on the early detection of the hazards and the application of preventive and / or corrective methods.

Active safety consist of the detection elements as well as the processing and action system and visualisation systems. The detection elements and processing systems are integrated into a detection system, which, depending of its design, will activate alarms, the selective shutdown of equipment and / or the Emergency Shutdown System (ESD), depending on the level of importance of the risk.

The Terminal must be provided with a Risk Assessment and Detection System designed for:

- Informing the operators of any incident
- Automatically activating the corresponding ESD

- Informing the process control system that a Process Shutdown system (PSD) and /or a ESD has been activated. For example, ESD-1: LNG unloading stop, ESD-2: LNG loading arm release, ESD-3: LNG send-out shutdown, ESD-4: Terminal shutdown..
- Monitoring and controlling the equipment and auxiliary systems.

Here is a list of the active safety elements needed on a Terminal:

- Risk Assessment System
- Risk Detection System
- Gas detectors
- Open Path Gas Detectors
- Cold Spill Detectors
- Flame Detectors
- Smoke Detectors
- Others active safety systems: Access control, Anti-intrusion system, Closed-circuit TV system and Internal communication and public address systems.

Active protection against fire: the installation will be provided with the type and amount of equipment necessary to minimise, control and extinguish possible fires or industrial incidents.

Fire-fighting Equipment and Systems:

- Active protection against fire
- Hydrants and Monitors
- Cooling system
- Water curtains
- Equipped fire hydrants
- Foam generation
- Other elements for prevention and fire-fighting

If an incident is detected, in the event of a LNG leak or a natural gas leak, the location and the magnitude of the incident must be reported and the general procedure will include the operation personnel activities:

- Emit an alarm signal or an evacuation call, according to the severity of the incident.
- Supervise the action of the PSD and ESD Systems.
- Activate the Plant alarm, if required.
- Activate the cooling systems on the equipment located near the accident.
- Leave the work in a safe position and proceed to the location of the incident.
- Stop truck loading operations and unloading or transfer operations in the vicinity of the hazard area.
- Evacuate injured people and provide first aid.
- Stop the leak by closing valves or shutting down pumps and compressors.
- Activate the fire protection system in order to disperse the vapours.
- Personnel must proceed to the location of the accident equipped with fire protection clothing and independent breathing apparatus.

In any case, the Operations Manager will direct Plant operations deciding on the adequate actions according to the situation at the affected installations.

Ship shore link is a key safety system activating ESD signals to stop LNG unloading and release unloading arms in the case of ship over movement and significant incidents occurring on jetty.

3.3.4.- DESIGN CODES AND STANDARDS.-

LNG facilities must comply with the Codes and Standards established by government administrations and other regulatory bodies with jurisdiction over said installations. These Codes and Standards have been developed over time in industrialised countries that have these types of installations. This is the case in the United States, Japan, United Kingdom, Spain and France, among others.

The standards that apply to LNG facilities, in countries within the European Union are those issued by the CEN/TC 282 Committee, many of which have already been published.

To date, the most widely accepted standard at a global level is the NFPA 59A: Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG) and for the design of process piping, the Code ASME B 31.3.

Another important standard is the European Standard EN 1473: Installations and equipment for liquefied natural gas – Design of onshore installations, that was approved by the European Committee for Standardisation (CEN) and which applies in all EU member states. The content of Standard EN 1473 covers the specification of the safety and environmental aspects to be taken into account in the design, construction and operation of LNG facilities. It is based on risk analysis studies, identifying potential hazards and estimating probabilities of occurrence and their consequences. It uses physical-mathematical models which are internationally recognised with experience and testing at both reduced scale and real scale.

Requirements of LNG carrier operations are governed by the regulations of Code 33 CFR Part 127, Liquefied Natural Gas Waterfront Facilities. Additional information on safety at docking facilities, as well as operating systems and procedures can be obtained from the standards published by the Society of International Gas Tanker and Terminal Operators (SIGTTO) and Oil Companies International Marine Forum (OCIMF).

In Canada, the applicable standard is the Canadian Standards Association: CSA Z276-07 LNG production, storage and handling, published in 2007 and prepared by the Technical Committee for Liquefied Natural Gas under the jurisdiction of the Executive Committee for Canadian Oil and Gas Industry Systems.

Other countries with LNG facilities have also developed specific codes and standards to supplement the provisions of the internationally accepted standards. Many of these standards and codes are adaptations of the American standards and codes. This is the reason why standards such as the NFPA 59A continue to be used as reference for projects in countries that do not have their own standards.

The Sedigas Handbook: LNG Receiving Storage and Regasification Terminals include a list (Chapter 3: Applicable Standards) of most of the standards and codes that are used in the design, construction and safety operation of LNG facilities, and among others we should mention:

- NFPA 59A Standard for the Production, Storage and Handling of LNG
- EN 1473 Installations and Equipment for LNG-Design of Offshore Installations
- EN 1474 Design and Testing of LNG Loading/Unloading Arms
- EN 1532 Ship to Shore Interface for LNG
- NFPA 10 Portable Fire Extinguishers
- NFPA 11A Medium and high expansion foam systems
- NFPA 13 Installation of sprinkler systems
- NFPA 17 Dry chemical extinguishing systems
- NFPA 20 Installation of centrifugal fire pumps
- NFPA 24 Installation of private fire service mains
- NFPA 2001 Standard on clean agent fire extinguishing systems

3.3.5.- ENVIRONMENTAL ISSUES.-

In the normal functioning of a LNG Plant, the following chemical products are used:

- LNG / Natural gas
- Liquid Nitrogen
- Ethylene
- Propane
- Methane
- Odorant
- Sodium bisulphite
- Sodium hypochlorite
- Hydrochloric acid
- Sodium hydroxide
- Diesel
- Lubricant oils

These products are used in different quantities and in different stages of the process and their main characteristics and effects on health or on the natural environment must be analysed.

The storage tanks must be associated with equipment for the containment or mitigation of pollution in the event of an emergency.

The issues to be considered in the water used as a heating fuel in the open-rack vaporizers (ORV) will depend on the conditions indicated by the Relevant Authority regarding Water Discharge Authorization. As a guideline:

- The lowest amounts of water and thermal jump possible for obtaining an adequate performance from the ORVs.
- Catchment pipes featuring a filter system to avoid sucking in marine organisms or other materials which may damage the installations.

- An adequate filtering system for retaining also part of the larval micro-organisms. This will also mean less hypochlorite in the electro-chlorination system.

It is important to avoid any contact between wastes and rainwater, if the waste cannot undergo processing by the provided purification system.

In the event of fire, water used in the Fire-Fighting System (FFS) containing solids, foam and chemical powder will be channelled to the pollution rainwater network for purification before discharge.

When carrying out environmental control and monitoring, the following must be considered:

- Sampling and metering must be representative. Therefore, they shall be implemented whenever there is disorder regarding the aspects to be controlled.
- Sampling, analytical tests and metering must be carried out by approved and / or accredited institutions and must be endorsed by the report signed by a competent technician.
- The promoter must appoint one or more people to take charge of the environmental surveillance and monitoring plan.

The environmental surveillance and monitoring plan will include at least:

- Preoperational campaigns regarding the environmental indicators under surveillance. The result of these campaigns will be included in the subsequent reports on environmental surveillance in order to establish comparisons.
- A specific surveillance plan for controlling the quality of water, sediments and shellfish resources for the operations stages. This plan must:

    - Verify forecasts indicated in the Environmental Impact Assessment (EIA) regarding the harmlessness of the discharge
    - Know the degree of compliance with the limits established by the relevant institutions regarding its authorization for discharge
    - To be specifically included are the control of discharge temperature, the transformation of grading on the seabed and the noise level in the Plant surroundings
    - A specific plan for maintenance and control to guarantee that emissions originating from the combustion of natural gas comply with legal stipulations if the submerged combustion vaporization system is activated

During the exploitation phase, a thorough inspection will be carried out on the projected systems. All necessary regular maintenance work will be performed, thus verifying their correct functioning in order to avoid any case of pollution. In this sense, all necessary measures to be applied in the event of possible accidents will be considered, in accordance with expected risks, which might cause damage to the environment.

Following the requirements of the Relevant Authority, a hydrocarbon analyser will be installed at the endpoint of the system for processing potentially contaminated waters.

Surveillance of these programmes will be carried out by issuing reports to the Relevant Authority following the established time-frame.

3.3.6.- BEST PRACTICES.-

Spain is the third largest LNG country importer in the world and Enagas is the Technical Manager of the Spanish Gas System. In Spain there are currently six Regasification Terminals in operation and one more with the construction finished and ready for start-up.

For references please go to www.enagas.es -> English -> Technical Management of the System -> Procedures -> Best Practices and that page includes the Best Practices Guide (in Spanish).

In order to find the Best Practices in English, a good reference is the following website: www.saggas.com/en/guia-de-buenas-practicas-en-las-plantas-gnl/ that includes the Best Practices for the Sagunto Regasification Plant and provides this guide for users in order to facilitate location of and access to useful information regarding the general and technical characteristics of the Sagunto Regasification Plant.

The title of that page is: Good Practice Guide for LNG Plants and it includes the following chapters:

1. **GENERAL ITEMS**, including the Technical Management of the Gas System (NGTS) Regulations for LNG Plants and the following Detailed Protocols (DP) are to be applied:

   DP-01: Measurement
   DP-02: Delivery Procedure at Transport-Distribution Connection Points (TDCP)
   DP-03: Demand Prediction
   DP-04: Communication Mechanisms
   DP-05: Procedure for determining energy unloaded of methane tankers
   DP-06: Operational rules for the unloading of methane tankers
   DP-07: Schedules and nominations for infrastructures and transport
   DP-08: Consumption schedules and nominations within distribution networks
   DP-09: Calculation of admissible ranges of the basic control variables within the system normal operating ranges
   DP-10: Calculation of installation capacity
   DP-11: Delivery procedure at entry points to the transport network

2. **PUBLICATION/INFORMATION ON THE TECHNICAL CHARACTERISTICS OF THE PLANT**

   2.1 Port and Berth: Information regarding characteristics of Port and Berth point is to be made at every Plant
   2.2 Storage Systems: Publication of information relating to the number of tanks and their technical capacity
   2.3 Unloading System.

Tanker-Plant Compatibility: The compatibility procedures for the Tanker Plant interface to ensure a safe berth are to be made available and published, in accordance with DP-06 which establishes the mechanisms and requirements for checking the compatibility of methane tankers loading and/or unloading at LNG installations, considering their respective characteristics.
The companies involved are to handle the vetting documentation for the tankers scheduled for unloading at the plants.
Unloading procedures: The procedure for unloading tankers is to be made available and published.

3 OPERATION

3.1 Measurement. Applicable regulations: the practices used for this process are to be published in accordance with Detailed Protocol DP-05.
The Custody transfer Handbook is to be used as reference.
The Plant users are to have access to the certificates of the equipment and instruments used for measuring.

4 MAINTENANCE

4.1 The Annual Maintenance Plan is to be published in accordance with NGTS-08.
4.2 Legal requirements are to be fulfilled in accordance with that established in the Industrial Regulations, in the following areas: Pressure equipment, high and low voltage regulations, storage of chemical substances, fire prevention systems.
Plant users are to have access to all mandatory equipment and/or component inspections they might require.

5 RISK PREVENTION

5.1 Information regarding Emergency Action Plans, both internal and external is to be made available in compliance with the ISPS Code.

6 LOGISTICS MANAGEMENT

6.1 Applicable Regulations. Prevailing regulations applicable to Plant logistics are to be made to Plant users as per NGTS and DP-06.
6.2 Capacity Management. The Plant’s operating capacity is to be published, indicating available and contracted capacity as per NGTS and DP-10.
6.3 Information regarding access to the infrastructure is to be made available for contracting: Application forms, Contracts forms and Capacity reservation applications.
6.4 Logistics-Scheduling Management.
Annual Schedules is to be published for unloading bays.
Monthly operating plans are to be published, with details of daily Plant

operations, so that users may be aware of the status of the Plant at all times. All necessary information regarding each port is to be made available in the event it is necessary, for example, information on tide heights. A list of all those tankers compatible with the Plant is to be published.

7 QUALITY, PREVENTION AND ENVIRONMENT CERTIFICATIONS

Valid certificates are to be published, including:

Quality: ISO 9001
Risk Prevention: OHSAS 18001
Environment: ISO 14001

Note: There is no global certification requirement.

8 INCIDENT MANAGEMENT

A system for the management of major, unexpected incidents affecting third parties is to be made available.

3.4.- VESSEL APPROVAL AND COMPATIBILITY PROCEDURE.-

To safely moor an LNG carrier at a jetty berth the compatibility of an LNG carrier need to be verified against the technical characteristics of the LNG Facility. An essential part of this process is the vessel approval and compatibility procedure. Such a procedure should include as a minimum the following content and steps.

3.4.1.- VESSEL APPROVAL PROCESS.-

The vessel approval and compatibility procedures should be designed and applied in line with the Gas LNG Europe (GLE) LNG Ship Approval Procedure issued on 29^{th} June 2004. The objective of the Ship Approval Procedure is to check the compatibility of the ship requesting access in terms of mechanical design, communication and safety; it aims at insuring the safety of the unloading operations pro-actively and sustaining the excellent safety record of the LNG industry. The methodology described below has successfully been used in other European Terminals and agreed upon by Shell, Petronas and BG Group shipping department.

The approval procedure should complement international rules and regulations, implemented either by the Flag State of the vessel or by the Port State of the Terminal, and on professional societies recommendations such as ISGOTT, OCIMF, SIGTTO or GIIGNL and the receiving Terminals duty of care.

3.4.2.- STRUCTURE OF THE PROCEDURE.-

Shippers proposing unload at the Terminal shall undergo the following chronological steps for each proposed ship:

- **Step 1**: Preparatory Information exchange;

The main objective of this first step is to gather all necessary material (information, data, drawings…) to study the good match of ships to berth.

- **Step 2**: Ship-Shore Interface study;

In order to verify not only the technical compatibility, but also the operational aspects an evaluation of the Ship/Shore Safety Working procedures to ensure they are compatible.

- **Step 3**: Ship safety Inspections;

The Terminal does not automatically inspect vessels, however it always reserves the right for a ship inspection (SIRE inspection) prior to berthing. This inspection is performed by a Terminal endorsed inspector.

The Terminal (as a member of OCIMF) has available the most recent SIRE inspection of the vessel. In addition the Class status report provide data on all inspections related to all ship equipment.

The Terminal marine supervisor will evaluate the fitness of vessel to carry their cargoes to and discharge them. The vetting process takes into account the use of Ship inspections (e.g. SIRE or ship owner), Port State Control inspections, Flag State profile, Class profile, Casualty data, Owners profile, Terminal feedback and for older vessels a Condition Assessment Program certificate or Fatigue analysis against a standard.

If the vessel shows deficiencies the Terminal will require corrective actions to be undertaken and demonstrated completion and validation of works.

- **Step 4**: Unloading Test and Ship Approval;

Only when the vessel has successfully discharge at the Terminal can the vessel be classed as Approved. Therefore, dependant upon the outcome of the previous steps, a ship may either be approved for an Unloading test, or rejected. In the event that a vessel is rejected, a request to undergo a further inspection in accordance with applicable agreements will be discussed.

In Europe and the U.S.A., the vessel approval procedures for the LNG terminals are included in Appendix E.

Appendix A: Gas Quality Specifications for countries importing LNG and Gas Quality requirements at the entry point of the transmission network in Europe, U.S.A and Mexico.

Belgium.

This information is available at Fluxys LNG website.

Specifications for the Fluxys LNG terminal Delivery Point.

Table 1: Gas quality requirements at the Zeebrugge LNG terminal.

	Unit	Min	Max
Methane	mol %	80	-
Nitrogen	mol %	-	1.2
Gross Calorific Value	kWh/m³(n)	10.83	12.43
Wobbe Number	kWh/m³(n)	14.17	15.56
LNG density at atmospheric equilibrium pressure, i.e. 1013.25 mbar absolute	kg/m³ LNG	425	480

Source: *Fluxys LNG website.*

Max. LNG temperature allowed at the delivery point:

The LNG temperature at the delivery point shall preferably be at or below the LNG atmospheric boiling point, i.e. the liquid temperature in equilibrium with an absolute pressure of 1013.25 mbar. In any case the calculated equilibrium vapour pressure, based on the LNG temperature and the LNG molar composition at the delivery point as calculation inputs, shall not exceed an absolute pressure of 1150 mbar.

Reference standards:

ISO standards, e.g. ISO 6976: 1995 for calorific values (calorific reference temperature: + 25°C)
Calculated LNG density: revised Klosek-McKinley method (Technical Note Nr. 1030, 1980).

Table 2: Limitations for impurities and components at the Zeebrugge LNG terminal.

Specific limitations for trace components and impurities in LNG	Unit	Max
iC4	mol %	1
nC4	mol %	1
iC5	mol %	0.2
nC5	mol %	0.2
C6+	mol %	0.1
H2S + COS (as S)	mg/m³(n)	5
Total S (as S)	mg/m³(n)	22.4
Mercaptans (as S)	mg/m³(n)	6
O2	Ppm (vol)	10
CO2	Ppm (vol)	100
CO	Ppm (vol)	1
H2	Ppm (vol)	1
H2O	Ppm (vol)	0.1
Hg	nano g/m³(n)	50
Hydrocarbon dew point (cricondentherm)	°C@0-69 barg	-20
Solids	no deposits on '32 mesh strainer'	

Source: *Fluxys LNG website.*

Impurities:

To avoid internal clogging or erosion of equipment, as a general rule the delivered LNG shall not contain any fluid component (e.g. aromatics, C_6H_6, CO_2, CH_3OH, etc.) in a concentration higher than 50% of the solubility limit in LNG of that particular fluid component in the operating pressure and operating temperature range of resp. 0 to 100 bar abs. and -162 to + 50 °C. C_6H_6: max. 1 ppm, CH_3OH: max. 0.5 ppm.

Contaminants:

As a general rule, the delivered LNG shall not contain any liquid or solid contaminants.

Specific requirements at the Redelivery Point: ZBT Entry Point of the Fluxys transmission grid

Table 3: Specific requirements at the Redelivery point.

	Unit	Min	Max
Gross Calorific Value	kWh/m³(n)	10.81	12.79
Wobbe Number	kWh/m³(n)	13.65	15.56
Pressure for off take by Fluxys[1]	bar gauge	55	80
Temperature	°C	2	38
Hydrocarbon Dew point	°C from 0 bar gauge up to 69 bar gauge	-	Minus 2
Water Dew point	°C at 69 bar gauge	-	Minus 8
Oxygen content (O2)	Ppm (vol)	-	5000
Carbon dioxide content (CO2)	vol %	-	2.0
Hydrogen sulphide content (H2S) (inclusive of COS) (as S)	mg/m³(n)	-	5
Total sulphur at any time (as S)	mg/m³(n)	-	150
Total sulphur (as S) yearly	mg/m³(n)	-	120

Source: *Fluxys LNG website.*

The natural gas redelivered may not contain other elements and impurities (such as but not limited to methanol, condensates, gas odorants) to the extent that the natural gas delivered cannot be transported, stored and marketed in Belgium without incurring additional cost for quality adjustment.

No blending service is currently offered.

Spain.

The gas quality requirements are available at Enagas' website[2].

Table 4: Gas quality requirements at the Spanish LNG terminals.

Property	Unit	Min	Max
Wobbe Index	kWh/m³	13.368	16.016
Gross Calorific Number	kWh/m³	10.23	13.23
D	m^3/m^3	0.555	0.700
Total S	mg/m^3	-	50
H_2S + COS (as S)	mg/m^3	-	15
RSH (as S)	mg/m^3	-	17
O_2	mol%	-	[0.01]
CO_2	mol%	-	2.5

1 The Shipper shall make available the Natural Gas at any pressure within that range as requested from time to time by Fluxys LNG (TO).

2 http://www.enagas.es/cs/Satellite?cid=1142417697719&language=es&pagename=ENAGAS%2FPage%2FENAG_pintarContenidoFinal

H_2O (DP)	°C at 70 bar (a)	-	+2
HC (DP)	°C at 1-70 bar (a)	-	+5

Source: *Enagás website.*

France

Fos Tonkin and Montoir-de-Bretagne.

The gas quality requirements are available at the document "Contract providing access to the LNG terminal – Appendix 1: General Terms and conditions, Art. 12.1 - Version of the 1st of January 2010". The unloaded LNG must comply with the following specifications:

Table 5: Gas quality requirements at the Fos Tonkin and Montoir-de-Bretagne.

Property	Unit	Min	Max
Wobbe Index (combustion conditions at 0ºC and 1.01325 bar)[3]	kWh/m(n)³	13.64	15.65
Wobbe Index (combustion conditions at 25ºC and 1.01325 bar)[3]	kWh/m(n)³	13.60	15.61
Gross Calorific Number (combustion conditions at 0ºC and 1.01325 bar)	kWh/m(n)³	10.70	12.75
Gross Calorific Number (combustion conditions at 25ºC and 1.01325 bar)	kWh/m(n)³	10.67	12.72
Total S[3]	mg/m(n)³	-	30
H_2S + COS (as S)	mg of S/m(n)³	-	5
RSH (as S)	mg of S/m(n)³	-	6
O_2	ppmv	-	100
Hg	ng/m(n)³	-	50
Trace elements	Gas that can be received without undergoing additional treatment on entering the Terminal.		

Source: *Elengy's website.*

Art. 12.3 of the referred document details that "If the value of the Loading Certificate does not comply with the specifications laid down in paragraph 12.1, the Operator shall be entitled either to refuse the corresponding Cargo, or make its acceptance dependent on:

(i) the Shipper's payment of an additional compensation intended to cover the costs of establishing the Cargo's conformity, and/or

(ii) making a change to the Cargo Window of Arrival."

[3] These values were taken from those discussed within the framework of the EASEE-gas association. Target dates for their application are yet to be fixed. Until these dates have been set, LNG with the following characteristics shall temporarily be considered acceptable for the Fos Tonkin and Montoir-de- Bretagne terminals:

- Wobbe index higher than 13.40 kWh/m³ (n) (combustion at 0°C),
- Total sulphur content up to 75 mgS/m³(n).

Fos Cavaou.

The gas quality requirements are available at the document "Contract for Access to the Fos Cavaou Methane Terminal – Appendix 2 – General Conditions - Version dated 2010-02-26", article 13. The unloaded LNG must comply with the following specifications:

Table 6: Gas quality requirements at the Fos Cavaou.

Property	Unit	Min	Max
Wobbe Index (combustion conditions at 25ºC and 1.01325 bar)	kWh/m(n)³	13.37	15.61
Gross Calorific Number (combustion conditions at 25ºC and 1.01325 bar)	kWh/m(n)³	10.67	12.72
Total S	mg/m(n)³	-	30
H_2S + COS (as S)	mg of S/m(n)³	-	5
RSH (as S)	mg of S/m(n)³	-	6
O_2	ppmv	-	100
Hg	ng/m(n)³	-	50
Other impurities	Components that enable the Gas to be received without undergoing any additional treatment at the Terminal entry.		

Source: *STMFC's website.*

Italy

Panigaglia.

This information is available at the regasification code Chapter 12.

The components of GCV (Gross Calorific Value) at the delivery and redelivery point are the same and are detailed in the next table:

Table 7: GCV components.

Property	*Value*	*Unit*
C_1	(*)	
C_2	(*)	
C_3	(*)	
iC_4	(*)	
nC_4	(*)	
C_{6+}	(*)	
N_2	(*)	
O_2	<= 0.6	%mol
CO_2	<= 3	%mol

(*)These components and their values are limited by the Wobbe Index requirements.

Source: *Codice di Rigassificazione, Chapter 12, and self-made.*

The following table details trace gas analysis at the delivery and redelivery point:

Table 8: Trace components.

Property	*Value*	*Unit*
H2S	<=6.6	Mg/Sm^3
S-RSH	<=15.5	Mg/Sm^3
S TOT	<=150	Mg/Sm^3

Source: *Codice di Rigassificazione, Chapter 12.*

The physical properties at the delivery point are detailed in the following table.

Table 9: Physic gas quality requirements at the delivery point.

Property	*Value*	*Unit*
H2S	< 6	mg/Sm^3
S-RHS	< 15	mg/Sm^3
STOT	< 150	mg/Sm^3
GCP	38.18 ÷ 43.18	MJ/Sm^3
Wobbe Index	47.31 ÷ 52.13	MJ/Sm^3
Wobbe Index Correction	52.13 ÷ 53.17	MJ/Sm^3
Density	430 ÷ 470	kg/m^3

Source: *Codice di Rigassificazione, Chapter 12.*

The following table details the physic gas quality requirements at the redelivery point:

Table 10: Physic gas quality requirements at the redelivery point.

Property	*Value*	*Unit*	*Conditions*
GCP	34.95 ÷ 42.28	MJ/Sm^3	
Wobbe Index	47.31 ÷ 52.33	MJ/Sm^3	
Density	0.5548 ÷ 0.8	kg/m^3	
Water dew point	<= -5	ºC	7000 kPa gauge
Hydrocarbon dew point	<=0	ºC	100 ÷ 7000 KPa gauge
Max Temperature	<50	ºC	
Min Temperature	>3	ºC	

Source: *Codice di Rigassificazione, Chapter 12.*

Adriatic LNG.

This information is available at the regasification code Annex (h) and Annex (i).

Gas transmitted by the TO to the Cavarzere Entry Point, shall contain equal to or less than the acceptable values for the components and substances listed below:

Table 11: NG GCV components.

Property	*Value*	*Unit*
C_1	(*)	
C_2	(*)	
C_3	(*)	
C_4 and heavier	(*)	
C_5 and heavier	(*)	
N_2	(*)	
O_2	<= 0.6	%mol
CO_2	<= 3	%mol
H_2S	<= 6.6	mg/SCM

Total sulphur	<= 150	mg/SCM
Metacarptans	<= 15.5	mg/SCM

(*)These components and their values are limited by the Wobbe Index requirements.

Source: *Access Code For the Offshore Regasification Terminal of Terminale GNL Adriatico S.r.l, Annex (h).*

Besides, the gas shall contain no traces of the following components:

- Water and/or hydrocarbon in liquid state;
- Solid particulates in such quantities that will damage the material used for transportation of the gas;
- Other gases which may affect the safety or integrity of the transportation system.

Gas transmitted by the TO to the Cavarzere entry point, shall have physical properties that fall within the acceptable ranges listed below:

Table 12: Physic gas quality requirements at the redelivery point.

Property	*Value*	*Unit*	*Conditions*
GHV	34.95 ÷ 42.28	MJ/Sm^3	
Wobbe Index	47.31 ÷ 52.33	MJ/Sm^3	
Density	0.5548 ÷ 0.8	kg/m^3	
Water dew point	<= -5	ºC	7000 kPa gauge
Hydrocarbon dew point	<=0	ºC	100 ÷ 7000 KPa gauge
Max Temperature	<50	ºC	

Source: *Access Code For the Offshore Regasification Terminal of Terminale GNL Adriatico S.r.l, Annex (h).*

LNG delivered by or on behalf of a user to the TO at the delivery point, in a gaseous state, shall have a Gross Heating Value in the range of 34.95 MJ/Sm^3 to 45.28 MJ/Sm^3 and a Wobbe Index in the range of 47.31 MJ/Sm^3 to 52.13 MJ/Sm^3. After the Correction Service Availability Date, the Wobbe Index range will be the following: 47.31 MJ/Sm^3 to 53.40 MJ/ Sm^3.

LNG delivered by or on behalf of a user to the TO at the delivery point, in a gaseous state, shall contain for the components and substances listed below, not more than the following:

Table 13: LNG GCV components.

Property	*Value*	*Unit*	*Conditions*
C_1	(*)		
C_2	(*)		
C_3	(*)		
C_4 and heavier	(*)		
C_5 and heavier	(*)		
N_2	(*)		
O_2	<= 0.05	%mol	
CO_2	<= 0.05	%mol	
H_2S	<= 4.59	mg/SCM	
Total sulphur	<= 45.88	mg/SCM	
Metacarptans	<= 9.18	mg/SCM	

Mercury	<= 10	Ng/SCM	
Hydrocarbons	>= -5	ºC	100 ÷ 7000 KPa gauge
Cargo vapour pressure	140	milibars gauge	

(*)These components and their values are limited by the Wobbe Index requirements.

Source: *Access Code For the Offshore Regasification Terminal of Terminale GNL Adriatico S.r.l, Annex (i).*

Portugal

Table 14: Gas quality requirements at Sines LNG terminal.

Property	**Unit**	**Min**	**Max**
Wobbe Index	$MJ/m^3(n)$	48.17	57.66
Density	Relative density	0.5549	0.7001
Water Dew Point	ºC	-	-5ºC
Total S	$mg/m(n)^3$	-	50
H_2S	$mg/m^3(n)$	-	5

Source: *REN Atlântico.*

UK

Isle of Grain.

Isle of Grain does not offer any information on gas quality requirements.

Grain LNG has installed, at the request of its current customers, a Nitrogen blending facility to blend a defined quality of LNG to within GSMR specification.

South Hook LNG.

According to the document "Guidance Document for Prospective Additional Users", nitrogen ballasting facilities have been designed and constructed on the assumption lean LNG produced in Qatar will be delivered at the terminal.

Dragon LNG.

Dragon LNG does not offer any information on gas quality requirements.

Greece

Gas quality specifications are detailed in the Annex I of the Network Code.

Table 15: Gas quality requirements at the entry point of the transmission network.

Property	Unit	Min	Max
Wobbe Index	KWh/Nm^3	13.10	16.37
Gross Calorific Number	KWh/Nm^3	10.20	13.71
Total S	mg/Nm^3	-	80
H_2S	mg/Nm^3	-	5.4
Relative Density	Kg/Kmol	0.56	0.71
CH_4	mole %	75	-
N_2	mole %	-	6
CO_2	mole %	-	3
O_2	mole %	-	0.2
Water Dew Point (under pressure reference of 80 bar)	ºC	-	+5
Hydrocarbons Dew Point (under any pressure from 1 to 80 bar)	ºC	-	+3

Source: *DESFA.*

Table 16: Gas quality requirements at the Revithoussa LNG terminal.

Property	Unit	Min	Max
Wobbe Index	KWh/Nm^3	13.10	16.37
Gross Calorific Number	KWh/Nm^3	11.16	12.68
Total S	mg/Nm^3	-	30
H_2S	mg/Nm^3	-	5
Molecular Weight	Kg/Kmol	16.52	18.88
LNG density	Kg/m^3	430	478
CH_4	mole %	85	97
N_2	mole %	-	1.24

Source: *DESFA.*

The Netherlands.

No public information about the gas quality requirements is provided about Gate gas quality requirements.

USA.

Cove Point

Natural Gas received by Operator and delivered to User hereunder shall at all times conform to the quality provisions show bellow:

a) shall be commercially free from particulates or other solid or liquid matter which might interfere with its merchantability or cause injury to or interfere with proper operation of the lines, regulators, meters and other equipment of Operator;

b) shall not contain more than twenty-five hundredths grains of hydrogen sulphide per one hundred cubic feet;

c) shall not contain more than twenty grains of total sulphur per one hundred cubic feet;

d) shall not contain more than 4.0% N_2 and 1.0% CO_2;

e) shall not contain in excess of seven pounds of water vapour per million cubic feet.

f) shall not contain O_2 in excess of two-tenths of one percent by volume; and

g) shall not contain any other harmful contaminants, including Hg, which might interfere with the proper operation of or cause damage to Operator's facilities.

Operator and User may agree, or governmental authorities may require, that the Natural Gas be odorized to indicate by a distinctive odour the presence of Natural Gas. User and Operator shall be for the purpose of detection of the Natural Gas only during the time it is in possession of the Operator, prior to delivery to User.

The LNG to be received hereunder for LNG Tanker Discharging Service shall be merchantable and shall have in its gaseous state:

a) A Gross Heating Value of not less than nine hundred sixty-seven Btu and, not more than one thousand one hundred thirty-eight Btu per standard cubic foot.

b) A hydrogen sulphide content not to exceed twenty-five hundredths grains of hydrogen sulphide per one-hundred cubic feet;

c) A total sulphur content of not more than twenty grains per one-hundred cubic feet;

d) No water or mercury;

e) No active bacteria or bacterial agent, including but limited to, sulphate reducing bacteria or acid producing bacterial; and

f) No hazardous or toxic substances.

Elba Island

In order to permit delivery into downstream facilities, the LNG received shall be merchantable and shall have in its gaseous state a gross heating value of not less than 1,000 Btu and not more than 1,075 Btu; and constituent elements conforming to the following:

free of objectionable liquids and solids;

not contain more than 200 grains of total sulphur or 10 grains of hydrogen sulphide, or 0.30 gallons of isopentane and heavier hydrocarbons, per Mcf;

not contain more than 3% by volume of carbon dioxide or nitrogen or 1% of oxygen;

not contain any water; and

free of liquids at 800 psig and 50° F.

Lake Charles

The LNG received by Operator and delivered to User hereunder shall at all times conform to the quality provisions show bellow:

a) a Gross Heating Value of not less than 950 Btu and not more than 1,200 Btu per standard cubic feet;

b) shall not contain more than twenty-five hundredths grains of hydrogen sulphide per one hundred cubic feet;

c) shall not contain more than 30 mg/Nm^3 of total sulphur;

d) shall not contain more than 2.30 mg/Nm3 of Mercaptan sulphur;

e) shall not contain in excess of seven pounds of water vapour per million cubic feet.

f) shall not contain O_2 in excess of two-tenths of one percent by volume; and

g) shall not contain any other harmful contaminants, including Hg, which might interfere with the proper operation of or cause damage to Operator's facilities.

h) shall not contain water, carbon dioxide or mercury;

i) shall not contain active bacteria or bacterial agent, including but not limited to, sulphate reducing bacteria or acid producing bacteria.

Mexico.

The gas quality requirements are available at CRE's website ("Norma Oficial Mexicana" NOM-001-SECRE-2003, which substitutes to the NOM-001-SECRE-1997).

Table 17: Gas quality requirements at the Mexican LNG terminals.

	Unit	Min	Max
O_2	% Vol.	-	0.2
N_2	% Vol.	-	5.0
CO_2	% Vol.	-	3.0
Humidity (H_2O)	mg/m^3	-	112
H_2S	mg/m^3	-	6.1
S	mg/m^3	-	150.0
Gross Calorific Value	MJ/m^3	35.42	41.53
Wobbe Number	MJ/m^3	45.8	50.6
Hydrocarbon dew point temperature (1-8000 kPa)	K (ºC)	-	271.15 (-2)

APPENDIX B.- LNG Quality Averages and Limits for LNG-Exporting Countries.-

Appendix B LNG Quality Averages and Limits for LNG Exporting Countries

	Qatar (a)	Qatar (b)	Norway	Indonesia	Malaysia	Australia	Abu Dhabi	United States	Brunei	Libya	Algeria	Nigeria	Oman	Trinidad & Tobago	Egypt	Equatorial Guinea	Yemen	Iran
Normal/Standard Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Standard Conditions Shown Below	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported	Normal Conditions Reported
Temperature	(1)	(1)	15°C	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Pressure	(1)	(1)	1.01325 bar	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
HHV Reference Temperature	(1)	(1)	25°C	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Gas Description	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas	Real Gas
Combustion Properties																		
Wobbe Number (WI) (MJ/m^3)	55.00 – 57.00 [2]	54.00 – 54.40 [2]	45.80 – 52.90 [2] [43.45 – 50.19]	55.71 (a) 55.78 (b)	55.89	56.48	56.21	53.49	56.13	56.93	55.64 (a) 55.26 (b) 54.35 (c) 54.36 (d)	55.92	56.36	54.22			54.91	50.0 – 53.2
Regas Density (kg/m^3)	0.808			0.803 (a) 0.801 (b)	0.813	0.831	0.826	0.719	0.816	0.867	0.813 (a) 0.818 (b) 0.775 (c) 0.778 (d)	0.809	0.867	0.834	0.730 (a) 0.738 (b)	0.756	0.73 \	0.55 – 0.70
Higher Heating Value (HHV) (MJ/m^3)	43.50 – 44.00 [2]	41.50 – 42.00 [2]	38.10 – 40.20 [2] [36.15 – 38.14]	43.90 (a) 43.92 (b)	44.32	45.27	44.93	39.89	44.59	46.62	44.11 (a) 43.96 (b) 42.07 (c) 42.17 (d)	44.24	45.28	41.05	40.8 (a) 41.0 (b)	42.0	42.34	37.2 – 44.0
LNG Density (kg/m^3)	460			457 (a) 456 (b)	461	467	467	423	461	485	464 (a) 469 (b) 451 (c) 453 (d)	458	470	432	427 (a) 430 (b)	439	444	
Composition																		
Methane (mole fraction)	89.94 – 90.50% [2]	92.49 – 92.99% [2]	>/= 84.55% [2]	90.7% (a) 91.2% (b)	90.3%	87.4%	84.8%	99.7%	90.6%	81.6%	88.0% (a) 87.6% (b) 91.4% (c) 91.3% (d)	91.3%	87.9%	96.8%	97.7% (a) 97.2% (b)	93.4%		>/= 90.01% [2]

Appendix B LNG Quality Averages and Limits for LNG Exporting Countries

	Qatar (a)	Qatar (b)	Norway	Indonesia	Malaysia	Australia	Abu Dhabi	United States	Brunei	Libya	Algeria	Nigeria	Oman	Trinidad & Tobago	Egypt	Equatorial Guinea	Yemen	Iran
Ethane (mole fraction)	6.08 – 6.38% [2]	6.14 – 6.33% [2]	</= 8.9% [2]	6.2% (a) 5.5% (b)	5.3%	8.3%	13.2%	0.1%	5.0%	13.4%	9.0% (a) 8.4% (b) 7.2% (c) 7.0% (d)	4.6%	7.3%	2.7%	1.8% (a) 2.3% (b)	6.5%		</= 5.8% [2]
Propane (mole fraction)	2.05 – 2.28% [2]	0.11 – 0.66% [2]	</= 3.15% [2]	2.0% (a) 2.4% (b)	3.1%	3.4%	1.6%	0.1%	2.9%	3.7%	2.0% (a) 2.1% (b) 0.5% (c) 0.7% (d)	2.6%	2.9%	0.3%	0.2% (a) 0.3% (b)	0.0%		</= 2.08% [2]
i-Butane (mole fraction)	0.35 – 0.40% [2]	0.00 – 0.03% [2]	</= 0.55% [2]	0.5% (a) 0.5% (b)	0.6%	0.4%	<0.1%	<0.1%	0.6%	0.3%	0.2% (a) 0.3% (b) 0% (c) <0.1% (d)	0.6%	0.8%	<0.1%				
n-Butane (mole fraction)	0.50 – 0.62% [2]	0.00 – 0.03% [2]	</= 0.70% [2]	0.5% (a) 0.4% (b)	0.5%	0.4%	<0.1%	0%	0.8%	0.4%	0.2% (a) 0.4% (b) 0% (c) <0.1% (d)	0.8%	0.7%	<0.1%				
i-Pentane (mole fraction)	0.01 – 0.02% [2]	0.00 [2]		<0.1% (a) <0.1% (b)	0%	<0.1%	0%	0%	<0.1%	0%	<0.1% (a) 0% (b) 0% (c) 0% (d)	<0.1%	<0.1%	<0.1%				
n-Pentane (mole fraction)	0.00 – 0.01% [2]	0.00 [2]		<0.1% (a) <0.1% (b)	0%	<0.1%	0%	0%	<0.1%	0%	<0.1% (a) 0% (b) 0% (c) 0% (d)	<0.1%	<0.1%	<0.1%				
C3+ (mole fraction)																		
C4+ (mole fraction)				1.0% (a) 0.9% (b)	1.1%	0.8%	0.1%	0.0%	1.5%	0.7%	0.5% (a) 0.7% (b) 0.0% (c) 0.1% (d)	1.4%	1.6%	0.7%	0.2%(a) 0.3%(b)	0.0%		</= 1.24% [2]
C5+ (mole fraction)			</= 0.15% [2]															</= 0.22% [2]
Nitrogen (mole fraction)	0.25 – 0.63% [2]	0.55 – 0.70% [2]	</= 1.1% [2]	0.2% (a) 0.3% (b)	0.3%	0.1%	0.1%	0.2%	0.1%	0.7%	0.6% (a) 1.2% (b) 0.9% (c) 1.0% (d)	1.0%	0.4%	0.1%	0.1%(a) 0.0%(b)	0.0%		

Appendix B LNG Quality Averages and Limits for LNG Exporting Countries

Notes:

[1] Normal Conditions Reported - 101.325kPA and 0°/0°C
[2] Gas quality limits. Other Data Represent Averages.

[ ] - Normal Conditions, Calculated - 101.325kPA and 15°/15°C.

Reference Standards:

ISO 6578, "Refrigerated Hydrocarbon Liquids – Static Measurement – Calculation Procedure," 1991-12-01
ISO 6976, "Natural Gas – Calculation of Calorific Values, Density, Relative Density and Wobbe Index from Composition," 1995-12-01.

Sources:

- IGU PGC D Membership and Triennium 2003 – 2006 Data
- International Group of Liquefied Natural Gas Importers (GIIGNL) by IGU/GIIGNL Information Exchange Protocol, 20 November 2008
- Various Commercial Data Sources.

Qatar	(a)	"Rich"
	(b)	"Lean"
Indonesia	(a):	Arun
	(b):	Badak
Algeria	(a):	Arzew
	(b):	Bethioua 1
	(c):	Bethioua 2
	(d):	Skikda
Egypt	(a):	Damletta
	(b):	Idku

APPENDIX C.- LIST OF INTERNATIONAL ORGANIZATIONS.-

This Appendix C includes the most important organizations involved in LNG quality, interchangeability and facilities compatibility.

They can be regulatory entities or only organizations providing guidelines. In addition they can be governmental bodies or local authorities providing permits or international shipping and Terminal organizations.

- AGA: American Gas Association
- ASTM: American Society for Testing and Materials
- ANSI: American National Standards Institute
- API: American Petroleum Institute
- BSI: British Standards Institute
- CEER: Council of European Energy Regulators
- CEN: European Committee for Standardization
- CNE: Spanish Energy Regulator
- CRE: French Energy Regulator
- DTI: Department for Trade & Industry (UK)
- EASEE: European Association for the Streamlining of Energy Exchange
- EFET: European Federation of Energy Traders
- EPA: Environmental Protection Agency
- ERGEG: European Regulators Group for Electricity and Gas
- FERC: Federal Energy Regulatory Commission
- GAMA: Gas Appliance Manufacturers Association
- GERG: European Gas Research Group
- GLE : Gas LNG Europe
- GIIGNL: Groupe International des Importateurs de Gaz Naturel Liquéfié
- GPA: Gas Processors Association
- IACS: International Association of Classification Societies
- IAPH: International Association of Ports and Harbours
- ICS: International Chamber of Shipping
- IGU: International Gas Union
- IMO: International Maritime Organization
- ISGOTT: International Safety Guide for Oil Tankers and Terminals
- ISO: International Organisation for Standardization
- MARCOGAZ: Technical Association of the European National Gas Industry
- MARPOL: International Convention for the Prevention of Pollution From Ships
- NGC: Natural Gas Council (USA)
- NRA: National Regulatory Authority
- OCIMF: Oil Company International Marine Forum
- PIANC: Permanent International Association of Navigation Congress
- SEDIGAS: Spanish Gas Association
- SIGTTO: Society of International Gas Tankers and Terminal Operators
- SIRE: Ship Inspection Report Programme
- SOLAS: International Convention for the Safety of Life at Sea
- USCG: United States Coast Guard

APPENDIX D.- LIST OF ABBREVIATIONS.-

The Appendix D includes the abbreviations related with the LNG quality, interchangeability and facilities compatibility.

- Bcm: billion cubic meters
- BOG: Boil Off Gas
- Btu: British thermal units
- C3MR: Propane & mixed refrigerant
- CAM: Capacity Allocation Mechanism
- CBP: Common Business Practices
- CCGT: Combined Cycle Gas Turbine
- CIF: Cost Insurance & Freight
- CMP: Congestion Management procedure
- CNG: Compressed Natural Gas
- CV: Calorific Value
- DES: Discharge Ex Ship
- DLE: Dry Low Emission
- DLN: Dry Low NOx
- ESD: Emergency Shut Down
- FHA: Fire Hazardous Analysis
- FCFS: First Come First Served
- FOB: Free On Board
- FSRU: Floating Storage and Regasification Unit
- GAD: Gas Appliance Directive
- GC: Gas Chromatograph
- GCV: Gross Calorific Value
- GGP: Guidelines for Good Practices
- GS(M)R: Gas Safety (Management) Regulations
- HAZOP: Hazard and Operability Studies
- HHV: Higher Heating Value
- ICF: Incomplete Combustion Factor
- LDC: Local Distribution Companies
- LDZ: Local Distribution Zone
- LEL: Lower Explosive Limit
- LHV: Lower Heating Value
- LNG: Liquefied Natural Gas
- LNGC: LNG Carrier
- LPG: Liquefied Petroleum Gas
- LSO: LNG System Operator
- LT: Long Term
- MJ: Mega Joules
- MLM: Mooring Load Monitoring
- MN: Methane Number
- MON: Motor Octane Number
- MW: Molecular Weight
- MWI: Modified Wobbe Index
- NCV: Net Calorific Value
- NGL: Natural Gas Liquids

- NGV: Natural Gas Vehicles
- NOx: Oxides of Nitrogen
- NTS: National Transmission System
- OEM: Original Equipment Manufacturer
- ON: Octane Number
- ORV: Open Rack Vaporizer
- OSP: Open Subscription Procedure
- OTC: Over-the counter
- ppm: Parts Per Million
- PERC: Power Emergency Release Couplings
- PPU: Portable Pilot Unit
- QCDC: Quick Connect Disconnect Coupling
- QRA: Quantitative Risk Analysis
- Rd: Relative Density
- RV: Regasification Vessel
- Scf: Standard Cubic Feet
- SCV: Submerged Combustion Vaporiser
- SDS: Specific Delivery Schedule
- SIL: Safety Integrity Level
- SG: Specific Gravity
- SI: Sooting Index
- SNG: Synthetic Natural Gas
- SOx: Oxides of Sulphur
- T: Temperature
- TIT: Turbine Inlet Temperature
- TPA: Third Party Access
- TSO: Transmission System Operator
- TWh: Terawatt hour
- UIOLI: Use it or lose it
- V: Volume
- VOC: Volatile Organic Compounds
- WI: Wobbe Index
- WN: Wobbe Number

APPENDIX E.- VESSEL APPROVAL PROCEDURES FOR THE LNG TERMINALS IN EUROPE , U.S.A. AND MEXICO-

Belgium.

Only LNG carriers that have successfully passed the Ship Approval Procedure may dock at the LNG terminal. The Ship Approval Procedure is attached to the terminalling contract and included in the “Terminalling Code – Appendix D”. The Procedure is made up of the following five stages:

Stage 1.

The main objective of this step is to gather all necessary information to determine the compatibility of the LNG carrier to the berth at the LNG terminal.

Information between the TO and the shipper shall be exchanged.

Stage 2.

In order to verify both the technical compatibility and the operational aspects, it is important to determine that the LNG ship and LNG Terminal know each party's Operating Procedures to work in a safe way.

This is completed by a careful scrutiny and review of all documents exchanged during stage 1.

Stage 3.

Fluxys LNG at its own discretion may or may not require an LNG carrier inspection (vetting) prior to the first berthing of the LNG carrier at the LNG terminal. This inspection is performed by an endorsed inspector of Fluxys LNG and performed according to Inspection Guidelines accepted by Fluxys LNG. Such inspection shall be without prejudice to the responsibility of the parties as specified in the relevant contracts. These Inspection Guidelines shall be consistent with the OCIMF inspection guidelines and SIGTTO's latest recommendations for crew safety standard and training on LNG ships.

Fluxys LNG's Inspection Guidelines focus on identifying risks occurring when the LNG carrier is within the unloading port (particularly at berth at the LNG terminal) and intend to reduce such risks, thereby assessing both procedures (operational and safety) and equipment.

A list of remarks and/or deficiencies, arising from such inspection, if any, shall be handed over to the master of the LNG carrier at an exit meeting held onboard the LNG carrier. Upon receipt of the implementation schedule of the corrective actions, Fluxys LNG shall decide whether the LNG carrier can be received at the LNG terminal.

Terminal user shall promptly notify or procure that Fluxys LNG is notified if any of its LNG carrier, pre-approved or approved according to this Ship Approval Procedure, has been rejected or has failed a ship safety inspection at another LNG terminal. Terminal user shall provide Fluxys LNG with all relevant technical details and information in that respect.

Stage 4.

Depending on the outcome of the previous steps, an LNG carrier shall either be approved or approved pending corrective action, for a single cargo unloading, which shall constitute the Unloading Test. Otherwise the LNG carrier shall be rejected.

Stage 5.

Before and during each call at the LNG terminal, terminal user shall provide timely assistance to Fluxys LNG, to clarify and solve any urgent issues that may arise before or during each call of one of the terminal user's LNG carrier. The terminal user's assistance can preferably be implemented by notifying Fluxys LNG for each call of the LNG carrier of who will be the terminal user's representative for that specific call. The terminal user shall provide Fluxys LNG all necessary and relevant details on how Fluxys LNG can reach terminal user's representative via telephone, mobile phone, e-mail, etc. This terminal user's representative shall be present before and during the LNG carrier's call, and be empowered to make all necessary "ad hoc" operational decisions on behalf of the terminal user, e.g. regarding any arising safety, security, technical, crew, environmental issues, LNG cargo off-spec issues, ship's chandler's issues, bunkering or waste handling issues.

Spain.

The procedure for tanker compatibility is established in the Detail Protocol 06 (PD-06). The development of this procedure is available at Enagas website.[4]

Stage 1.

TO and user of the LNG terminal or the ship-owner shall exchange information in order to study the compatibility between the LNG carrier and the terminal.

Stage 2.

After having analysed the information gathered in stage 1, TO will make a study to establish the technical compatibility of the LNG carrier.

Stage 3.

Before the first unloading at the LNG terminal, TO must certify that the LNG carrier is compatible with the LNG terminal.

Previously the LNG carrier must have passed a favourably safety inspection ("vetting") by a specialised company of worldwide recognized prestige, for what the LNG carrier will need to have the copy that certifies it.

Furthermore, additional safety inspections can be required by the TO, carried out by an accredited company, to verify the continuous fulfilment of the LNG carrier with the safety and operational rules of the LNG terminal. These inspections may take place during the stay time of the LNG carrier at the LNG terminal or at any other moment or place.

This inspection shall be carried out by an inspector designated by the TO according to the "TO's Inspection Guidelines".

A list of remarks and/or deficiencies, arising from such inspection, if any, shall be handed over to the master of the LNG carrier by the TO. Once the corrective action is made, the TO shall decide whether the LNG carrier can be received at the LNG terminal (pre-approved).

The ship owner shall promptly notify or procure if any of its LNG carriers, pre-approved or approved by another LNG terminal, has been rejected or has failed a ship safety inspection at another LNG terminal.

Depending on the outcome of the previous steps, the LNG carrier may be approved or rejected. The TO will issue a compatibility certificate for the first unloading at the LNG terminal.

Stage 4.

In order to check compatibility of the LNG carrier during the berth and to approve or reject its authorization, the LNG carrier shall undergo the Unloading Test that will be carried out during the first unloading.

Depending on the outcome of this test, the LNG carrier shall either be "approved" or "approved pending corrective action", which shall constitute another Unloading Test. Otherwise, the LNG carrier shall be rejected.

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[4] http://www.enagas.es/cs/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1146252726418&ssbinary=true

Stage 5.

Before and during each unloading at the LNG terminal, terminal user shall provide timely assistance to the TO, to clarify and solve any urgent issues that may arise before or during each LNG carrier unloading. The TU's assistance can preferably be implemented by notifying the TO of each LNG carrier unloading.

The TU shall provide the TO with all the necessary and relevant details on how the TO can reach TU's representative via telephone, mobile phone, e-mail, etc. This TU's representative shall be present before and during the LNG carrier's call, and be empowered to take all necessary operational decisions on behalf of the TU, e.g. regarding any problem related to safety, security, etc.

During the period of validity of the compatibility certificate, the TO will have to be informed of any modification made to the LNG carrier as far as technical subjects, safety or management are concerned. According to these modifications the LNG carrier will have to pass another approval procedure.

France.

Fos Tonkin and Montoir-de-Bretagne.

The ship approval procedure for Montoir-de-Bretagne and Fos Tonkin LNG terminals is described in article 14 at the document "LNG terminal access contract – Appendix 1: General Terms and conditions - Version of the 1st of January 2010" and further explained at the document "Ship access to Montoir de Bretagne or Fos Tonkin LNG Terminals - Approval Procedure -", Revision 4 dated 25.11.2009, available at Elengy's website.

The ship approval procedure for Fos Cavaou is detailed at the document "Ship access to Fos Cavaou LNG Terminal - Procedure for scheduling cargoes to terminal", available at STMFC 's website.

The ship approval procedure at Elengy's terminal is similar to the ship approval procedure at Fos Cavaou LNG terminal. Thus, find hereafter the common explanation.

Only vessels included in the list of vessels authorized to access the LNG terminal and vessels unloading cargo for the first time within the scope of the authorization procedure, are authorized to unload their cargo at the LNG terminal. Such vessels are only added to the said list once their authorization is obtained.

To be added to the list of vessels authorized to access the LNG terminal, a vessel must have successfully undergone all the stages in the authorization procedure. Throughout the validity period, the TO reserves the right to check the acceptability of any vessel, in particular through inspections and, if need be, make the maintaining of its authorization dependent on the implementing of corrective measures, refuse access to the LNG terminal or withdraw its authorization.

The shipper is solely liable for the condition, operating conditions and adapting of its equipment to the LNG terminal. It is solely liable for any damage consequences that may result from the aforementioned conditions not being complied with, as regards the TO and third parties.

The TO may at any time change the configuration of a berth safety system for effectiveness reasons. In that case, it shall inform and cooperate with the shipper.

The Authorization Procedure is defined in accordance with the GLE (Gas Liquefied Europe, European LNG Terminals' Operators Group) LNG tanker authorization procedure.

The Authorization Procedure is published on the Operator's website.

The steps required for LNG vessels to be accepted to deliver cargo lots at Montoir de Bretagne and Fos Tonkin LNG terminals are summarised as follows:

- information exchange and ship / shore interface study,
- confirmation meeting at LNG terminal,
- unloading test at LNG terminal,
- ship safety inspection,
- follow-up and subsequent updating of the list of regular ships according to re-inspections, events, modifications of ship operation profile.

Information exchange and ship / shore interface study.

This information exchange is mandatory to assess possibility to accommodate ship to berth and to enhance safety of operations while alongside and manoeuvring in port.

Documents made available by the terminal operator to the shipper:

- Terminal information to LNG carriers,
- Shore safety plan (including terminal emergency procedure and unloading procedure),
- Communication procedure between vessel and the terminal operator prior to ship's arrival.

Shipper shall make sure these documents are made available to the ship master before the call.

Documents to be submitted by the shipper / ship owner to the terminal operator:

Shipper / ship owner shall make sure that these documents are circulated well in advance in the process.

In case of a vessel unloading for the first time at the terminal:

- Vessel operational procedures:
    - Unloading procedure,
    - Mooring procedure.
- Vessel safety procedures:
    - Reflex sheets or equivalent for emergency situations alongside and in port,
    - Muster list for emergency situations,
    - Minimum manning in port to cope with emergency situations,
    - List of critical equipments.
- Ship questionnaire duly filled according to OCIMF (VPQ[5]),

[5] Vessel Particulars Questionnaire.

- Gas form of the charter party,
- Confirmation list from SIGTTO,
- Squat curves, pilot card and manoeuvring characteristics,
- Main cargo pumps characteristics and curves with delivery pressure at manifold,
- General arrangement drawing and ship / shore interface plan (according to SIGTTO paper n°5 “Communication necessary for matching ship to berth”). If ship / shore interface plan is not available, manifold drawing and fore and aft station drawing (mooring equipments) are required, as well as fire plan and cargo piping system,
- Custody transfer monitoring system description and certification, gas flow meter description and certification if gas burned during discharging if available,
- Cargo tanks tables and cargo lines volumes,
- Ship’s insurance documents (P&I Club membership),
- The “Pre Acceptance Questionnaire for scheduling non regular vessels” dully filled, documented[6], and certified by ship owner[7],
- International ship security certificate.

In case the vessel did not come since twelve months to the terminal:

- The “Pre Acceptance Questionnaire for scheduling non regular vessels” dully filled, documented, and certified by ship owner.

Ship / shore interface study and confirmation meeting.

The shipper, ship owner or shipyard carries out a ship / shore interface study based on previously exchanged information and submitted it to the terminal operator.

After the study phase, a ship / shore confirmation meeting shall be held at the terminal with ship owner and shipper to clarify interface issues. Ship agent, port authority and pilots may participate as well to this confirmation meeting.

This meeting aims to reconfirm all the parameters of the call and to establish the Ship / Shore Safety Plan which gathers:

- technical data, including a mooring pattern agreed with port authorities and
- operational, safety and communication procedures.

All conclusions are indicated in minutes of meeting signed by each party.

Unloading test scheduling and Ship / Shore Safety Plan.

The Ship / Shore Safety Plan and a satisfactory review of the “Pre Acceptance Questionnaire for scheduling non regular vessels” are required for scheduling an unloading test.

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[6] With in particular VIQ (Vessel Inspection Questionnaire – SIRE Report).

[7] This document certified by ship owner, including its appendices, shall be reviewed before scheduling.

An updated version of the Ship / Shore Safety Plan duly signed by both parties is necessary to be able to fill in the IMO checklist.

Unloading test is carried out at shipper's risks for all interface issues.

Ship safety inspection.

As part of the approval procedure, the terminal operator will inspect the vessel during an unloading test, prior to grant authorisation for scheduling cargoes on a regular basis. This inspection will be made according to OCIMF / SIRE questionnaire and subsequent ELENGY report may be uploaded in the SIRE database.

The ship owner must address the deficiencies and observations with appropriate comments and corrective actions.

List of ships registered with terminal.

If the vessel has proceeded to a satisfactory unloading test at the terminal, and ship safety inspection has been successful, the terminal operator may add the vessel's name to the list of regular ships if requested.

Shipper can deliver cargo lots to the terminal using vessels on this list without specific clearance, unless an event or modification occurs.

However, if last visit was made more than twelve months before or if an event occurs, ship owner needs to submit a new "Pre-Acceptance Questionnaire for scheduling non regular vessels" dully filled, documented and certified as per step in case the vessel did not come since twelve months to the terminal for specific clearance.

Re-inspections.

A new inspection may be planned after three years or anytime needed to reconfirm the regular status of the vessel.

Italy.

Panigaglia.

According to the Regasification Code "Codice di Rigassificazione" chapter 6, the main steps the Ship Approval Procedure (SAP) shall follow are detailed above and all necessary information is available on the GNL Italia website (www.gnlitalia.it).

1. *Ship Approval Procedure.*

If a shipper desires to obtain from the TO the authorization to unload a LNG carrier that it is not yet included in the *"Elenco Navi metaniere"* (list of vessels authorized to access the LNG, available at GNL Italia website), all necessary information to carry out the technical appraisal and shall be submitted to the TO. In case of positive outcome of the procedure, TO shall arrange to carry out an unloading test. The conclusions will be communicated via fax from GNL Italia within and not beyond sixty days from the authorization date.

2. *Unloading Test.*

The unloading test should be passed by any LNG carrier prior to its first berthing in the LNG Panigaglia terminal, and by all the LNG carriers that have made any modifications susceptible to modify the vessel compatibility after the last unloading made in the terminal.

A ship that must carry out an unloading test should be in advance at the La Spezia port, before beginning the mooring procedures to the LNG terminal, so that the TO can proceed with the revision of the documentation of LNG carrier.

After having carried out the aforesaid control of documentation, if the LNG carrier cannot make the unloading test the criteria established in the Regasification Code at chapter 10, point 1.1 shall be applied, except the penalties due to unloading failure fulfilment.

If during the berthing, and before the finish of the unloading, some problems that can affect the workers, unloading operations or the structure security arise, the LNG carrier should leave immediately.

Within ten days form the unloading test, TO shall communicate via fax the result:

- Positive: the LNG carrier will be included in the list of vessels authorized to access the LNG, or

- Negative: the possible solutions the shipper should adopt to carry out another unloading test are indicated.

3. *Authorization and license.*

All the LNG carriers that moors in the LNG terminal, in accordance with the International Ship and Port Facility Security Code, shall own the ISSC (International Ship Security Certificate) issued by the competent authority.

LNG carriers authorized to moor in the terminal must present, when TO requested, the Ship Inspection Report issued by an accredit inspector within twelve months previous the unloading, in order to verify that the contained information meets the minimum security requirements.

4. *Revoke of the mooring authorization.*

TO can revoke the mooring authorization whenever the LNG carrier does not meet the security requirements or has modify the vessel so that the compatibility between the LNG terminal and the carrier is no more guarantee.

Moreover, TO can also revoke the mooring authorization if it is necessary to realize any modifications to the reception structures so the LNG carrier is no more compatible due to legislative provisions.

5. *Pre-requirement of the cargo system ("Calibration table").*

The "Tables of Calibration" of the LNG carrier cargo and the measure system must be accepted by the custom authorities.

If the "Tables of Calibration" and the measure system of the cargo have not been accepted or have been revoked, the LNG carrier mooring authorization is automatically revoked by TO.

Adriatic LNG.

The Ship Approval Procedure at Adriatic LNG terminal is detailed at the document "LNG Carrier Vetting Procedure Terminale GNL Adriatico S.r.l" available at Adriatic LNG website. The procedure described below is taken from the version dated on 15 June 2009, revision 1.0, of the referred document.

Each LNG Carrier proposed for unloading at the ALNG terminal undergoes a quality assurance (vessel vetting) process. This comprises of an assessment of the LNG Carrier plus an assessment of the carr ier's operator. The process steps are detailed below:

1. *Step 1 – Preparatory Information.*

The main objective of this step is to gather all necessary material (for example, information, data, drawings) to conduct the ship/shore interface study (compatibility study).

When ALNG receives a request to unload LNG at the Terminal from a LNG Carrier not listed on the ALNG Acceptable Vessel/Terminal Compatibility List, ALNG sends the documents described in the following table to the requestor.

- Society of International Gas Terminal Operators (SIGTTO) Ship/Shore Questionnaire for Compatibility of Liquefied Gas Ships with Loading/Unloading Jetties. This document provides details on mooring and manifold arrangements, loading arm and gangway data, and other Terminal aspects required to conduct a Ship/Shore compatibility study.

- Terminal Regulations and Information Manual. This document includes information and procedures (shore part) pertaining to safety and operational requirements at the Terminal that is necessary to, for example but not limited to, fill out the International Maritime Organization (IMO) checklist at the Unloading Port.

- Cargo Handling Manual This document describes the procedures for cargo handling.

Note: Users must retrieve port information related to marine aspects for access and berthing at the Terminal directly from the Port Authority in Chioggia (Italy).

Listed below is the information that the user must send to ALNG before the Ship/Shore Interface Study is performed as part of the approval procedure application associated with user's application:

- Ship/Shore Interface Plan This document, if available (for example, new ships contain this item), is provided as per the *SIGTTO Paper #5*, "Communication Necessary for Matching Ship to Berth." If it is not available, the user submits the following documents:

  - General Arrangement

  - Manifold layout

  - Mooring arrangements

  - Parallel body Flat body line (parallel mid body) of the LNG Carrier drawing

  - Details of the landing area for the shore gangway

- SIGTTO Ship/Shore Questionnaire. The user must submit a completed SIGTTO Ship/Shore Questionnaire for Compatibility of Liquefied Gas Ships with Loading/Unloading Jetties.

- Ship Questionnaire. The questionnaire is completed according to the SIGTTO form "Ship Information questionnaire for Gas Carrier" 1998, 2nd edition. Alternatively latest copy of OCIMF Vessel Particular Questionnaire (VPQ) may be provided.

- Certified Custody Transfer Measurement System description. Description of the LNG Carrier Custody transfer system and certificate of accuracy.

- Tank Gauge Tables User must provide approved copies.

- Ship Operational and Safety Procedures while Alongside. Procedures pertaining to the International Safety Management (ISM) code addresses:

  - Mooring

- Cargo transfer
- Fire fighting

Complete the information for the ship part necessary to complete the IMO checklist.

- List of Survey Status. This is issued by the Classification Society for an LNG Carrier. Inspection Reports The user must provide the latest copies of these inspection reports:
    - Classification Society
    - Port State Control (Paris MoU).
- Certificate of Entry. The Certificate of Entry must be with a registered Protection & Indemnity (P&I) Club.
- Departure Plan (Membrane Vessels). A safe condition departure plan in event LNG Carrier is required to depart the Terminal prior to cargo completion[8].

2. *Step 2 - Ship/Shore Interface Study.*

In order to verify both the technical compatibility and the operational aspects, it is important to determine that both the LNG Carrier and ALNG acknowledge each other's operating procedures. This is possible after reviewing of all documents exchanged under the step 1.

After examining the information received in the previous step, ALNG performs an interface study to establish technical acceptability of the LNG carrier at the terminal. The interface study conclusions are provided to the user or the user's designated representative.

In particular, ALNG checks the following minimum criteria:

- Physical and technical compatibility with the terminal dimensions
- Nautical and safety aspects
- Compliance with terminal communication link and ESD system
- Certification of gauge tables[9] covering all cargo tanks in the LNG carrier and Custody Transfer Measurement System[10].

The TO prepares a proposed mooring arrangement and mooring calculation.

Upon receiving the mooring arrangement, ALNG issues, for operational purposes only, a drawing of the approved mooring arrangement for the specific LNG Carrier.

Following the completion of the document analysis, a preliminary ship/shore Interface meeting may be called. This is attended by representatives of the LNG carrier owner, charterer and terminal, in order to examine berth, ship-shore Interfaces, safety and communications items in relation to the LNG carrier and the terminal.

The minimum agenda of the Preliminary Meeting is:

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8 Reference: Terminal Regulations and Information Booklet.

9 Certification of gauge tables is approved by the relevant authorities and by ALNG before the first unloading. This certification must be carried out by a qualified organization (for example, the Japanese NKKK).

10 Custody Transfer Measurement system specifications and methods must comply with the latest recommendations of the GIIGNL LNG Custody Transfer Handbook.

- Review of Interface Study conclusions.

- Review all parameters of the Ship Shore Safety Plan completion. This includes the documents dealing with safety and security, such as fire fighting, cargo transfer, and mooring. All this is checked and, if necessary, adapted.

- Cargo tank custody transfer management

- Agent assignment and tasks.

Any LNG Carrier that successfully completes the two previous steps is considered a "compatibility pre-approved" LNG Carrier for its initial voyage to the Unloading Port, subject to a successful vetting analysis

3. Step 3 - Ship Safety Inspections.

Introduction ALNG may require, at any time and at its own discretion, an LNG carrier inspection prior to the first berthing. This inspection is performed by an ALNG endorsed inspector and is done according to the inspection guidelines accepted by ALNG.

These inspection guidelines are consistent with the Oil Companies International Marine Forum (OCIMF) inspection guidelines and SIGTTO's latest recommendations for crew safety standard and training on LNG carriers.

The following table describes the ship safety inspection process.

Table 18: Adriatic LNG safety inspection process.

Step	Who does it	Action
1.	Inspector	The Inspector hands over a list of remarks and/or deficiencies, arising from such inspection, if any, to the Master of the LNG Carrier at an exit meeting held onboard the LNG Carrier.
2.	ALNG	Sends the list of remarks and/or deficiencies to the user.
3.	User	The user forwards them to the LNG Carrier Operator and/or the Charterer.
4.	ALNG	Upon receipt and review of the implementations of corrective actions, ALNG decides whether to receive the LNG Carrier at the terminal.
5.	User	The user promptly notifies or procures that ALNG is notified if any of its LNG Carriers, pre-approved or approved according to this vetting procedure, have been rejected or have failed a ship safety inspection at another LNG terminal.
6.	User	The user provides ALNG with all relevant technical details and information in that respect.

Source: *LNG Carrier Vetting Procedures Terminale GNL Adriatico S.r.L.. 15th June 2009, revision 1.0.*

4. Step 4 - Unloading Test and Ship Compatibility Approval.

Depending on the outcome of the previous steps, an LNG Carrier is deemed either technically approved or approved pending corrective action, for a single cargo unloading, subject to successful voyage screening which constitutes the unloading test. Otherwise, the LNG carrier is rejected.

If the LNG carrier is approved pursuant to steps 1, 2 and 3, a single cargo unloading is permitted and conducted.

During unloading, the LNG carrier undergoes the unloading test. This determines whether the LNG carrier crew understands the terminal interface and establishes ship/shore compatibility.

Before unloading the LNG cargo, a pre-discharge meeting is held on-board. During this meeting, the following occurs:

- A review of the terminal regulations and information manual is completed in order to have a understanding of the terminal requirements, including but not limited to:
  - Mooring, piloting and towing; and
  - Fire fighting; and
  - Cargo transfer; and
  - Cargo tank management; and
  - Unloading communication; and
  - Operational procedures
- A terminal regulations and information manual is signed by the LNG carrier's master and ALNGs representative duly authorized to fulfil this function.
- The LNG carrier's master and ALNG's representative duly authorized to fulfil this function checks and signs the "IMO Ship/Shore safety checklist and guidelines"

Upon completion of these actions, the LNG cargo delivery can take place.

Depending on the findings of the unloading test, ALNG determines if an LNG carrier is technically compatible and suitable for unloading at the terminal. ALNG advises if:

- The LNG carrier is approved for a 36 months approval period, without being subjected to further unloading tests.
- The LNG carrier is accepted in future for another unloading test pending implementation of corrective action to the LNG carrier provided by ALNG.
- The LNG carrier is not accepted in future at the ALNG terminal (without completion of the full approval procedure).

Any approval or conditions is based upon the LNG carrier's state at the moment of the approval or condition definition. In case of change in the commercial, technical capabilities or specification, the LNG carrier shall, as soon as practical, notify the change to ALNG. Based on the change assessment it is ALNG option to review its approval or condition.

5. Step 5 - LNG Carrier Compatibility Approval Follow-Up.

Before and during each call at the terminal, the user must provide timely assistance to ALNG, to clarify and solve any urgent issues that arise before or during each call of one of user's LNG carriers.

The user must keep ALNG informed of any modifications to the LNG carrier, or any changes in its condition or maintenance status related to technical, safety and/or managerial issues. Based on these modifications, ALNG assesses if the LNG carrier requires a new approval.

ALNG may require additional safety and technical inspections, in order to check the continued compliance of the LNG carrier with safety and operational requirements of the terminal. These inspections, at ALNG option, may occur during the berthing time or at any other time and place.

Portugal.

All ships need to be approved by the Terminal prior their arrival to Terminal facilities. The ship vetting at Sines LNG Terminal is performed according to the GTE (Gas Transmission Europe) LNG Ship Approval Procedure.

UK.

Isle of Grain.

The ship vetting requirements can be obtained once a confidential agreement with Grain LNG has been fulfilled.

Isle of Grain does not offer any public information on ship vetting at the LNG terminal. According to the NERA Economic Consulting study on "Third Party Access to LNG terminals", ships are vetted by a specialist authority as well as by Grain. Procedure could take as little as 4 or 5 days in an urgent case.

South Hook LNG.

The document "Guidance Document for Prospective Additional Users" establishes that a user may only use an LNG tanker which is approved by the TO. Vetting and approval procedures are covered in the SHM, this document is not public available.

Additional users are also encouraged to submit a list of the LNG tankers they propose to use for deliveries of LNG to the terminal and to make this submission well ahead of the arrival window for the relevant tanker. The TO will make a charge for the vetting procedure and details of this and other terms and conditions applicable to the vetting of LNG tankers are set out in the relevant section in the SHM.

Dragon LNG.

No public information is provided about ship vetting at Dragon LNG terminal.

Greece.

The Ship Approval Procedure to unload LNG vessels at Revithoussa LNG terminal is described at the document "LNG Vessel Approval Procedure English version, Rev.01", dated on 28/06/2011, which is available at Desfa website.[11]

The object of LNG Vessel Approval Procedure is to describe the steps which should be followed for (1) taking place the exchange between DESFA and the LNG Vessel Representative of all required certificates, documentation and information concerning any technical and safety specifications for the berthing, mooring, connection, LNG discharging, disconnection and departure of the LNG Vessels from the LNG Terminal facilities, the type and the content of the legal certificates and inspections of the LNG Vessel and (2) checking the technical and operational compatibility of the vessel and any other action that will be held essential during the compatibility study.

The above mentioned steps of LNG Vessel Approval Procedure are detailed below:

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[11] http://www.desfa.gr/files/YFA/ENGLISH%20VERSION%20DOC/LNG%20VESSEL%20APPROVAL%20PROCEDURE%20_DESFA%20LNG%20TERMINAL%202011_.pdf

Preparatory information exchange concerning valid certificates, technical and safety specifications of LNG vessel

In this paragraph are described all the necessary information (manuals, drawings, certificates, etc.) exchanged between LNG vessel representative and DESFA concerning any technical and safety specifications for berthing, mooring, connection, LNG discharging, disconnection and departure of the LNG vessels from the LNG terminal , as well as the type and the content of all vessel certificates and inspections for the evaluation of the technical and operational compatibility procedure of the LNG vessel with the LNG terminal.

Information provided by DESFA to LNG Vessel Representative

LNG user, who intend to deliver LNG to the LNG terminal, using a LNG vessel, which is not included in DESFA's list of compatible vessels, should ask from DESFA for the following documents:

- The "Marine Procedures Manual".
- The "Jetty and Terminal Information" booklet, which are published in DESFA website (www.desfa.gr) according to the Network Code for Regulation of the NNGS.

The LNG user or the LNG vessel representative should also gather information related to the approaching procedures to DESFA's LNG terminal, the anchorage area and pilot station, directly from the port authority or the Agency that will be used for the specific LNG vessel.

Information provided by the LNG User to DESFA

The LNG user has to send to DESFA the following information regarding the specific LNG vessel, prior to the preliminary meeting between the LNG vessel representative and DESFA, as anticipated hereinafter:

- Ship Inspection Report (SIRE) valid within 12 months, prior to its arrival and during alongside at DESFA LNG terminal
- Vessel Certificate of Fitness for the carriage of liquefied gasses in bulk
- Class Status Report issued by a recognised Classification Society,
- LNG Vessel's insurance documents, Protection and Indemnity (P&I) Club membership,
- An updated Vessel Particular's Questionnaire,
- Description and certified tables of the Custody Transfer Monitoring System,
- LNG Vessel Operational and Safety Procedures. These procedures relating to mooring, LNG cargo transfer and fire fighting, pertain to the (ISM) code and constitute the SSSP for the LNG vessel,
- The vessel's specifications for approaching, berthing, mooring procedures, number and horse power of tugs and mooring boats.
- Emergency Shut Down system, communication information (type, pin configuration and connection point distance from vapour line),
- Drawing of LNG vessel flat body, General Arrangement
- Mooring study for berthing to the LNG terminal jetty. All mooring plans will be developed using a certified software

- Drawings or photos port / starboard side for the placement of the LNG terminal gangway (the gangway tower is located on the LNG terminal jetty, 36m west, seaward of vapour line).

- Main cargo pumps characteristics and curves of the LNG vessel with delivered pressure at manifold.

Ship-shore interface study

DESFA and the LNG vessel representative will have to examine all documents referred above, so that both LNG vessel and LNG terminal to be aware of the interface in order to verify technical, operational and safety compatibility of the LNG vessel and the LNG terminal.

Document analysis

DESFA, after having examined carefully all exchanged information, shall conclude for the technical compatibility of the LNG vessel at DESFA LNG terminal.

Conclusions of this interface study are then transmitted to LNG vessel representative.

The following minimum criteria are checked as part of the interface study:

- LNG vessel's physical and technical compatibility with DESFA LNG terminal.

- LNG vessels chartered for unloading to DESFA LNG terminal must comply with IMO Gas Carrier code. According to the International Gas Carrier code or other international regulations all deviations or omissions from the code applicable to the nominated vessel are listed.

- LNG ship mooring equipment shall comply with Mooring Equipment Guidelines, OCIMF, 2008.

- LNG ship manifold construction shall anticipate with the "Recommendations for Manifolds for Refrigerated Liquefied Natural Gas Carriers (LNG), SIGTTO, 1994.

- LNG vessel navigational and safety equipment shall comply with all international and national regulations.

- LNG vessel ESD and communication system shall comply with the corresponding DESFA LNG terminal ESD systems.

- Certification of gauge tables shall be issued by a qualified authority (for instance Japanese NKKK) in order to be approved by DESFA prior to the first unloading.

- Custody transfer measurement system specifications and methods shall comply with the GIIGNL LNG custody transfer handbook recommendations.

Mooring plan

LNG vessel mooring calculations and mooring plan should be prepared by the LNG vessel representative and should be notified to DESFA. DESFA shall examine and approve or reject the mooring plan. The final mooring plan must be agreed by DESFA and the LNG vessel representative and it should be known to the captain and the Agent of the LNG vessel prior to the vessel's arrival to the LNG terminal.

Preliminary Ship/Shore Interface meeting

After completion of the document analysis DESFA organizes at the LNG terminal a preliminary meeting with the LNG vessel representatives in order to discuss and review all the above issues and to jointly decide upon them.

LNG user representative and authorized Agent shall attend to this meeting.

The minimum agenda of the preliminary meeting is as follows:

- Ship / Shore Interface study conclusions.
- Deviations or omissions of the LNG vessel, if any, compared to the International Gas Carrier Code or other international regulations, which are found to exist by the inspections have been conducted and the LNG vessel certificates. DESFA has the ability to demand further inspections by an authorized third party.
- Review of all parameters of the completion of the Ship Shore Safety Plan. The documents dealing with firefighting, LNG cargo transfer and mooring are checked, completed accordingly and co-signed.
- The LNG vessel representative ensures the appropriate number and power of needed tugs for berthing, standby and unberthing according to the relevant port authority regulations.
- LNG cargo tank custody transfer management.
- Shipper agent assignment and tasks.

Any LNG vessel that shall have successfully completed abovementioned steps shall be considered as a pre-approved LNG vessel for her unloading test.

LNG Vessel Inspections

DESFA reserves the right to ask for additional inspection of the LNG vessel prior to the test unloading. This inspection is carried out by an authorized inspector by DESFA, according to international organizations' standards.

An essential prerequisite, in order for a LNG vessel to be considered acceptable for the LNG terminal facilities, is the accomplishment of a satisfactory result for the aforementioned inspection.

A complete list with all comments and / or omissions, if any, will be handed to the LNG vessel representative. The list with the above mentioned comments / omissions is notified to the LNG user, who has the ability to forward it to the ship owner and / or the charterer in order to carry out all the necessary corrective actions, according to the suggestions of DESFA's inspector. By receiving the implementation plan of the corrective actions, DESFA shall decide whether the vessel can be accepted to LNG terminal.

Vessel acceptance by DESFA LNG following such inspection does not release the LNG vessel representative and the LNG user by their responsibility and obligations that arise from international rules and regulations, the Network Code and the LNG Agreement and for any and all consequences of any such noncompliance.

Shipper shall promptly notify DESFA if any of its pre-approved or approved LNG vessels has been rejected or has failed a ship safety inspection at another LNG terminal. The LNG user shall provide DESFA with all relevant details and information in that request.

Unloading Test and Vessel Approval

Depending on the outcome of the previous steps, a vessel may either be approved for an unloading test, or rejected.

Unloading Test

Any LNG vessel that has successfully completed the abovementioned steps will have the ability to undergo an unloading test in order to verify absolute compatibility with DESFA LNG terminal.

After the LNG vessel has securely moored and before initiating the LNG cargo unloading, a joint meeting is held on board among DESFA, the LNG vessel representative and the LNG vessel's representative, during which:

- A review and validation of the SSSP is completed in order to have a duly implemented document, concerning mooring, firefighting, LNG cargo transfer, cargo tank management, unloading communication and operational procedures.
- Vessel representative and LNG terminal representative check and sign the Ship/Shore Safety Check list according to IMO.
- Unloading test takes place according to standard operational procedures of the LNG terminal and the LNG vessel.

Conclusions of the Vessel Approval Procedure

DESFA, after having evaluated all aspects of the unloading test, decides whether the LNG vessel:

- Will not be accepted for future unloading to the LNG terminal, accompanied by a written justification to the LNG vessel representative and the LNG user,
- Will be accepted in the future for another unloading test after having completed any corrective modifications on the vessel, exhaustively notified by DESFA,
- Will be accepted in the future without being subjected to further tests for a three years approval period and included in DESFA's list of compatible vessels.

Vessel Approval Follow Up

Before and during each call at the LNG terminal, the LNG vessel representative shall provide instant assistance to DESFA LNG terminal, to clarify and/or solve any urgent issues that may arise before or during each unloading. The LNG vessel representative must be announced to DESFA prior to each arrival either by the LNG user or the Agent; otherwise the captain of the vessel will be perceived by DESFA as the LNG vessel representative.

The LNG user or the Agent shall provide to DESFA all necessary and relevant information on how DESFA can reach the LNG vessel representative via telephone, mobile phone, e-mail, etc.LNG vessel representative shall be on continuous standby before and during the vessel's unloading and he is empowered to make all necessary "ad-hoc" operational decisions on behalf of the LNG user, e.g. regarding any arising safety or security issues, LNG cargo off spec issues, vessel's chandler's issues, bunkering or waste handling issues.

During the approval period, DESFA shall be kept informed of any modifications performed to the LNG vessel concerning any technical, safety and managerial issues. Based on these modifications DESFA shall verify whether the vessel needs a new approval.

An additional safety inspection may be required by DESFA in order to check the continuous compliance of the ship with safety and operational requirements of the LNG terminal.

These inspections may occur during the berthing time at DESFA LNG terminal or at any other time and place.

The Netherlands.

The SAP is available at Gate website[12] as well as the the list of approved vessels is available at Gate website.[13]

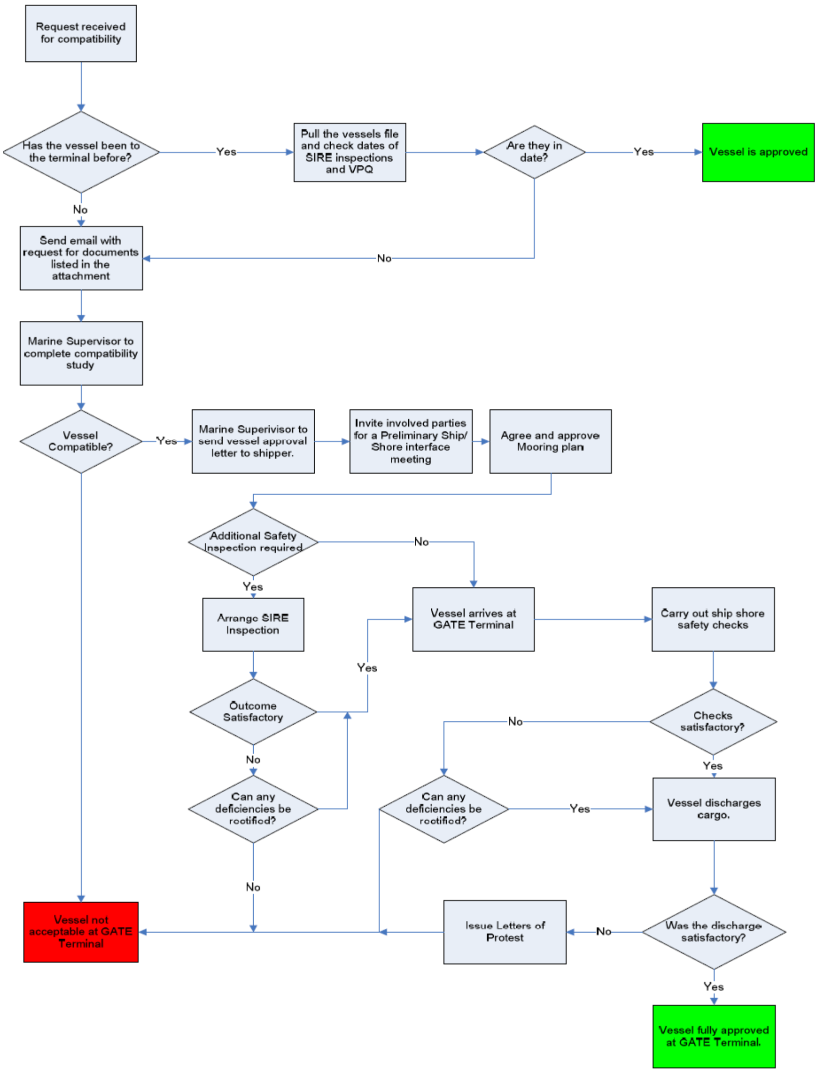
The vessel approval and compatibility procedures of Gate terminal is in line with the GLE LNG Ship approval Procedure issued on 29th June 2004. The objective of the ship approval procedure is to check the compatibility of the ship requesting access in terms of mechanical design, communication and safety; it aims at insuring the safety of the unloading operations pro-actively and sustaining the excellent safety record of the LNG industry.

The approval procedure mostly rely on the existing international rules and regulations, implemented either by the Flag State of the vessel or by the Port State of the Terminal, and on professional societies recommendations such as ISGOTT, OCIMF, SIGTTO or GIIGNL.

12 http://www.gate.nl/fileadmin/user_upload/Documenten/PDF/Vessel_Approval_and_Compatibility.pdf

13 http://www.gate.nl/en/services-gate/slots.html

Figure 1: Gate Terminal compatibility flow chart.



Source: *Gate terminal B.V. LNG RECEIVING TERMINAL, MAASVLAKTE ROTTERDAM Vessel Approval and Compatibility.*

Step 1 – Preparatory information exchange

The main objective of this first step is to gather all necessary material (information, data, drawings…) to study the good matching of ships to berth.

One of the most important steps of this standard is the information exchange between:

- Gate terminal to the Shipper;
- Shipper to Gate terminal.

The documents listed hereunder form the exhaustive list of minimum required documents to be submitted by each party before final approval of the ship; these documents may be circulated either in one batch at the beginning of the procedure or progressively along the progress of the ship approval procedure.

Step 1.1 Information to be submitted by GATE LNG terminal to the Shipper

After receiving the request from the Shipper who wishes to import LNG using a ship not listed in the Gate Vessel Register, Gate terminal shall send to the Shipper the following documents:

- Master Marine Service Manual
- Gate Populated Compatibility Spreadsheet

Remark: Shipper should receive the Port Information Guide and the Port Bye laws related to marine aspects for port access and berthing directly from Port Authority.

Step 1.2 Information to be submitted by Shipper to the GATE LNG terminal

Listed below is the information that the Shipper shall send before the preliminary meeting to Gate terminal during the approval procedure application:

- Completely filled in Gate Populated Compatibility Spreadsheet;
- LNG Carrier General Arrangement;
- A OCIMF Vessel Particular Questionnaire less than one year old;
- An Optimoor mooring study or an accepted industry equivalent;
- A Gas Form C;
- An OCIMF TMSA report less than one year old;
- Pump capacity curves and maximum discharge rate;
- Survey Class Status Report less than one (1) month old;
- An OCIMF SIRE Inspection Report available on the OCIMF SIRE website. For LNG Tankers less than twenty (20) years old, the SIRE report shall be less than one (1) year old, and for LNG Tankers more than twenty (20) years old, the SIRE report shall be less than six (6) months old);
- LNG Tanker's certificate of entry with its P&I Club (see Annex 2);
- LNG Tanker's Cargo Tank Gauging Tables;
- LNG Tanker's Custody Transfer Calibration Certification;
- Plan diagram showing all positions and SWL's of mooring bits and closed chocks;
- Copy of certificate showing rated capacity of escort towing bits (The LNGC should be fitted with a escort mooring bit or other suitable set of bits and associated closed chock lead of at least 200t SWL as per OCIMF guidelines);
- Detailed manifold drawing showing dimensions and design of spool pieces and strainer arrangements;
- A photo of the gangway landing area on the vessels Port side, clearly showing the foot print for the gangway pedestal (1.5 meters by 1.5 meter); which should be at 14 and at 22 meters (plus/minus 10mtr) astern of the ships vapour manifold;

- Ship Operational and safety Procedures while alongside. These procedures concerning mooring, cargo transfer and fire fighting pertain to ISM code.

- If the vessel is more than 20 years old a valid CAP cert less than 2 years old.

Step 2 – Ship / Shore Interface study

In order to verify not only the technical compatibility, but also the operational aspects it is important to make sure that ship and terminal know each other's Ship / Shore Safety Working Procedures to work on the safety way. This is possible by careful scrutiny of all documents exchanged during step 1.

It is the duty of the Marine Supervisor to ensure that sufficient information has been gathered and exchanged in order to perform this study.

The Marine Supervisor will either perform or review the study depending on the role being played and reach a judgment of Compatible, Compatible with recommended mitigation or Incompatible.

The process used is a comparative one. The ship and terminal specifications are compared side by side to determine if they are mutually compatible.

After the document analysis a Vessel Approval Letter will be sent to the Shipper giving the preliminary results of the document study (see Annex 3)

Step 2.1 Document analysis

After having closely examined the aforementioned information, Gate terminal performs an interface study to establish a technical ship acceptability. Conclusions of this interface study are then transmitted to the Shipper. In particular the following minimum criteria are checked:

- Physical and technical compliance with terminal dimension;

- Nautical and safety aspects;

- Compliance with Terminal Communication and ESD system;

- Certification of gauge tables[14] and Custody Transfer Measurement[15].

Step 2.2 Preliminary Ship / Shore Interface Meeting

Pursuing the document analysis a Preliminary Ship / Shore Interface Meeting, attended by at least representatives of the Ship Owner, Shipper and Gate terminal is called to examine berth, Ship-Shore interfaces, safety and communication items. (Pilots, Line handlers Tug companies and Local Ship Agent will also be invited)

The agenda of the meeting will be as follows:

1. General Measures of Nautical Management (Nautical Admission Policy)

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[14] Certification of gauge tables shall be approved by national authorities (i.e. custom authority) and by Gate terminal before the first unloading. This certification shall be carried out by a qualified organism (for instance the Japanese NKKK).

[15] Custody Transfer Measurement system specifications and methods shall comply with the GIIGNL LNG custody transfer handbook recommendations.

2. Discussion about the mooring arrangement (Optimoor Calculation Note)
3. Discussion of the Towing arrangement for the tugboats (Towing procedure)
4. Overview of the Ship Shore Interface Procedure
5. Discussion about the technical Interfaces
    a. E-link: instrumentation link
    b. Manifold configuration: loading arms, connection, flange surface, joints …
    c. Process: cool down procedure, unloading procedure
    d. Custody Transfer Method
    e. Bunkers and other supplies
    f. Miscellaneous

Step 2.3 Mooring Plan

During above mentioned meeting the mooring plan will be agreed and approved by all parties involved. A copy of this mooring plan will be handed over to the pilots and the line handlers during this meeting or, if they are not present, they will be forwarded to them before the vessel arrives.

Step 3 – Ship Safety Inspections

Gate terminal reserves the right for a ship inspection (SIRE inspection) prior to the first berthing. This inspection is performed by a Terminal endorsed inspector.

Ship acceptance by Gate terminal following such inspection shall be without prejudice to the responsibility of the parties as specified in the relevant contracts for the ship to comply with all applicable rules and regulations and/or for any and all consequences of any such non compliance.

A list of remarks and/or deficiencies, if any, is handed over to the ship master at an exit meeting held onboard. The list of above remarks and/or deficiencies is sent to the Shipper who shall forward them to the ship owner and/or the Charterer. Upon receipt and review of the implementation schedule of the corrective actions, Gate terminal shall decide whether the ship can be received at the terminal.

Shipper shall promptly notify Gate Terminal or procure that Gate terminal is notified if any of its LNG ships, pre-approved or approved according this Ship Approval Procedure, has been rejected or has failed a ship safety inspection at another LNG terminal.

Shipper shall provide Gate terminal with all relevant technical details and information in that respect.

Step 4 – Unloading Test and Ship Approval

Depending on the outcome of the previous steps, a ship may either be approved for an Unloading test, or rejected. In the event that a Customer’s LNGC is rejected, the Customer shall be entitled, at its own cost and risk, to request that Customer’s LNGC undergo a further inspection in accordance with applicable agreements.

Step 4.1 Unloading Test

To verify a good matching of the ship to berth and confirm or not the authorization, the ship shall undergo the Unloading test.

The unloading test primary objective is to assess the actual understanding of the Terminal interface by the crew of the Customer's LNGC.

Immediately before starting the LNG cargo unloading, a pre-discharge meeting shall be held onboard.

During this meeting

- a review and validation of the SSSP shall be completed in order to have a duly implemented document, including mooring, fire fighting, cargo transfer, cargo tank management, unloading communication and operational procedures'
- a finalised version of the SSSP shall be signed by the Master and the Terminal; and
- the Master and Gate terminal shall check the Ship and Shore Safety Interface according to ISGOTT Ship Shore Safety Check List (SSSCL).

Step 4.2 Conclusion of the ship approval procedure

Depending on the findings of the Unloading Test, the terminal shall decide if:

- The ship will not be accepted in future at the Terminal;
- The ship will be accepted in future for another Unloading test pending to implementation of corrective actions listed by the Terminal
- The ship will be accepted in future without being subjected to further tests for a three year approval period

Step 5 – Ship approval follow up

Before and during each call at the Terminal, Shipper shall provide instant assistance to the Terminal, to clarify and/or solve any urgent issues that may arise before or during each call of one of the Shipper's LNGC.

This Shipper's instant assistance can preferably be implemented by notifying the Terminal for each call of who will be the Shipper's representative for that specific call. The Shipper shall provide the Terminal all necessary and relevant details on how the Terminal can reach Shipper's representative via telephone, mobile phone, e-mail etc.

This Shipper's representative shall be on continuous standby before and during the ship's call, and be empowered to make all necessary "ad hoc" operational decisions on behalf of the Shipper, e.g. regarding arising safety or security issues, LNG cargo off-spec issues, ship's chandler's issues, bunkering or waste handling issues, etc.

During the approval period, Gate terminal shall be kept informed of any modifications brought to the ship related to technical, safety and managerial issues.

Based on these modifications, Gate terminal shall verify whether the ship needs a new approval.

USA

Cove Point

Unloading LNG at the Cove Point terminal shall be carried out in strict conformity with all operating and safety rules and procedures of Operator, as may be amended from time to time, and with all federal, State and local laws, rules and regulations pertaining, but not limited to operational, environmental, health and safety. Cove Point shall have no obligation to carry out receipts not in complete compliance with these.

Elba Island

The Receipt Point for all LNG unloaded from user's vessel shall be at the point, whether one or more, at which the flange at the outlet of the unloading piping of user's vessel joins the flange at the entry of the receiving LNG pipeline at Southern LNG's marine terminal. Southern LNG receives natural gas only in a liquefied state.

The receipt of LNG from user's vessel shall be carried out by use of pumps and other equipment on user's vessel at an hourly rate of approximately one-twelfth of the maximum cargo capacity of user's vessel and at an average pressure of forty psig at the receipt point; provided, however, that the hourly rate shall not exceed an hourly rate of one-tenth of the cargo capacity of user's vessel. Southern LNG shall not be obligated to receive LNG at a rate or pressure that exceeds prudent operating conditions under conditions at that time.

Southern LNG shall have no obligation to carry out receipts not in complete compliance with applicable safety regulations.

Lake Charles

Loading and unloading of LNG shall be carried out in accordance with applicable safety and other regulations.

Trunk line LNG shall not be obligated to receive LNG at a flow-rate or saturation pressure that exceeds prudent conditions or that may interfere with the normal operations of the Terminal.

Mexico

User must guarantee that the Ship fulfils all the Terminal’s specifications, which are provided for the Operator in the General Conditions documents. In the case that the user does not provide the security measures, the Operator is not obligated to allow Ship’s unloading.

APPENDIX F.- REFERENCES.-

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