Economic Commission for Europe

Inland Transport Committee

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Working Party on the Transport of Dangerous Goods

Joint Meeting of Experts on the Regulations annexed to the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) (ADN Safety Committee)

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Item 8 of the provisional agenda
Special authorizations, derogations and equivalents

Request for a special authorization for the transport of liquefied natural gas (LNG)

Transmitted by the Government of the Netherlands

Report for the request of SPECIAL AUTHORIZATION LNG transport

Rotterdam, the Netherlands
May 31st, 2012

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1. Introduction

1.1 Objective of request

In September 2011 Chemgas Shipping B.V. applied to the Ministry of Infastructure and the Environment for a Special Authorization concerning the transport of Liquefied Natural Gas (LNG, UN 1972).
At present ADN does not allow transport LNG (UN 1972) per inland tank vessel. Chemgas Shipping is convinced that considering additional safety measures in addition to ADN LNG can be transported sufficiently safe.

The scope of the request for this Special Authorization is limited to the transport of LNG and excludes LNG used as fuel.

Transfer of LNG will only be between shore and vessel.

Used material, design, execution, inspection and testing will be according Class Rules and ADN requirements.

1.2 Content of report

Chapter 2 describes the specific properties of LNG. In Chapter 3 the proposed technical specification of the vessel including the spaces for the cargo tanks are set out.
In addition to the technical requirements additional safety measures associated with the transport of LNG are proposed which are described in chapter 4.
Chapter 5 of this report concludes with a proposal for the entry of UN1972 in table C in the ADN.

2. Properties LNG (UN1972)

Liquid Natural Gas (LNG) is the liquid form of the natural gas used in many European households. It is a hydrocarbon mixture of variable composition with Methane as the main component, whereas small percentages of Ethane, Propane, Butane and Nitrogen may be present. LNG is almost depressurized at a temperature of -162°C. At ambient temperature the vapour is lighter than air. More detailed information about LNG can be found in annex 1.

For decades LNG has been transported by seagoing vessels under the rules of the IMO-IGC code, with a very good safety track record. It is also already allowed to transport LNG by train or by truck as described in respectively the RID and ADR.

3. Ship design

3.1 Vessel

For transport of LNG a double hull tanker type G is proposed. The vessel will have four cargo tanks, each of approx.730 m^3. As these volumes are larger than allowed in ADN 9.3.1.11.1 the vessel will be built with a more crashworthy side structure in compliance with ADN 9.3.4.
The more crashworthy side structure is designed in such way that after a collision more energy can be absorbed than the hull of a conventional designed vessel. The possibility that the cargo tank will be structurally damaged during a collision are thereby diminished.

On board a gas detection system will be installed as required by ADN 9.3.1.52.3 Taking into consideration that LNG vapour is lighter than air the detection system will be installed as high as possible near the entrances of the wheelhouse, engine room and accommodation, which is contrary to the ADN regulation which requires the installments as low as possible. The specific properties of LNG obliges this deviation.

3.2 Cargo area

On deck a water-spray system will be installed. In case of leakage of LNG on deck the evaporation will be accelerated by the water-spray and this diminishes the risk of LNG causing damage to the deck and leaking into the lower parts of the vessel. For the same reason a water shield will be fitted at the back of the cargo area to protect the wheelhouse and accommodation behind it.

On board stainless steel drip trays are available which must be placed under the manifolds that are in use (maintained with an overboard drain). This prevents the cold liquid to get in contact with the steel structure of the vessel in case of small leaks during disconnecting of the shore connections. Stainless steel is suitable to withstand the low temperature of LNG. The capacity of the drip trays will be designed to contain the possible leakage.

Cargo pipes will all be adequately insulated to keep the cargo in refrigerated state and subsequently minimize any possible cold transfer to the hull. Valves, flanges and expansion bellows are not to be insulated in order to allow maintenance and visual detection of leakages.

Cargo pipes will have to bridge large temperature differences. Special attention must be given to adequate means of expansion in order to minimize the risk of damage to these pipes and their supports.

Regarding the possibility of excessive pressure-build up in isolated parts of the cargo piping system containing liquid due to temperature increase, special attention will be given to prevent this risk. This includes particular procedures in order to ensure that - in

accordance with ADN regulations – cargo lines will be empty during the voyage, as well as the installation of additional safety relief valves discharging to a cargo tank.

To avoid damage to pumps and safety relief valves by icing, the LNG should be free of water and CO2, as is the standard.

Because of the low temperatures in the hold space, condensation may occur which will impair the tank insulation. This risk will be prevented by using only dry air in the hold spaces. Vent openings on hold spaces will therefore be fitted with low-loaded pressure/vacuum valves. Such valve arrangements have already been applied on many gas carriers throughout the years. Moreover, before the first loading of the ship a positive pressure in the hold spaces must be ensured in order to prevent vacuum due to temperature decrease.

3.3 Cargo tanks

Cargo tanks will be made from steel which is resistant to the low cargo temperature.

As a method for regulation of temperature and pressure of the cargo, a system according ADN 9.3.1.24.1 (b) is chosen: the temperature of the cargo will be controlled by fitting insulation to the outside of the cargo tanks and the choosen margin between tankpressure during loading and the opening pressure of the safety relief valves will be such that cargo vapour discharge to the atmosphere due to temperature increase will be prevented.

Herewith it is taken into account that this will not happen during the time frame of at least three times the operational period (time necessary for the vessel to sail including loading and unloading).

Taking into account the theoretical heat transmission coefficient of the cargotank, the time necessary to reach the opening pressure of the safety relief valves will be calculated. These calculations will be verified by the Class Society.

An exemplary representative calculation is attached in annex 2 as the actual cargo installation is not yet known. This calculation shows that the safety relief valves will open after 32 days and therefor the operational period will be limited to 10 days.

At the delivery of the vessel, a heat test, witnessed by the Class Society will be carried out in order to determine the actual heat transmission coefficient and the above mentioned calculated period will be adjusted if necessary.

The parameters used in the calculation are:

- opening pressure of the safety relief valves with a minimum of 4 barg (in accordance with the definition of a pressure tank)
- Maximum pressure during loading is 0,14 barg
- Ambient temperature +30 °C
- Water temperature +20 °C

To verify the condition of the tank and pipe insulation during the lifespan of the vessel, and subsequently the safety of the system, inspection of the insulation is incorporated in the survey scheme of the Class Society.

4. Additional measures

4.1 Crew

In addition to the technical requirements set out in chapter 3 additional measures will need to be taken to safeguard a safe treatment of LNG.

Firstly, all crew on board will in addition to the normal training for a type G vessel receive a demonstrable training on how to handle LNG as cargo and how to deal with the associated risks, until LNG is added to the standard training set forth in chapter 8.2 of the ADN.

Secondly, in addition to the personal protective equipment for all crew members, the following must be on board for crew members which are engaged in loading and unloading operations:

1. Long-sleeve gloves to protect against low temperatures (-162 °C).
2. Face shields.

4.2 Cargo handling procedures

Due to the very low temperature of the cargo, before the first loading, the cargo tanks shall be cooled down gradually to prevent temperature shocks on materials and equipment.

To prevent an explosive tank atmosphere, the tanks will be inerted before loading. This will be included as requirement no.2 in table C, column 20.

Another requirement concerns the maximum degree of filling of the cargo tanks.

This requirement is twofold:

1. During the operational period and under operational conditions a degree of filling will not exceed 95%.
2. During a time frame of three times the operational period a degree of filling will not reach 98% in order to prevent opening of the safety relief valves when a cargo tank is in liquid-full condition. This is included in requirement no.40. In order to comply with these two conditions, the maximum degree of filling during loading, as defined in table C column 11 and in ADN 1.2.1, must be calculated and it is therefore proposed to leave column 11 blank.

4.3 Empty cargo tanks

In case the cargo tanks of the vessel are empty and free of liquid there is (at ambient temperature) no risk of the safety relief valves' opening due to increase of temperature and pressure.

Also with a small quantity of liquid residue in a tank the tank pressure (at ambient temperature) will remain below the set pressure under the condition that this residue quantity will not exceed what is normally left in a cargo tank after unloading (maximum 1 m^3 per tank).

In annex 3 a representative calculation is given as an example for the statement above.

5 Conclusion and entry table C

The proposed requirements set out in this report will ensure a sufficiently safe method for the transport LNG with an ADN type G tanker

The proposed entry in table C of the ADN for UN1972 can be seen on the next page:

(1)	(2)	(3)a	(3)b	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
UN-No. or substance identification No.	Name and description	Class	Classification code	Packing group	Dangers	Type of tank vessel	Cargo tank design	Cargo tank type	Cargo tank equipment	Opening pressure of the high-velocity vent valve in kPa	maximum degree of filling in %	Relative density atj 20 °C	Type of sampling device	Pump room below deck permitted	Temperature class	Explosion group	Anti-explosion protection required	Equipment required	Number of cones/blue lights	Additional requirements/Remarks
1972	METHANE, REFRIGERATED LIQUID or LIQUEFIED NATURAL GAS, REFRIGERATED, with high content of methane	2	3F		2.1	G	1	1					1	no	T1	II A	yes	PP, EX, A	1	2, 31, 40

Additional requirement 40:

a) As a deviation from 9.3.1.52.3 b)2 – second indent, a gas detection system should be installed at the highest part of the entrance to the accommodation, the wheelhouse and the engine room.

b) A water-spray system must be installed in the cargo area for the purpose of acceleration of the evaporation of liquid cargo on deck. The water-spray system must include a vertical water shield at the end of the cargo area to protect accommodation and wheelhouse. The system shall be fitted with a connection device for supply from the shore and shall be capable of being put into operation from the wheelhouse and from the deck. The capacity of the water-spray system shall be such that when all the spray nozzles are in operation, the outflow is at least 5 l/m^2 per minute for horizontal and vertical surfaces.

c) To protect the hull construction drip trays made of material able to resist the low temperature of the cargo and with sufficient capacity, should be placed under the manifolds used during loading and unloading (maintained with an overboard drain).

d) Unacceptable pressure build-up, caused by heating of liquid cargo in closed cargo lines should be avoided at all times. A procedure to check if all pipes are free of liquid should be on board.

e) Cargo shall be free of water and carbon dioxide.

f) To protect the insulation of the tanks cargo tank spaces should only contain dry air.

g) During the operational period as set out in 9.3.1.24 and under operational conditions a degree of filling of 95% is not to be exceeded. In addition during a time frame of three times the operational period the degree of filling is not to reach 98%. The operational period and the maximum degree of filling during loading for each cargo tank and for each loading temperature which may be applied, must be approved by the Class Society and must be kept onboard.

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1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1 Product Identifier

Material Name : **LNG (CAS 8006-14-2)**
Other Identifier : Liquified Natural Gas

1.2 Relevant identified uses of the substance or mixture and uses advised against

Product Use : Use only as a fuel.

1.3 Details of the supplier of the substance or mixture

Manufacturer/Supplier : **Shell Western LNG B.V.**
PO Box 162, 2501 AN
The Hague
Netherlands

Telephone : +31 10 431 9111

1.4 Emergency Telephone Number

: +44 (0)151 350 4595

1.5 Other Information

: This product is exempt from the obligation to register under REACH in accordance with Article 2(7)(b).

2. HAZARDS IDENTIFICATION

2.1 Classification of substance or mixture

Regulation (EC) No 1272/2008 (CLP)	
Hazard classes / Hazard categories	**Hazard Statement**
Flammable Gas, Category 1	H220
Refrigerated liquefied gas, Refrigerated liquefied gas	H281

67/548/EEC or 1999/45/EC	
Hazard Characteristics	**R-phrase(s)**
Extremely flammable.	R12

2.2 Label Elements

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Labeling according to Regulation (EC) No 1272/2008

Symbol(s) :

Signal Words : Danger

CLP Hazard Statements : PHYSICAL HAZARDS:
H220: Extremely flammable gas.
H281: Contains refrigerated gas; may cause cryogenic burns or injury.

HEALTH HAZARDS:
Not classified.

ENVIRONMENTAL HAZARDS:
Not classified.

CLP Precautionary statements

Prevention : P210: Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P243: Take precautionary measures against static discharge.
P377: Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381: Eliminate all ignition sources if safe to do so.

Storage : P410+P403: Protect from sunlight. Store in a well-ventilated place.

Labeling according to Directive 1999/45/EC

EC Symbols : F+ Extremely flammable.

EC Risk Phrases : R12 Extremely flammable.
EC Safety Phrases : S9 Keep container in a well-ventilated place.

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S16 Keep away from sources of ignition - No smoking.
S33 Take precautionary measures against static discharges.

2.3 Other Hazards

Health Hazards : High gas concentrations will displace available oxygen from the air; unconsciousness and death may occur suddenly from lack of oxygen.
Exposure to high gas/vapour concentrations may lead to narcotic or anaesthetic effects that may impair judgement or lead to central nervous system depression.
Exposure to rapidly expanding gases may cause frost burns to eyes and/or skin.

Environmental Hazards : Not classified as dangerous for the environment.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substance

Synonyms : Liquified Natural Gas

3.2 Mixtures

Preparation Description : Complex mixture of hydrocarbons, predominantly methane with some other lower alkanes. It may also contain trace amounts of mercury (unlikely) and different sulphur compounds. Product is not a mixture according to regulation 1907/2006/EC.

Hazardous Components

Classification of components according to Regulation (EC) No 1272/2008

Chemical Name	CAS No.	EINECS	REACH Registration No.	Conc.
Liquified Natural Gas	8006-14-2	232-343-9	Exempt	>= 85,00%

Chemical Name	Hazard Class & Category	Hazard Statement
Liquified Natural Gas	Flam. Gas, 1; Refrig. Liq. Gas, Refrig. Liq. Gas;	H220; H281;

Classification of components according to 67/548/EEC

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Chemical Name	CAS No.	EINECS	REACH Registration No.	Symbol(s)	R-phrase(s)	Conc.
Liquified Natural Gas	8006-14-2	232-343-9	Exempt	F+	R12	>= 85,00%

Additional Information : Refer to chapter 16 for full text of EC R-phrases.

Contains Methane, CAS # 74-82-8 Contains Propane, CAS # 74-98-6 Contains Ethane, CAS # 74-84-0 Contains Butane, CAS # 106-97-8

4. FIRST AID MEASURES

4.1 Description of First Aid Measures

Inhalation : Remove to fresh air. Do not attempt to rescue the victim unless proper respiratory protection is worn. If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting, or unresponsive, give 100% oxygen with rescue breathing or Cardiopulmonary Resuscitation (CPR) as required and transport to the nearest medical facility.

Skin Contact : Do not remove clothing that adheres to skin due to freezing. In the event of frostbite, slowly warm the exposed area by rinsing with warm water. Otherwise: Obtain medical treatment immediately. Contaminated clothing may be a fire hazard and therefore should be soaked with water before being removed. Loosen tight clothing.

Eye Contact : If persistent irritation occurs, obtain medical attention. Cold product - All burns should receive medical attention.

Ingestion : In the unlikely event of ingestion, obtain medical attention immediately.

4.2 Most important symptoms/effects, acute & delayed : Breathing of high vapour concentrations may cause central nervous system (CNS) depression resulting in dizziness, light-headedness, headache, nausea and loss of coordination. Continued inhalation may result in unconsciousness and death.

4.3 Indication of immediate medical attention and special treatment needed : Treat symptomatically.

5. FIRE FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

5.1 Extinguishing Media	:	Shut off supply. If not possible and no risk to surroundings, let the fire burn itself out.
Unsuitable Extinguishing Media	:	Do not use water in a jet.
5.2 Special hazards arising from substance or mixture	:	Forms flammable mixture with air. If released, the resulting vapours will disperse with the prevailing wind. If a source of ignition is present where the vapour exists at 5-15% concentration in air, the vapour will burn along the flame front toward the source of the fuel.
5.3 Advice for fire-fighters	:	Wear full protective clothing and self-contained breathing apparatus.
Additional Advice	:	Keep storage tanks, pipelines, fire exposed surfaces cool with water delivered as a fine spray.

6. ACCIDENTAL RELEASE MEASURES

Avoid contact with spilled or released material. Immediately remove all contaminated clothing. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. For guidance on disposal of spilled material see Chapter 13 of this Material Safety Data Sheet. Observe the relevant local and international regulations.

6.1 Personal Precautions, Protective Equipment and Emergency Procedures	:	Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Attempt to disperse the gas or to direct its flow to a safe location for example by using fog sprays. Take precautionary measures against static discharge. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Monitor area with combustible gas meter.
6.2 Environmental Precautions	:	Shut off leaks, if possible without personal risks.
6.3 Methods and Material for Containment and Clean Up	:	Allow to evaporate. Attempt to disperse the vapour or to direct its flow to a safe location, for example by using fog sprays. Otherwise treat as for small spillage.
Additional Advice	:	Notify authorities if any exposure to the general public or the environment occurs or is likely to occur.

7. HANDLING AND STORAGE

General Precautions	:	Take precautionary measures against static discharges.
7.1 Precautions for Safe Handling	:	Avoid contact with skin, eyes and clothing. Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks. This product can create a low temperature exposure hazard when released as a liquid. Electrostatic charges may be

		generated during handling. Electrostatic discharge may cause fire.
7.2 Conditions for safe storage, including any incompatibilities	:	Keep away from sources of ignition - No smoking. Keep container tightly closed and in a cool, well-ventilated place. Cleaning, inspection and maintenance of storage tanks is a specialist operation, which requires the implementation of strict procedures and precautions. These include issuing of work permits, gas-freeing of tanks, using a manned harness and lifelines and wearing air-supplied breathing apparatus. Prior to entry and whilst cleaning is underway, the atmosphere within the tank must be monitored using an oxygen meter and explosimeter.
7.3 Specific End Uses	:	Not applicable
Product Transfer	:	Earth all equipment. Electrostatic charges may be generated during handling. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Restrict line velocity during pumping in order to avoid generation of electrostatic discharge. Delivery lines may become cold enough to present a cold burns hazard.
Recommended Materials	:	For containers or container linings, use stainless steel. For lines and fittings, use mild steel, stainless steel.
Unsuitable Materials	:	Elastomers (gaskets, seals): Natural rubber (NR). Nitrile rubber (NBR), Ethylene propylene rubber (EPDM), Butyl rubber (IIR), Chlorosulphonated polyethylene (CSM), Styrene butadiene rubber (SBR), Neoprene rubber (CR). PVC.
Container Advice	:	Containers, even those that have been emptied, can contain explosive vapours.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

If the American Conference of Governmental Industrial Hygienists (ACGIH) value is provided on this document, it is provided for information only.

8.1 Control Parameters

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Methane	MAC (NL)				Included in the regulation but with no data values. See regulation for further details
	ACGIH	TWA	1.000		

			ppm		
Ethane	MAC (NL)				Included in the regulation but with no data values. See regulation for further details
	ACGIH	TWA	1.000 ppm		
Propane	MAC (NL)				Included in the regulation but with no data values. See regulation for further details
	ACGIH	TWA	1.000 ppm		
Butane	MAC (NL)	MAC TGG	600 ppm	1.430 mg/m3	
Natural gas	ACGIH	TWA	1.000 ppm		

Material	**Source**	**Hazard Designation**
Methane	MAC (NL)	Asphyxiant.
Ethane	MAC (NL)	Asphyxiant.
Propane	MAC (NL)	Asphyxiant.

Biological Exposure Index (BEI)

No biological limit allocated.

Derived No Effect Levels (DNEL) : Not applicable

PNEC related information : Exposure assessments have not been presented for the environment therefore PNEC values not required.

8.2 Exposure Controls

General Information : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Adequate ventilation to control

airborne concentrations below the exposure guidelines/limits.

Occupational Exposure Controls

Personal Protective Equipment	:	Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.
Eye Protection	:	Chemical splash goggles (gas-tight monogoggles) and face shield with chin guard.
Hand Protection	:	Select gloves tested to a relevant standard (e.g. Europe EN374, US F739). Breakthrough times for gloves varies depending on, e.g. chemical resistance, material thickness, frequency and duration of contact. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, glove thickness, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced.
Body protection	:	Chemical and cold resistant gloves/gauntlets, boots, and apron.
Respiratory Protection	:	If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are unsuitable (e.g. airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus. Where respiratory protective equipment is required, use a full-face mask. All respiratory protection equipment and use must be in accordance with local regulations. Where air-filtering respirators are suitable, select an appropriate combination of mask and filter. Select a filter suitable for organic gases and vapours [boiling point <65°C (149°F)] meeting EN14387.
Thermal Hazards	:	When handling cold material that can cause frost burns, wear heat resistant gloves, safety hat and visor, cold resistant overalls (with cuffs over gloves and legs over boots) and heavy duty boots e.g. leather for cold resistance.
Monitoring Methods	:	Monitoring the oxygen content of the air is often the best means of ensuring safety. There are substantial risks if the concentration of oxygen in the atmosphere varies from the normal (20.8%) under normal atmospheric pressure.

Environmental Exposure Controls

Environmental exposure control measures	:	Local guidelines on emission limits for volatile substances must be observed for the discharge of exhaust air containing vapour.

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9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

Appearance	:	Refrigerated liquefied gas
Odour	:	Odourless.
pH	:	Not applicable.
Initial Boiling Point and Boiling Range	:	Typical -161,5 °C / -258,7 °F
Freezing Point	:	Data not available
Flash point	:	Typical -187 °C / -305 °F
Upper / lower Flammability or Explosion limits	:	Typical 5 - 15 %(V)
Auto-ignition temperature	:	537 °C / 999 °F
Vapour pressure	:	Data not available
Density	:	Typical 420 kg/m3 at -165,5 °C / -265,9 °F Liquid methane at boiling point.
Water solubility	:	0,08 g/l at 25 °C / 77 °F
Solubility in other solvents	:	Data not available
n-octanol/water partition coefficient (log Pow)	:	Data not available
Dynamic viscosity	:	Data not available
Kinematic viscosity	:	Not applicable.
Vapour density (air=1)	:	Typical 0,58
Evaporation rate (nBuAc=1)	:	Data not available
Flammability	:	Flammable Gas

9.2 Other Information

Other Information	:	Not applicable.

10. STABILITY AND REACTIVITY

10.1 Reactivity	:	Release of LNG into water may cause explosive boiling due to rapid phase transition (liquid to gas).
10.2 Chemical Stability	:	Stable under normal use conditions.
10.3 Possibility of Hazardous Reactions	:	Release of LNG into water may cause explosive boiling due to rapid phase transition (liquid to gas).
10.4 Conditions to Avoid	:	Heat, flames, and sparks. May form explosive mixture on contact with air.
10.5 Incompatible Materials	:	Strong oxidising agents.

10.6 Hazardous Decomposition Products	:	Hazardous decomposition products are not expected to form during normal storage.

11. TOXICOLOGICAL INFORMATION

11.1 Information on Toxicological effects

Basis for Assessment	:	Information given is based on product testing.
Likely Routes of Exposure	:	Inhalation is the primary route of exposure although exposure may occur through skin or eye contact.
Acute Oral Toxicity	:	Not applicable.
Acute Dermal Toxicity	:	Not applicable.
Acute Inhalation Toxicity	:	LC50 >20 mg/l / 4 h, Rat
Skin Corrosion/Irritation	:	Expected to be non-irritating to skin.
Serious Eye Damage/Irritation	:	Essentially non-irritating to eyes.
Respiratory Irritation	:	Inhalation of vapours or mists may cause irritation to the respiratory system.
Respiratory or Skin Sensitisation	:	Not expected to be a sensitiser.
Aspiration Hazard	:	Not considered an aspiration hazard.
Germ Cell Mutagenicity	:	Not considered a mutagenic hazard.
Carcinogenicity	:	Not expected to be carcinogenic.
Reproductive and Developmental Toxicity	:	Not expected to impair fertility. Not a developmental toxicant.
Specific target organ toxicity - single exposure	:	High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.
Specific target organ toxicity - repeated exposure	:	Low systemic toxicity on repeated exposure.
Additional Information	:	Rapid release of gases which are liquids under pressure may cause frost burns of exposed tissues (skin, eye) due to evaporative cooling. High gas concentrations will displace available oxygen from the air; unconsciousness and death may occur suddenly from lack of oxygen.

12. ECOLOGICAL INFORMATION

Basis for Assessment	:	Incomplete ecotoxicological data are available for this product. The information given below is based partly on a knowledge of the components and the ecotoxicology of similar products.

12.1 Toxicity

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Acute Toxicity	:	Physical properties indicate that hydrocarbon gases will rapidly volatilise from the aquatic environment and that acute and chronic effects would not be observed in practice.
12.2 Persistence and degradability	:	Expected to be readily biodegradable. Oxidises rapidly by photo-chemical reactions in air.
12.3 Bioaccumulative Potential	:	Not expected to bioaccumulate significantly.
12.4 Mobility	:	Because of their extreme volatility, air is the only environmental compartment that hydrocarbon gases will be found.
12.5 Result of the PBT and vPvB assessment	:	The substance does not fulfill all screening criteria for persistence, bioaccumulation and toxicity and hence is not considered to be PBT or vPvB.
12.6 Other Adverse Effects	:	In view of the high rate of loss from solution, the product is unlikely to pose a significant hazard to aquatic life.

13. DISPOSAL CONSIDERATIONS

13.1 Waste Treatment Methods

Material Disposal	:	Do not discharge into areas where there is a risk of forming an explosive mixture with air.
Container Disposal	:	In commercial premises empty containers should be disposed of to a recognised waste contractor. Do not pierce or burn empty containers.
Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be complied with. Classification of waste is always the responsibility of the end user.

14. TRANSPORT INFORMATION

Land transport (ADR/RID):
ADR

14.1 UN No.	:	1972
14.2 UN Proper Shipping Name	:	NATURAL GAS, REFRIGERATED LIQUID

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14.3 Transport Hazard Class	:	2
14.4 Packing group	:	Not applicable.
Danger label (primary risk)	:	2.1
14.5 Environmental Hazard	:	No
14.6 Special Precautions for user	:	Special Precautions: Refer to Chapter 7, Handling & Storage, for special precautions which a user needs to be aware of or needs to comply with in connection with transport.

RID

14.1 UN No.	:	1972
14.2 UN Proper Shipping Name	:	NATURAL GAS, REFRIGERATED LIQUID
14.3 Transport Hazard Class	:	2
14.4 Packing group	:	Not applicable.
Danger label (primary risk)	:	2.1
14.5 Environmental Hazard	:	No
14.6 Special Precautions for user	:	Special Precautions: Refer to Chapter 7, Handling & Storage, for special precautions which a user needs to be aware of or needs to comply with in connection with transport.

Inland waterways transport (ADN):

14.1 UN No.	:	1972
14.2 UN Proper Shipping Name	:	NATURAL GAS, REFRIGERATED LIQUID
14.3 Transport Hazard Class	:	2
14.4 Packing group	:	Not applicable.
Danger label (primary risk)	:	2.1
14.5 Environmental Hazard	:	No
14.6 Special Precautions for user	:	Special Precautions: Refer to Chapter 7, Handling & Storage, for special precautions which a user needs to be aware of or needs to comply with in connection with transport.

Sea transport (IMDG Code):

14.1 UN No.	:	UN 1972
14.2 UN Proper Shipping Name	:	NATURAL GAS, REFRIGERATED LIQUID
14.3 Transport Hazard Class	:	2.1
14.4 Packing group	:	Not applicable.

14.5 Marine pollutant	:	No
14.6 Special Precautions for user	:	Special Precautions: Refer to Chapter 7, Handling & Storage, for special precautions which a user needs to be aware of or needs to comply with in connection with transport.

Air transport (IATA):

14.1 UN No.	:	1972
14.2 UN Proper Shipping Name	:	Natural gas, refrigerated liquid
14.3 Transport Hazard Class	:	2.1
14.4 Packing group	:	Not applicable.
14.6 Special Precautions for user	:	Special Precautions: Refer to Chapter 7, Handling & Storage, for special precautions which a user needs to be aware of or needs to comply with in connection with transport.

Sea (Annex II of MARPOL 73/78 and the IBC code)

Pollution Category	:	Not applicable.
Ship Type	:	Not applicable.
Product Name	:	Not applicable.
Special Precaution	:	Not applicable.

15. REGULATORY INFORMATION

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Other regulatory Information

15.2 Chemical Safety Assessment	:	A Chemical Safety Assessment was not performed for this substance, as this substance was not required to be registered under REACH.

16. OTHER INFORMATION

R-phrase(s)

R12	Extremely flammable.

Safety Data Sheet

CLP Hazard Statements

H220	Extremely flammable gas.
H281	Contains refrigerated gas; may cause cryogenic burns or injury.

Identified Uses according to the Use Descriptor System

Other Information

MSDS Distribution	:	The information in this document should be made available to all who may handle the product.
MSDS Version Number	:	1.3
MSDS Effective Date	:	06.10.2011
MSDS Revisions	:	A vertical bar (|) in the left margin indicates an amendment from the previous version.
Disclaimer	:	This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.

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Chemgas Shipping BV.

Project LNG Inland Waterways Transport.
Ship: 4x Bilobe Tanks = 4 x 730 = 2920 m3.
Insulation Thickness Cargo tanks = 0,300 meter.
Insulation Thermal Conductivity 0,02398 W/m^2.K
Days until 95% filling rate is reached = ± 20 days.
Set Pressure Main Safety Valves 5,0 bara (= 4,0 barg).
Temperature in Void space (filled with dry air) = +18 °C.
Water Temperature 20 °C. # Ambient Temperature 30 °C.
Days until Maximum Pressure of 5,000 bara is reached = ± 33 à 34 days.

Loading Cargo Temperature LNG = -161 °C. (by 90,6 % of filling limit).
Cargo Temperature LNG = -148 °C. (by 95,0 % of filling limit).
Cargo Temperature LNG = -138 °C. (by 98,0 % of filling limit).

Table 1.2
Relation : Pressure # Temperature # Time in days

Pressure in bara – Temperature in °C – Time in days – Methane/LNG - UN 1972									
Press.	0,893	0,963	**1,046**	1,134	1,228	1,317	1,444	1,545	1,664
Temp.	-163°C	-162°C	**-161°C**	-160°C	-159°C	-158°C	-157°C	-156°C	-155°C
Filling	90,0 %	90,3 %	**90,6 %**	90,9 %	91,2 %	91,6 %	91,9 %	92,2 %	92,5 %
Days	0	1	**2**	4	5	6	8	9	10

Pressure in bara – Temperature in °C – Time in days – Methane/LNG - UN 1972									
Press.	1,789	1,921	2,075	2,223	2,378	2,525	**2,696**	2,901	3,200
Temp.	-154°C	-153°C	-152°C	-151°C	-150°C	-149°C	**-148°C**	-147°C	-146°C
Filling	92,9 %	93,2 %	93,6 %	94,0 %	94,3 %	94,7 %	**95,0%**	95,3 %	95,6 %
Days	11	13	14	16	17	18	**20**	21	22

Pressure in bara – Temperature in °C – Time in days – Methane/LNG - UN 1972								
Press.	3,500	3,700	3,900	4,000	4,250	4,500	4,750	**5,000**
Temp.	-145°C	-144°C	-143°C	-142°C	-141°C	-140°C	-139°C	**-138°C**
Filling	95,9 %	96,2 %	96,5 %	96,8 %	97,1 %	97,4 %	97,7 %	**98,0 %**
Days	24	25	27	28	29	31	32	**34**

Conclusion:
The maximum time will be 34 days. Taking into account the safety coefficient of 3 times; the actual operational period must not exceed (34 – 2) : 3 = 10,7 days.

Tank pressure during voyage with empty tanks

During unloading into an almost pressureless shore tank , the gas return line between ship and shore will be connected and subsequently at the end of unloading the ship's tank and the shore tank will have the same pressure.

Cargo tank volume is 730 m^3
Opening pressure safety relief valves is 4 barg

At the end of loading:

Assumed pressure:	1.1 bara
Associated temperature:	-160.5 ^oC (= 112.5 Kelvin)
Liquid residue in cargo tank	0.5 m^3

The delay of the ship is such that the tank temperature will reach the maximum ambient temperature of +30 ^oC (= 303 Kelvin)

Pressure due to vapour density increase:

(P2=P1xT2/T1)	2.96 bara

Pressure due to evaporation of liquid:

(0.5 m^3 liquid to 300 m^3 vapour)	0.41 bara	
	---------- +	
Total pressure at +30 ^oC	3.37 bara	= 2.37 barg

Conclusion:

Since the cargo tank pressure at +30 ^oC will only reach 2.37/4 = 60% of the opening pressure of the safety relief valves, there will be no risk of vapour release.

Notes: > The realistic quantity of liquid residue after unloading is approx. 0.3 m^3.
> The same calculation may be applied for various cargo tank volumes under the condition that comparatively the quantity of liquid residue will be the same.
> bara = absolute pressure in bar ; barg = overpressure (bar gauge) in bar

chemgas SHIPPING