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**Economic Commission for Europe****Inland Transport Committee****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)****Twenty-second session**

Geneva, 21 – 25 January 2013

Item 4 (b) of the provisional agenda

**Special authorizations, derogations and equivalents**

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**Evaluation report for the tank vessel Argonon****Transmitted by the Government of the Netherlands**

By derogation No. 1/2012 of 27 January 2012 issued by the ADN Administrative Committee, the competent authority of the Netherlands was authorized to issue a trial certificate of approval to the motor tank vessel *Argonon* (yard No. 07 KHO 169 of Trico Shipyard, Rotterdam, European vessel identification No. 02334277), type C tanker, for the use of diesel and liquefied natural gas (LNG) as fuel for the propulsion installation.

According to the derogation, an evaluation report shall be sent to the UNECE secretariat for information of the Administrative Committee. The evaluation report shall contain at least information on the following:

- (a) system failures;
- (b) leakages;
- (c) bunkering data (diesel and LNG);
- (d) pressure data;
- (e) abnormalities, repairs and modifications of the LNG system including the tank;
- (f) operational data;
- (g) inspection report by the classification society which classed the vessel.

The evaluation report appears below.

## **Evaluation report inland waterway tanker barge 'Argonon'**

### **Introduction**

The 'Argonon' is the first inland waterway barge with a dual fuel propulsion. The use of Liquefied Natural Gas (LNG) as fuel on this barge is allowed according Derogation No. 1/2012 of the ADN Administrative Committee dated January 27<sup>th</sup> 2012.

Item no. 5 of this Derogation prescribes an annual evaluation report should be sent in by the applicant, Argonon Shipping BV.

This is the first annual evaluation report.

Along with some general information, the several topics as mentioned in item 5 of the Derogation are described.



### **General data**

Chemical Tanker Type C

Length 110 m

Breadth 16.20 m

Depth 6.23 m

Draught 5.00

Deadweight 6100 t

Propulsion 2 \* Caterpillar DF3512 engines, 2 \* 1127 kW

In service since November 25<sup>th</sup> 2011

The barge is classed by Lloyd's Register, and the statutory certificates are issued by Lloyd's Register on behalf of the Netherlands Shipping Inspectorate.

General information of the LNG system is part of the Derogation. For reference purposes this description is added as Annex 1 to this report.

### System failure



Since commissioning on November 2011 there hasn't been a single system failure in the LNG system. So there hasn't been the need for any system modification due to failure.

### Leakage



There hasn't been any leakage in both the LNG and the natural gas system. The natural gas system is checked by the ships' crew on a two week cycle by testing the connections in the natural gas lines in the engine room with soap. The data of these inspections are recorded on board. The piping and valves in the cold box are visually checked on a weekly basis. Also during bunkering there hasn't been any leakage of LNG.



### Bunkering data



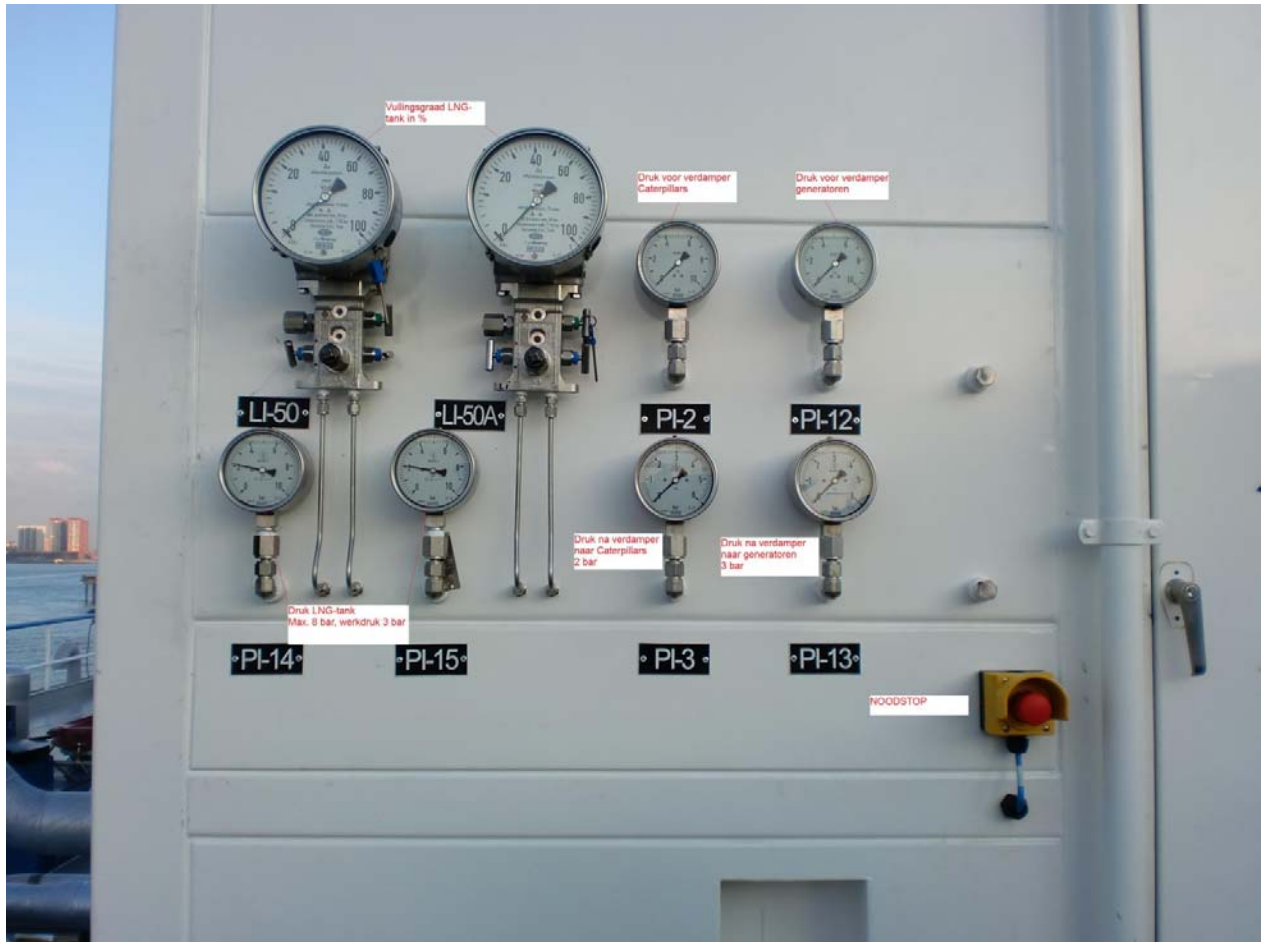
The barge sails on a mixture of 81 % LNG and 19 % gas oil (EN590). This mixture has been optimised for using the maximum percentage of LNG without decreasing the engine characteristics. The engines are Caterpillar DF3512 engines which haven't been changed for the use of natural gas. The natural gas is mixed with the combustion air before injection in the engine. During the first few weeks of the barge sailing this mixture has been changed from a 60-40 % to the final 81-19 %.

The bunkering with LNG is done by a truck. The total bunkering procedure takes approximately 1.5 hours. This is including the completion of the bunkering checklist, the purging of the bunkering lines and the coupling and decoupling of these lines. The LNG flows into the storage tank on the barge by the pressure difference between the truck and the storage tank. No pumping is needed. An average of 15 Tons LNG is bunkered each time. Every bunkering has been done without any mistakes or failures. The bunkering procedure is followed each time and has proven to be useful and applicable.

The first bunkering was done at the premises of a bunkering station in Zwijndrecht, The Netherlands. The other bunkering operations were done on a dedicated location in the Port of Rotterdam. The first bunkering with LNG took place on November 22<sup>nd</sup> 2011. This bunkering has been witnessed by Lloyd's Register. Since then 10 times a bunkering with LNG has been done.

A total of 148 Tons LNG has been bunkered (30 Tons has been used for the micro turbines only). A total of 36 M<sup>3</sup> of gas oil for the use of the main engine has been bunkered.

**Pressure data**



The LNG is stored in the tank at a temperature between -158 and -162 degrees Celsius with a pressure of 3.5 bar. The system is equipped with a pressure build up unit which keeps this pressure on this level. The safety valves on the tank have a pressure setting of 8 bar, but this pressure has never been reached. So no LNG or natural gas has escaped from the storage tank. The maximum tank pressure during the operation of the vessel was 3.5 bar.

The LNG is evaporated in the cold box into natural gas which is transported at ambient temperature with a pressure of 3.5 bar to the engine room.

At the entrance in the engine room the pressure is reduced to 1.0 bar.

Direct on the engine the pressure is reduced to atmospheric pressure, and mixed with the combustion air and injected into the engine.

### **Abnormalities, repairs and modifications**



The installation on board has been done according to the approved plans. The commissioning of the system has been done under the supervision of Lloyd's Register. As a requirement of some oil majors, the direction of outlet of the safety relieve valve is modified from horizontal to vertical. As the whole system is operating as expected, no repairs or further modifications of whatever kind have been necessary during this first year. The LNG system isn't modified in any way since the installation on board.

### **Operations data**

The engines have 1300 running hours since November 25<sup>th</sup> 2011. This relatively limited number of sailing hours is due to the service operation of the vessel. The vessel mainly operates as a bunker tanker in the ports of Rotterdam, Amsterdam and Antwerp, and this includes a large number of non-sailing hours.

### **Survey report**

As this is the first dual fuel inland waterway barge, it has the special attention of Lloyd's Register. Therefore, the average numbers of surveys and visits on board have been increased. The annual survey of the LNG system has been done by Lloyd's Register in December 2012. This survey has been done according to the Lloyd's Register Rules and Regulations for the Classification of Natural Gas Fuelled Ships (July 2012). Although the vessel has been built according to the provisional version of these rules from 2007, the now final version of the rules doesn't have any influence on the system as it is installed on board. The survey report is attached as Annex 2 to this report.

Emission data



The use of LNG as fuel obviously leads to a significant reduction of emission of CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub> and Particulates Matter (PM).

To increase the emission reduction of NO<sub>x</sub> even more the exhaust system is equipped with an oxidation catalyst. These also can reduce the possible methane slip.

In the first 368 days since entering into service the 'Argonon' has saved 157 tons CO<sub>2</sub>. This is compared to a similar vessel which runs on gas oil only. As the owner of the 'Argonon' has several nearly similar vessels into service on the same trade this equation can be easily made.

The NO<sub>x</sub> emission is 3.4 gr/kWhr, which is 50 % of the CCNR II value. By optimising the motor management system this can be further decreased. Expected end result is 70 % of the CCNR II value. The PM emission is with 0.04 gr/kWhr already less than the expected CCNR IV value. As the gas oil used is the normal EN590 the SO is already extremely low. But never the less the SO<sub>x</sub> parts decreased with 80% in this configuration.

On the barge also two Capstone turbines of 30 kW are installed. These run on natural gas only. The NO<sub>x</sub> emission of these turbines is 0.29 gr/kWhr. This is approximately 15 % of the expected CCNR IV value. The emitting of particles is none.

The reduction of the fuel costs is approximately 25 % compared to a similar barge which runs on gas oil only.

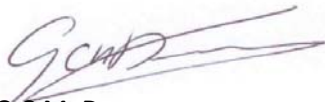


**Promotion**



The Argonon participated in various promotional activities including the Rotterdam Port Promotion days (on 8 & 9 September 2012) where we received approximately 8000 people in two days. This event was organized and approved by the Rotterdam port authority.

December 2012



G.C.M. Deen  
CEO Argonon Shipping B.V. Zwijndrecht

## **Annex 1 to the 1<sup>st</sup> annual evaluation report**

### **General information about the liquefied natural gas system on board of the motor tanker “Argonon”**

#### **1. Introduction**

In this document the design of the motor tanker ‘Argonon’, European vessel identification number 02334277, is described. Chapter 2 describes the procedure applied by the classification society prior to the classification and certification of the vessel. Chapter 3 gives a description of the liquefied natural gas system. The storage tank is dealt with in chapter 4. Additional information is provided in chapter 5.

#### **2. Procedure**

The vessel has to comply with all statutory regulations applicable for inland waterway vessels such as RVIR and ADN. However, both RVIR and ADN do not allow the use of fuel with a flashpoint below 55 degrees Celsius. Arrangements not complying with the regulations are to be proposed to the CCNR and UN-ECE and could be accepted provided the alternative arrangement is at least as safe as conventional arrangements accepted under RVIR; i.e. it needs to be demonstrated that the level of safety is the same as that of a diesel powered vessel.

The procedure as proposed by Lloyd’s Register and discussed with the Netherlands Shipping Inspectorate is to examine the liquefied natural gas system arrangements against existing legislation and requirements as far as applicable, such as IGF Code (IMO Resolution MSC.285(86), June 1<sup>st</sup> 2009) and the Lloyd’s Register Provisional Rules for Methane Gas Fuelled Ships.

As part of the approval, the safety of the liquefied natural gas system has been assessed by performing a HAZID study which uses the ‘What if Technique’ as defined in IMO Resolution MSC.392 Appendix 3, Section 5.

This leads to the following steps being taken:

1. Concept design of the liquefied natural gas propulsion system reviewed by Lloyd’s Register.
2. Plans updates by the designer.
3. The hazards associated with the arrangements have been considered by a Hazard Identification Study (HAZID) which has been undertaken by Lloyd’s Register. The influence of ship operations and conditions, environmental conditions, auxiliary systems (power, cooling water) and failure (human error, machinery, control) have been considered.
4. HAZID report issued by Lloyd’s Register (see annex 1 to the recommendation). It is considered that none of the issues raised in the HAZID prevent an approval in principle. Safety actions and other recommendations need to be resolved and are to be submitted to Lloyd’s Register.
5. The engineering is continued and the plans are updated. New plans to be sent to Lloyd’s Register for plan approval in which safety actions and recommendations as reported by HAZID report are solved, added and incorporated.
6. Approval of plans in which the verification of compliance to the Lloyd’s Register Rules, HAZID conclusions and other applicable requirements have been dealt with.

7. The system will be built under survey, and tested by Lloyd's Register.

All steps have been completed. During the construction of the vessel some changes were made in the design of the liquefied natural gas system following the safety actions and the recommendations in the HAZID Report (step 4 and 5). These are minor changes in e.g. the liquefied natural gas piping system and the location of the tank. This explains the differences between the annexes to the HAZID Report and the annexes to this General Information Document. All changes have been approved by Lloyd's Register (step 6).

Apart from the above mentioned actions, a qualitative risk analysis has been carried out by TNO. A few questions were raised and answers were provided by the Lloyd's Register. (See attachments 7, 8 and 9).

### **3. Liquefied natural gas system**

At the design of the liquefied natural gas system the relevant parts of the following regulations are used:

- Rules and Regulations for the Classification of Inland Waterways Ships, Lloyd's Register November 2008.
- Provisional Rules for the Classification of Methane Gas Fuelled Ships, Lloyd's Register January 2007.
- Interim Guidelines for Natural Gas-Fuelled engine installations in ships, IMO Resolution MSC.285(86), June 1<sup>st</sup> 2009 (IGF Code).
- Rules and Regulations for the Classification of Ships (Part 7, Chapter 16), Requirements for Machinery and Engineering Systems of Unconventional Design, Lloyd's Register.
- Cryogenic vessels – Static vacuum insulated vessels – Part 2: Design, fabrication, inspection and testing (European standard EN 13458-2 : 2002).
- Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres (European standard EN 60079-10-1 : 2009).
- Requirements ADN 2011.

The liquefied natural gas system will be surveyed annually by Lloyd's Register according to the international standards for the storage and use of liquefied natural gas, as described in the recommendation.

The ships' crew will survey the liquefied natural gas system visually on a weekly basis. This requirement is also included in the ship's safety manual.

All data will be collected during the operation of the liquefied natural gas system. An annual evaluation report will be made and sent to the secretariat of both the CCNR and the UN-ECE, as described in the recommendation. All procedures in the ships' safety manual will be updated according to the findings during the evaluation.

According to the IGF Code it is allowed to use either single-walled or double-walled piping in liquefied natural gas systems. In case of double-walled piping the outer wall is considered as a second barrier and for insulation purposes. For this system single-wall piping is used. The stainless steel cold box is considered to be the second barrier. The cold box is of a very compact design resulting in maintaining the desired thermal insulation of the piping system.

The piping on deck is protected against mechanical damage. A second barrier is considered not necessary here because the piping is in the open air.

The piping in the engine room is also single-walled. The Computational Fluid Dynamics (CFD) Analysis has shown that in case of a gas leak in the engine room there will never be an explosive atmosphere. The piping in the engine room is all welded without flanges.

The connection between the storage tank and the Pressure Build Up Unit is by means of piping in the tank bottom. The piping system is designed in a way that the connection from the tank to the first valve is as short as possible:

- The valve is situated within the radius of the curved end of the storage tank and inside the cold box, so the risk of mechanical damage is minimized.
- All valves in piping which can contain fluids are redundant. The first valve is always manually operated.
- The second valve is automatically operated, and closes immediately in case of an alarm. The valves are situated inside the cold box, and can be operated from outside the cold box.

The cold box is fitted with temperature and gas detection alarms which automatically shut down the valves. All valves are of an approved cryogenic type.

During the normal operation of the liquefied natural gas system it's not necessary to enter the cold box. All valves used for operational and control devices are accessible from outside the cold box. The entrance to the cold box is only permitted to competent persons anyway.

The liquefied natural gas system is designed in a way that leakage of liquid liquefied natural gas will never occur. The used safety devices prevent the leakage of liquefied natural gas in a single failure event. Liquefied natural gas is used permanently during normal operational conditions of the vessel. This prevents a pressure build up in the storage tank.

The liquefied natural gas piping system is suitable for inerting.

The bunkering manifold is situated more than six metres from openings and entrances of the accommodation. In conformity with the ADN, the distance of the bunkering manifold from the vessel's side is at least the same as the distance of the cargo manifolds.

#### **4. Liquefied natural gas storage tank**

##### **4.1 General**

The liquefied natural gas storage tank complies with the requirements of European standard EN 13458-2 : 2002, Cryogenic vessels - Static vacuum insulated vessels - Part 2: Design, fabrication, inspection and testing. The storage tank also meets the requirements of Lloyd's Register. The tank is connected to the vessel in a way that it remains attached to the vessel under all circumstances.

The storage tank is situated on the main deck. The location of the storage tank in relation to the distances to the accommodation, wheelhouse and machinery spaces meets the requirements of the ADN.

To protect the liquefied natural gas storage tank, the tank is situated behind the bunkering crane. The distance to the vessel's side is at least 1/5 B. The distance between the liquefied



natural gas storage tank and the accommodation or wheelhouse is such that additional measures for protecting these are not considered necessary.

The storage tank is equipped with a water spray system according IMO Resolution MSC.285(86).

The liquefied natural gas storage tank consists of an inner shell and an outer shell. The space between these stainless steel shells is vacuum insulated and filled with Perlite. This space is fitted with a pressure relief valve to prevent intolerable high pressure in case of leakage from the inner tank.

All piping is located in the space between the two shells. The tank itself is fitted with a pressure relief valve which opens at a pressure of 8 bar. All connections are located within the cold box which contains drip tray arrangements to prevent spills on deck.

The open space between the tank bottom and the deck of the ship is sufficient to prevent the deck from being cooled down in an intolerable way.

The pipe connections are not located above the highest liquid level. For inland navigation vessels the natural gas is required for propulsion. To realize a safer way to generate the required quantity of gas, the connection needs to be in the liquid phase and controlled by a heat exchanger. Otherwise the whole storage tank needs to be heated to generate the required amount of gas.

As the liquefied natural gas storage tank is always externally heated the generated gas will increase the tank pressure. For this reason the vessel has installed two gas turbines (redundant Capstone installations) permanently using gas for generating electricity and heating for the vessels own operating systems. This will prevent any leakage or exhaust of gas to atmosphere and keep the storage tank cooled, also when the vessel is not sailing.

The liquefied natural gas storage tank meets the requirements in the European standard EN 13458-2 : 2002. Because liquefied natural gas does not include water, water drainage is not necessary.

#### **4.2 Filling line**

All connections of the liquefied natural gas system are located in the cold box which contains drip tray arrangements to prevent spills on deck. The cold box is located at one end of the storage tank. Except for the bunkering connections no cryogenic valves are fitted outside the cold box. All components meet the requirements for cryogenic use.

The liquefied natural gas storage tank is not equipped with a breather pipe which meets the requirements that the cross-section is at least 1,25 times the cross-section of the filling line. The liquefied natural gas storage tank and so also the breather pipe meets the requirements in the European standard EN 13458-2 : 2002.

#### **4.3 Alarms**

The storage tank is equipped with two, independently electronic level measuring devices. All equipment complies with the criteria for use in gas-dangerous areas.

All alarms concerning the liquefied natural gas installation shall activate a visual and audible alarm in the wheelhouse. When the wheelhouse is unoccupied the alarm shall be perceptible in a location permanently occupied by a crew member.

## **5. Additional information**

### **5.1 Engine room**

Contrary to the Lloyd's Register Rules, the IMO Interim Guidelines accept two alternative concepts: gas safe machinery spaces and ESD-protected machinery spaces (Emergency Shut Down). (Refer to Section 2.6 of IMO Resolution MSC.285(86)). In a gas safe machinery space the arrangements are such that the space is considered gas safe under all conditions, normal as well as abnormal conditions; i.e. inherently safe. An ESD machinery space is considered non-hazardous under normal conditions but may have the potential to become hazardous. An emergency shutdown of non safe equipment is automatically executed upon detection of a gas hazard. The machinery space fully complies with the Lloyd's Register Rules.

The Lloyd's Register Provisional Rules for the Classification of Methane Gas Fuelled Ships are based on the gas safe machinery space concept and requires gas fuelled machinery to be located within designated gas safe machinery spaces.

To consider a machinery space in which gas fuelled machinery is located gas safe, Lloyd's Register has requirements on automatic shutdown of master valves outside the machinery space and block and bleed valves at the machinery, ventilation in the machinery space, and gas detection.

By placing the gas fuelled machinery inside a machinery space, this space may become gas hazardous. However, according to the European standard EN 60079-10-1 : 2009, it is permitted to have different zone classification if specific arrangements are made for ventilation.

The minimum capacity of the ventilation system for a gas safe machinery space containing gas fuelled machinery is to be based on recognized hazardous area classification standard such as the Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres (European standard EN 60079-10-1 : 2009), and a Computational Fluid Dynamics (CFD) Analysis showing air flow patterns and absence of stagnant areas. In the calculation a leak from a flange is assumed to size the capacity of the ventilation such that if this happens the machinery space remains a safe space.

The ventilation is to be continuously in operation when there is gas fuel in the piping. The capacity of the ventilation system is at least 30 cycles per hour, and the system complies with the requirements for use in gas dangerous areas. The ventilation air is to sweep across the gas fuelled machinery, valves and pipes. When the required air flow cannot be maintained, or in the event of total loss of ventilation, the liquefied natural gas supply to the machinery will close automatically.

The engine room is designed according the ADN Zone requirements as specified on the drawing included as appendix.

### **5.2 Propulsion system**

The vessel is equipped with a redundant main propulsion system. The main engine is a dual-fuel engine and can run on diesel oil only in case the liquefied natural gas system fails.

In a dead-ship condition the propulsion system can be started with a 24V back-up system. The starting procedures are mentioned in the engine manual.

Regarding the emission of gaseous and particulates pollutants, all engines installed comply with the CCR-II standards.

The safety instructions of the engines are taken over from the manufacturers' manuals and will be included in the vessel's safety manual and safety rota.

The quality of the liquefied natural gas used is determined by the engine manufacturer.

### **5.3 Fire safety**

The water capacity for cooling the liquefied natural gas storage tank according IMO Resolution MSC.285(86) is 10 l/min/m<sup>2</sup> on horizontal surfaces and 4 l/min/m<sup>2</sup> on vertical surfaces (for comparison: the water spray system for cargo tank cooling as prescribed in the ADN 9.3.2.28 is 50 l/hr/m<sup>2</sup>). The calculated pump capacity for this cooling system is 48 m<sup>3</sup>/hr. The installed pump capacity complies with the requirements of this IMO Resolution.

The fire extinguishing system in the engine room will comply with the requirements of chapter 10 of the RVIR. When a fire in the engine room is detected, the supply of liquefied natural gas will be shut off. The amount of gas in the piping system in the engine room is too small to be of any influence on the fire. The manufacturer of the extinguishing system has confirmed that the medium used in this system don't need to be adjusted as a result of the presence of this small amount of gas (Maximum amount of gas after shut-down present in the gas piping is less than 0,1 m<sup>3</sup>).

### **5.4 Inspection and testing**

It is common industry practice that cryogenic tanks (both transport tanks and static tanks) are not fitted with manholes for internal inspection of the tank. Periodic visual inspection of the outside of the cryogenic tank is considered sufficient.

The tank is made of stainless steel and corrosion caused by the liquefied natural gas is considered highly unlikely. If there are problems with the inner tank the loss of vacuum is immediately detected, and problems with the insulation are detected by icing on the outside. In either case no immediate danger will occur.

If manholes were fitted, the sealing of the manholes to ensure the vacuum between the inner and outer shell causes more problems than benefits and if this fails it will result in loss of insulation and condensation.

The liquefied natural gas system will be annually surveyed by Lloyd's Register according the international standards for the storage and use of liquefied natural gas.

The ships' crew will survey the liquefied natural gas system visually on a weekly basis. This procedure will be included in the ships' safety manual.

### **5.5 Special equipment**

Personal protection equipment will fully comply with the requirements of the liquefied natural gas data sheet.

The personal protection equipment, as well as all precautions to be taken will be mentioned in the ships safety rota and in the ships' safety manual.

## **5.6 Training**

The ships' crew will be trained on the use of liquefied natural gas, as stated in the recommendation. This is one of the basic assumptions of the HAZID study. The training will contain the hazards of liquefied natural gas, the bunkering procedure, and the measures to be taken in case of calamities. The suppliers of the engines, the cryogenic storage tank and the liquefied natural gas system will contribute to this training.



**INTERIM CERTIFICATE  
PROVISIONAL ISSUE**

*Ship's Name:* **ARGONON**  
*LR/IMO Number:* **9552903**

*Port of Survey:* **Antwerpen**

*Date of Build:* **25/11/2011**  
*Port of Registry:* **Zwijndrecht**  
*Gross Tons:*

*Certificate Number:* **ROT 1201197**  
*First Visit:* **05/12/12**  
*Last Visit:* **05/12/12**

**I have carried out the surveys detailed below. All recommendations made by me have been dealt with to my satisfaction. I am recommending that class be maintained with new records as follows.**

	<b>SURVEYS HELD</b>	<b>STATUS</b>	<b>NEW RECORD</b>
	<b>MACHINERY</b>		
MCHY	Annual Examination LNG Fuel System	COMPLETE	05/12/12

\*\*\* END \*\*\*

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**The above recommendation is made subject to any outstanding conditions of class being dealt with as previously recommended.**

**Signed:**

**A.G. Fredrikze**

**Surveyor(s) to Lloyd's Register EMEA  
A member of the Lloyd's Register Group.**

**Date: 05/12/2012**