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The training of officers and crew of LNG-fuelled vessels: a case study of Norway

Master of Sciences Thesis

ANA PAULA RODRIGUES

Department of Shipping and Marine Technology
CHALMERS University of Technology
Gothenburg, Sweden 2013
Master's Thesis NM-13/43

REPORT NO. NM-13/43

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Department of Shipping and Marine Technology

Chalmers University of Technology

SE-412 96 Gothenburg

Sweden

Telephone + 46 (0)31-772 1000

Printed by Chalmers Reproservice
Gothenburg, Sweden 2013

Preface

This report is my thesis for the degree of Nordic Master of Science in Maritime Management at Chalmers University of Technology in Gothenburg, Sweden. It is about the training of officers and crew on LNG-fuelled vessels. This subject was chosen in May 2013. It was then one and a half year for the new stringent MARPOL requirements on SOx and NOx to enter into force in January 2015. Recent feasibility studies and cooperating projects in the maritime industry indicated that LNG maybe extensively adopted as fuel. Consequently, along with the new IGF Code, the maritime industry was developing at that time equipment standards for the bunkering of LNG. In addition, a number of risk analysis associated with LNG-fuelled vessels where flourishing a bit everywhere. However, with the exception of DNV standard No. 3.325, of April 2013, and the minutes of meetings at IMO, I could not find at that time any public document that openly discussed what training would be needed by the officers and crew of LNG-fuelled vessels from January 2015. Considering that the new MARPOL rules enter into force in just over a year, the time is ripe to discuss and prepare such training. Therefore I chose this subject for my study, aspiring to fill this possible gap. This thesis was concluded in December 2013, in time to provide some support to the shipowner who is considering changing to LNG as fuel soon.

I would like to thank those who have been helpful during the course of my research for their guidance, in particular my supervisor Monica Lundh, and to those who peer-reviewed this report and helped improve its quality. Special thanks also to the events company Mercatormedia for sponsoring my participation in the 4th Gas-fuelled Ships Conference onboard the Viking Grace on 11 & 12 September 2013. Finally, a special thanks to the three companies that accepted to participate in this research.

I hope you will enjoy the case study and find the results worthwhile!

Gothenburg, the 13th of December 2013

Ana Paula Rodrigues
anaprodrigues@hotmail.com

Abstract

Most of the world's fleet has been running on heavy fuel oils but a shift of paradigm seems to be on the way as we move towards a generalized use of LNG as marine fuel. Consequently, the need of preparing the officers and crew for handling LNG becomes evident, and rather urgent. Currently, only Norway has experience on operating LNG-fuelled vessels other than LNG-carriers. This report studied the Norwegian experience, with two purposes:
a) To describe what training was needed for officers and crew of LNG-fuelled vessels, and how it was developed in Norway for meeting those needs.
b) To find out if there are any lessons to be learned from that experience.

The methodology followed is that of a case study based on literature study, a questionnaire based on the Training Need Analysis model, and interviews to two Norwegian shipowners and a course supplier. Content analysis of the data was used to find patterns in the information and to synthetize results, and to relate findings to the theoretical framework of the subject.

Main conclusions:

- Training needs identified included the knowledge of critical properties of LNG, of the critical moments for bunkering LNG, knowledge of the LNG fuel system, its associated systems and impact on vessel operation (maneuvering of the vessel, maintenance and emergencies);
- How training was developed: training needs were recognized early on and training plans were developed early, in collaboration between ship owners, equipment suppliers and other experts in LNG and gas fuel systems, courses were differentiated by crew duties onboard (two levels/three categories), internal/external courses. Moreover, training has been ship specific.
- Lessons learned: the absence of reported gas-related accidents suggest that training solutions developed by Norway are successful, at least for a relatively small fleet. There are indications that the model with two levels/three categories for differentiated training may be used in the future internationally. The requirement of ship specific training could have negative impact if gas-fuelled fleet expands rapidly though.

Keywords: case study natural gas LNG fuelled vessels training Norway

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List of abbreviations

BLG	*IMO's Sub-Committee on Bulk Liquids and Gases*
BOG	*Boil-off gas*
ECA	*Emission Control Areas*
HFO	*Heavy fuel oil*
IGC Code	*IMO's International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*
IGF Code	*IMO's International Code of Safety for ships using Gases or other low flashpoint Fuels*
IMO	*International Maritime Organization*
ISO	*International Organization for the Standardization*
LNG	*Liquefied natural gas*
LNG-carrier	*A tank ship designed to transport liquefied natural gas (LNG). These vessels may use natural gas as fuel.*
LNG-fuelled vessel	*A vessel that uses natural gas as fuel, other than an LNG-carrier.*
MARPOL Convention	*IMO's International Convention for the Prevention of Pollution from Ships (1973/78)*
MGO	*Marine Gas Oil*
MSC	*Maritime Safety Committee (IMO)*
Natural gas	*A hydrocarbon gas mixture consisting mainly of methane.*
NOx	*Nitrogen oxide*
PSV	*Platform Supply Vessel*
SIGTTO	*The Society of International Gas Tanker and Terminal Operators*
SOLAS	*IMO Convention for the Safety of Life at Sea*
SOx	*Sulphur oxide*
STCW Convention	*International Convention on Standards of Training, Certification and Watchkeeping for Seafarers including Manila amendments*
STW	*IMO's Subcommittee on Standards of Training & Watchkeeping*

PART I – INTRODUCTION

1. Background

Most of the world's fleet runs on heavy fuel oil (HFO). Until recent times, the regular use of liquefied natural gas (LNG) as fuel in shipping was confined to LNG carriers (boil-off gas, BOG), under the scope of The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). MARPOL's annex VI introduced Emission Control Areas (ECAs) and a global cap limiting permitted sulphur oxides (SOx)/nitrogen oxides (NOx) levels from 2015. This prompted a number of projects for switching to other fuels in shipping, in particular to LNG. The number of LNG fuelled vessels is expected to increase substantially in the coming years.

Consequently, standards and operational requirements for these vessels need to be developed and ready for implementation by the end of 2014. The international shipping community is currently addressing technical, operational, bunkering and manning challenges that result from this change. International standards and best practices are under development by the International Organization for the Standardization (ISO) and The Society of International Gas Tanker and Terminal Operators (SIGTTO). International mandatory requirements and standards for LNG-fuelled vessels do not exist at the moment. Non-mandatory Interim Guidelines Resolution MSC.285 (86) are temporarily in place while IMO's Sub-Committee on Bulk Liquids and Gases (BLG) develop the International Code of Safety for ships using Gases or other low flashpoint Fuels (IGF Code), and IMO's Subcommittee on Standards of Training & Watchkeeping (STW) develop training requirements for sea personnel on LNG-fuelled vessels. This research contributes to the current discussion in the international arena, with information that may help bridge the current gap in the training for officers and crew in LNG-fuelled vessels.

With this gap in mind, Norway makes an interesting case study because of its pioneer experience on the use of LNG as fuel in vessels other than LNG carriers. The first LNG fuelled passenger ferry in the world is Norwegian (MV Glutra, in 2000); The Det Norske Veritas (DNV) was the first classification society classifying an LNG fuelled vessel (MV Glutra, in 2000) and has accumulated an experience of 13 years having classed more than 30 LNG fuelled vessels; Finally, most of the 35 LNG fuelled vessels currently operating in the world are Norwegian. Lessons learned from the Norwegian experience can be useful in this moment for the rest of the world, as more vessels are expected to be run on LNG and adequate training for their officers and crew is needed.

2. Purpose and research questions

This report aims at studying how Norway developed the training of officers and crew of its LNG fuelled vessels: what training was needed and how training was developed to meet those needs, best practices and standards developed along the way by the Norwegian maritime industry, milestones during this process, and training regulations implemented on a national level.

As the use of LNG as fuel is expected to extend to other countries, it would be interesting to see if there are any lessons to be learned from the Norwegian experience, for eventually taking that into account in future decisions. Hence, the purpose of this research is two-fold:

a) To describe what training was needed for officers and crew of LNG-fuelled vessels, and how training was developed in Norway to meet those needs.

b) To find out if there are any lessons to be learned from that experience.

The purpose of this study is to provide a contribution to current research and discussions on the development of LNG as marine fuel.

3. Scope of the study and limitations

This research focused on onboard training needs of sea-going LNG-fuelled vessels only. LNG-fuelled vessels in inland shipping were not considered in this report, nor where LNG-carriers. LNG is not the only alternative fuel for HFO in the market but this research focuses only on the LNG alternative because it is expected to be the one most widely used in the future and where the number of trained sea-personnel needed in the near future is likely to be larger. The training on LNG as fuel for office-personnel of shipping companies seems to be needed as well, but this was outside the scope of this study.

In geographic terms, this research is limited to Norway, where LNG has been used as marine fuel in the past 13 years. For the international context section, this study focused on the short sea shipping in the North and Baltic Seas.

In temporal terms, the time span covered by this research is limited to the interval 2000–2013 approximately, reflecting the time-span in which LNG-fuelled vessels have been operating in Norway.

4. Methodology

The methodology followed is that of a case study with qualitative methods, fitting the explorative nature of the research questions. Data collection is based on literature study, a questionnaire grounded on the Training Need Analysis (TNA) model, and interviews to three relevant stakeholders in Norway. Data analysis consists of context analysis to find patterns in the data and compare findings to the theoretical framework of the subject.

PART II – THEORY

1. The route towards LNG as fuel

The driving forces

Most of the world's fleet runs on heavy fuel oil (HFO) (Svensson, 2011, p.1). But a shift of paradigm is now on the way. Forces acting in the near future are driving up this change, with particular impact on shipping in Emission Control Areas (ECAs)(DNV, 2012):

- Limitation of the sulphur oxide content permitted in marine fuels from 2015, and
- Restrictions in the emission of nitrogen oxides in shipping from 2016.
- The difference in price between LNG and HFO (Germanischer Lloyd, 2012).

Environmental concerns about air pollution, documented evidence of its impacts on the human health, and the effects of acidification led to new international regulations to tackle the problem (Svensson, 2011, pp.15-22). They aim, on the one hand, at reducing air pollution caused by ships and, on the other hand, at increasing the efficient use of fuel in shipping. IMO introduced, on a progressive basis, limitations on sulphur oxides (SOx) and nitrogen oxides (NOx) emissions from shipping, and the designation of Emission Control Areas (ECA). Fig.1 plots milestones in air emission regulations for shipping:

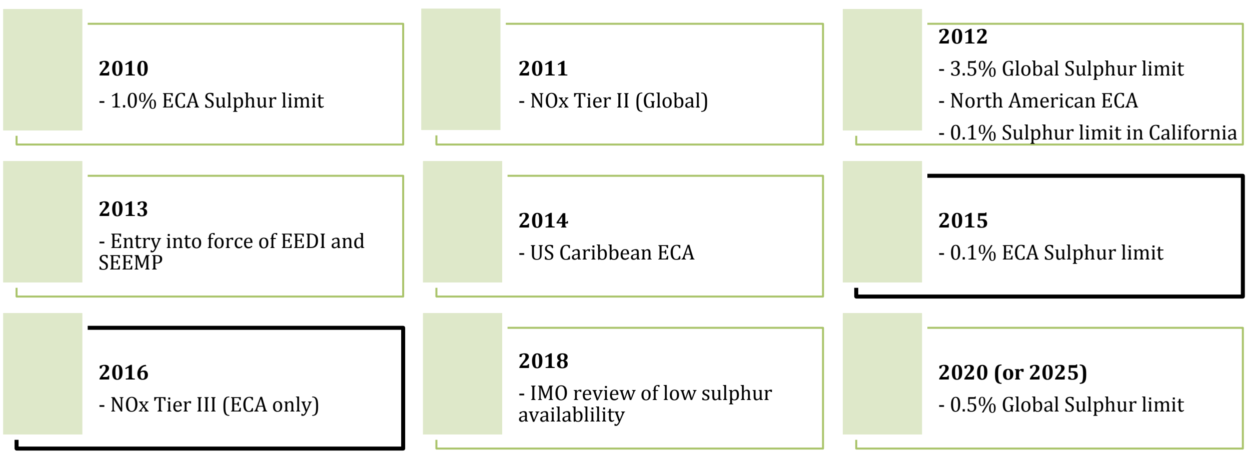

Figure 1. Milestones in air emission regulations for shipping 2010-2020 (adapted from DNVb, 2010, and IMO, 2013b, and IMO, 2013c).

These mandatory requirements are the object of Marpol's Annex VI on the Prevention of Air Pollution from Ships, which entered into force in 2005 (IMO, 2013c). In addition, IMO introduced requirements to reduce greenhouse gases (GHG, in particular CO2 released by shipping) and to improve fuel efficiency, through an Energy Efficiency Design Index (EEDI) and a Ship Energy Efficiency Management Plan (SEEMP) (IMO, 2013a).

By 2015 there will be three designated ECAs: Baltic Sea, North Sea and English Channel (including English Channel's coast of France), North America and US Caribbean. In these areas there will be then strict restrictions for shipping in regards of SOx and NOx permitted. By then, ships sailing in these areas have to comply with these restrictions, which implies having to switch to other fuels or installing exhaust abatement equipment onboard; The shipping industry, marine engines' industry, technology R&D and suppliers of alternative fuels are working intensely on this issue now, and seminars and conferences on this subject have multiplied in recent years.

Moving towards LNG as a marine fuel

Sulphur oxides are present in conventional fuels, such as HFO. To reduce emissions of SOx into the atmosphere, scrubbers are installed onboard ships using residual oils for capturing SOx in the exhaust gases. Alternatively, other fossil fuels with less or no SOx at all can be used (marine gas oil, marine diesel oil, or natural gas). Nitrogen oxides are formed during combustion. To reduce the emission of NOx into the atmosphere, Selective Catalytic Reduction (SCR) systems are installed onboard vessels using fuel oils for capturing NOx in their exhaust gases. Alternatively, a fossil fuel that generates a negligible amount of NOx can be used (natural gas).

Along with the renewable fuel methanol, the most often discussed alternatives at the moment are fossil fuels:

- Combined use of HFO, scrubbers and SCR;
- Marine distillates, such as marine gas oil MGO;
- Liquefied Natural gas (LNG).

One solution does not necessarily have to fit all cases. For example, it is possible that methanol could be the most suitable solution for a particular company in the near future once the costs and availability of methanol near to regular sailing routes are analysed. The “Methanol: marine fuel of the future” project (2013-2015), benefiting among others Stena and the port of Gothenburg (European Commission, 2013), is working on this option. However, under the present climate of uncertainty, natural gas has been highlighted by different sources as the maritime fuel of the future. This in spite of initial hesitation about the bunkering infrastructure and distribution network needed in Europe for this solution, uncertainty about the development of gas/LNG prices, and the added costs this option represents to shipping companies in retrofittings and newbuildings.

John Hatley, Wartsila North Americas: *“It will increase substantially (…) natural gas will definitely become a significant fuel given the benefits of clean, abundant, affordable, and American.”*

Henrik Madsen, CEO DNV: *“I am convinced that gas will become the dominant fuel for merchant ships. By 2020, the majority of owners will order ships that can operate on liquefied natural gas.”*

Mogen Schrœder Bech, Danish Maritime Authority: *“I find LNG to be an obvious solution to comply with the implications of the North European waters becoming an Emission Control Area (ECA) in 2015”.*

Figure 2. *Natural gas: the marine fuel of the future? (Source: DNV, 2010)*

Ships using natural gas as fuel reduce the emission of CO2 by 15%-20% (DNV, 2010) compared with using other fossil fuels. Most importantly, such ships are inherently compliant both with 2015’s SOx restrictions in ECAs and 2016’s Tier III NOx requirements. In a longer perspective, natural gas will inherently also comply with the global sulphur limits set for 2020 (DNV, 2012). In fact, recent research comparing different solutions with three fossil fuels concluded that natural gas gave the best overall environmental performance (Nikopoulou, Cullinane, Jensen, 2013, pp.147-148). For vessels operating exclusively or mainly inside ECA area this is a particular advantage. However, ships that use natural gas as fuel are more expensive to build. DNV estimations point to a 20-25% added cost compared with ships using conventional engines, but this cost should decline as more gas-fuelled ships are built and become standardized (Nikopoulou, 2008, p.17, Nikopoulou, Cullinane, Jensen, 2013, pp.147-148). Retrofitting is another option.

In what concerns prices for LNG, these can show regional variations (Nikopoulou, 2008, p.16, Germanischer Lloyd, 2012). Natural gas production and liquefaction, and the distribution and storage of liquefied natural gas (LNG) are capital-intensive activities. The natural gas industry is therefore characterized by long-time contracts. This locks gas prices for longer periods of time. On the one hand this makes it easier to plan costs ahead (Nikopoulou, 2008, p.16) but on the other hand it also makes it more difficult to negotiate gas prices (Stopford, 2009, p.487). However, with the indexation of gas prices to oil and the possibility for hedging gas prices, there is more flexibility on gas pricing today, as defended by Stopford (2009, p.487). This applies also to LNG, as LNG prices follow natural gas prices (DNV, 2012, p.25, DMA, 2012, p.16). As a result, different scenarios for LNG prices can be expected for the future. Several sources indicate that LNG will be cheaper than MGO, and the same price as HFO (Germanischer Lloyd, 2012).

The supply chain of LNG as marine fuel in Europe's ECAs is still under development. Until recently, there were no LNG-fuel supply infrastructure was available for shipping, except in Norway (Germanischer Lloyd, 2013). A possible model will consist of a network of LNG bunker vessels and intermediate terminals, feeder LNG vessels and large-scale LNG terminals. The figure below illustrates a possible structure for the distribution of LNG to shipping:

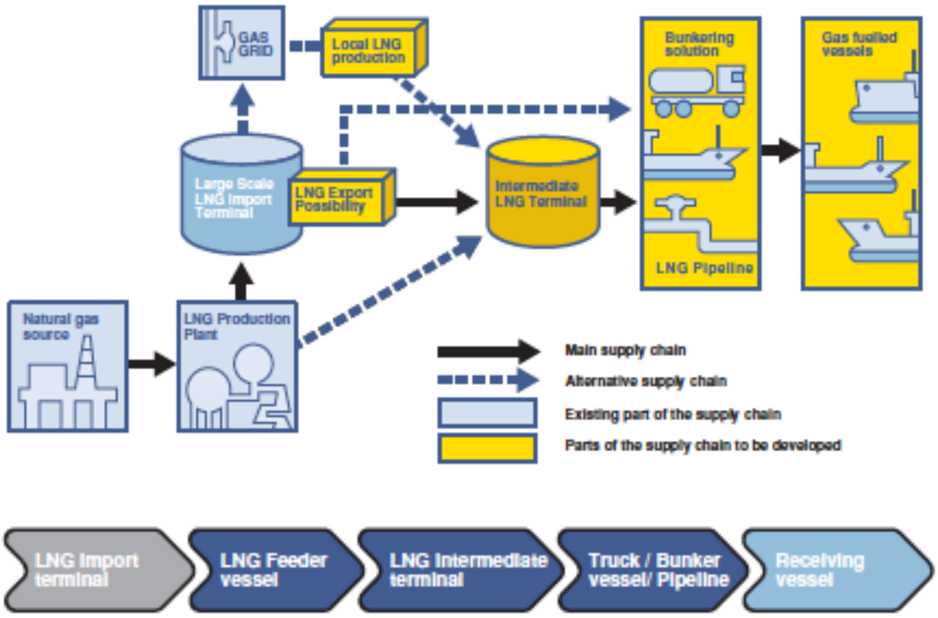

Figure 3. *LNG distribution channels (Source: CNSS, 2013).*

LNG carriers deliver large LNG cargoes to existing large-scale LNG terminals. LNG is then distributed to regional small-scale terminals by tanker feeders or directly to LNG-fuelled vessels by LNG bunker vessels. Note that IMO's IGC Code applies to LNG carriers as well as to LNG bunker/feeder vessels, whereas the future IGF Code will apply to receiving vessels i.e. LNG-fuelled vessels.

The supply and demand of marine LNG fuel has been met by the industry with uncertainty and hesitation. Shipping is going through a trough, in parallel with the prolonged recession in Europe since 2008, evidenced by a number of articles in the shipping specialist press. The stringent SOx and NOx restrictions add to the bulk of uncertainties experienced by shipowners at the moment. Shipowners are facing the decision whether to invest in engines that run on natural gas or in abatement equipment, or in both (Dual Fuel engines). Either way, the prospect of additional costs lurking in the near-horizon in times of such financial struggling does not improve the sentiment. On the other hand, LNG fuel infrastructure and distribution network need to be created in Europe in order to ensure efficient supply of LNG to gas-fuelled vessels operating in the near future in the ECAs. However, it is a considerable financial risk to invest in the supply chain without having assured first that there will be a demand for LNG as marine fuel. A clear sign from shipping companies on the adoption of LNG as fuel is needed first. These initial hesitations about the LNG as marine fuel in shipping in Europe are now dissipating. The European Commission (EMSA, 2013) is clearly encouraging the use and distribution of LNG as marine fuel, through financial incentives to the maritime industry and R&D. The number of projects and studies in the North and Baltic Seas have multiplied in recent years:

- The “Make a Difference” project (2012-2014), led by SSPA Sweden, benefiting Sirius Rederi and Viking Line, among others.
- The “LNG in Baltic Sea Ports” project (2012-2014): the development of an harmonized LNG bunkering infrastructure in the Baltic Sea area, benefiting among others the ports of Stockholm and Helsingborg.
- The “North European LNG Infrastructure” project (2010-2013) led by the Danish Maritime Authority (DMA), benefiting Fjordlines’ new LNG-fuelled vessels, among others. This study includes recommendations on training.
- The project for converting Fjalir into the world’s first LNG-bunker vessel (Seagas) (2012-2013), benefited by AGA.
- The “Clean North Sea Shipping” project (2007-2013): the development of strategies and guidelines for clean shipping, benefiting among others the Ports of Gothenburg and Bergen, Gasnor and the Swedish Marine Technology Forum (CNSS, 2013).
- The “LNG Bunkering Infrastructure Solution and Pilot actions for ships operating on the Motorway of the Baltic Sea” project (2013-2015), benefiting the port of Brofjorden and several shipping companies, among others (European Commission, 2013).

The use of LNG as fuel has been until recently limited to Norwegian vessels, operating on the Norwegian coast, near their supply sources of LNG. However, new developments in LNG-fuel infrastructure include the terminals in Fredrikstad, Lysekil, Gothenburg and Gävle (Skangass, 2013), an LNG-bunker vessel Seagas. More vessels have recently adopted LNG as fuel, e.g. Bit Viking, Viking Grace, Fjordline ferries. Based on the information of above projects it is clear that we are moving toward a generalized use of LNG as fuel in shipping and a multiplication of sources of LNG marine fuel in Northern Europe.

2. LNG as marine fuel

2.1. Operational aspects

The main operational challenges of LNG marine fuel is its handling, bunkering operation, and storage onboard (DNV, 2012).

Handling LNG

The safe handling LNG requires knowledge about its properties and behaviour. Based on McGuire and White (2000), a brief description follows. LNG is methane gas that has been cooled down to -162C so that it condenses into a liquid state (LNG) at normal atmospheric pressure. The purpose with liquefaction is to reduce the volume it would otherwise occupy had it been in gas form (natural gas). Methane can then be shipped as LNG, instead of being transported as gas by pipelines, and stored in insulated tanks – cargo tanks on LNG carriers, storage tanks in terminals, cargo tanks in LNG bunker vessels or storage LNG-fuel tanks in gas-fuelled vessels. LNG requires special materials (cryogenic materials) that can withstand such low temperatures when in contact with it e.g. tanks, piping, valves, etc. If LNG comes in contact with a surface that is not able to withstand such low temperatures, such as the ship's deck and hull, this will cause the material to crack (brittle fracture). LNG should never come in contact with a person, as it would cause frostbite. Mitigation measures in place for the event of a leak include emergency shut down, water trays and water curtains on ship's side. LNG's flashpoint is -175C. This means that at -175C LNG gives off enough gas vapour which can ignite if oxygen is present in the right proportion (the flammable range) and there is an ignition source. Gas vapours also causes asphyxiation. Therefore gas-detecting systems, both portable and fixed, are needed to detect any unsafe atmosphere. Pressure and temperature are important parameters when handling LNG. It is important to know that even a slight increase in the temperature of LNG generates vapour gases, which, in turn, increase the pressure in pipes and tanks. With the right knowledge and techniques, this pressure is controlled and managed properly. LNG vapours, i.e. natural gas, are flammable within the range 5-14% mixture with oxygen. This knowledge is important, so that safeguards can be implemented in order to prevent gas vapours to mix with oxygen e.g. inerting with nitrogen or preventing ignition sources in areas where gas vapours are likely e.g. in the bunkering stations. The boiling point of liquefied methane is -161.5C, slightly higher for LNG fuel, since it is not pure methane. Therefore, leaks of LNG fuel will first sink and form a pool of boiling LNG. As its temperature increases further, its density decreases and soon the boiling pool turns into a vapour cloud and starts rising, as natural gas becomes lighter than air. Knowing the properties of LNG helps understand the behaviour of an LNG fire. The figure below shows typical characteristics of a LNG fire, taught at LNG fire trainings (Linde, 2012).

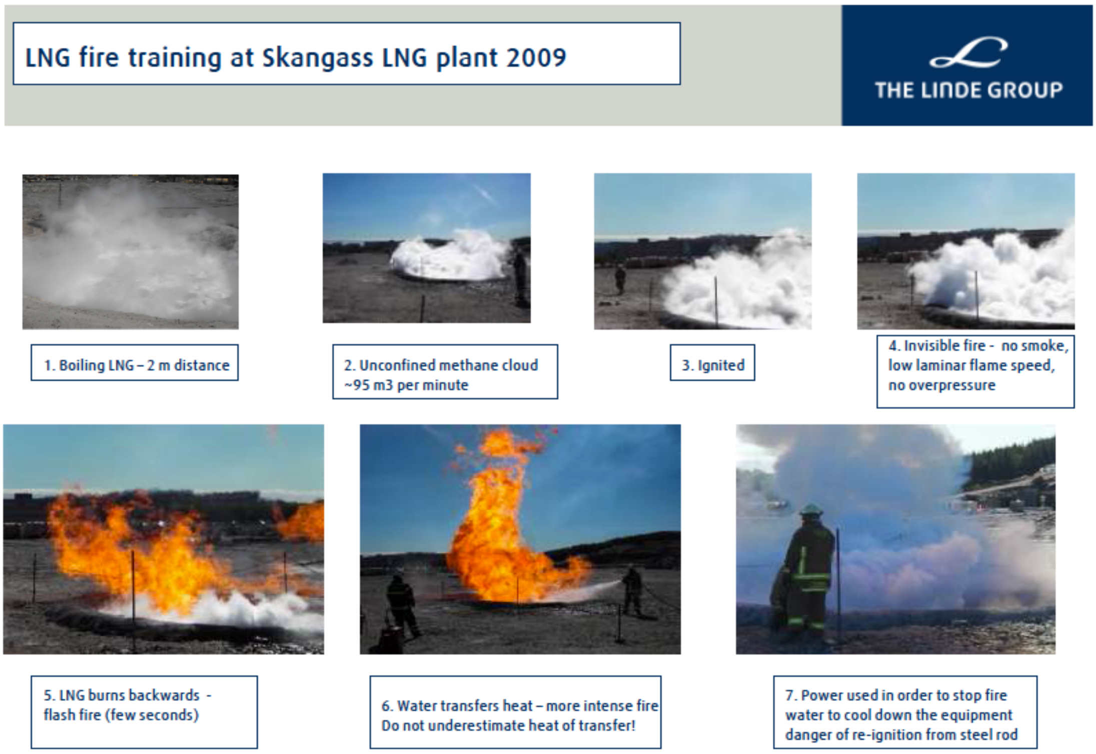

Figure 4. *Typical characteristics of LNG fires (Source: Linde, 2012).*

Knowing the properties of LNG is important for prevention of accidents, for personal safety, for LNG-fire-fighting competence and emergency response/mitigation, but extends also to understanding the systems needed for the normal operation of a LNG-fuelled vessel, such as bunkering operations, such as gas engine system, gas detecting systems, emergency valves, instrumentation and other gas related equipment, adequate personal protective equipment, and safe practices onboard.

The figure below shows a section of an engine room in a LNG-fuelled vessel, where a Dual Fuel (DF) engine system has been installed. A Dual Fuel engine operates with gas or marine diesel oil, for flexibility. Another option is a gas-only engine.

Figure 5. *Wärtsila DF Engine (Source: www.wärtsila.com)*

In a LNG-fuelled engine system, LNG is transferred from pressurized LNG storage tanks into the gas engine in insulated pipes coloured yellow. Before entering the engine, LNG has first to be turned into gas, using vaporizers/heat exchangers, and have a given pressure toward the engine (this is regulated by a gas valve unit, GVU). Besides of the gas engine, LNG storage tanks, insulated piping, and gas valve units, other features that differ a gas engine system from a conventional engine system include gas detections systems, specific automation, and bunker stations suitable for receiving LNG (Wärtsila, 2013).

Bunkering operation

Bunkering of LNG-fuelled vessels is carried out in any of the following three ways (see figures below):

1. ship-to-ship (STS)
2. truck-to-ship (TTS)
3. terminal-to-ship (pipeline or tank) (TPS)

The figure below illustrates these methods. Examples of application of each method are shown on following page.

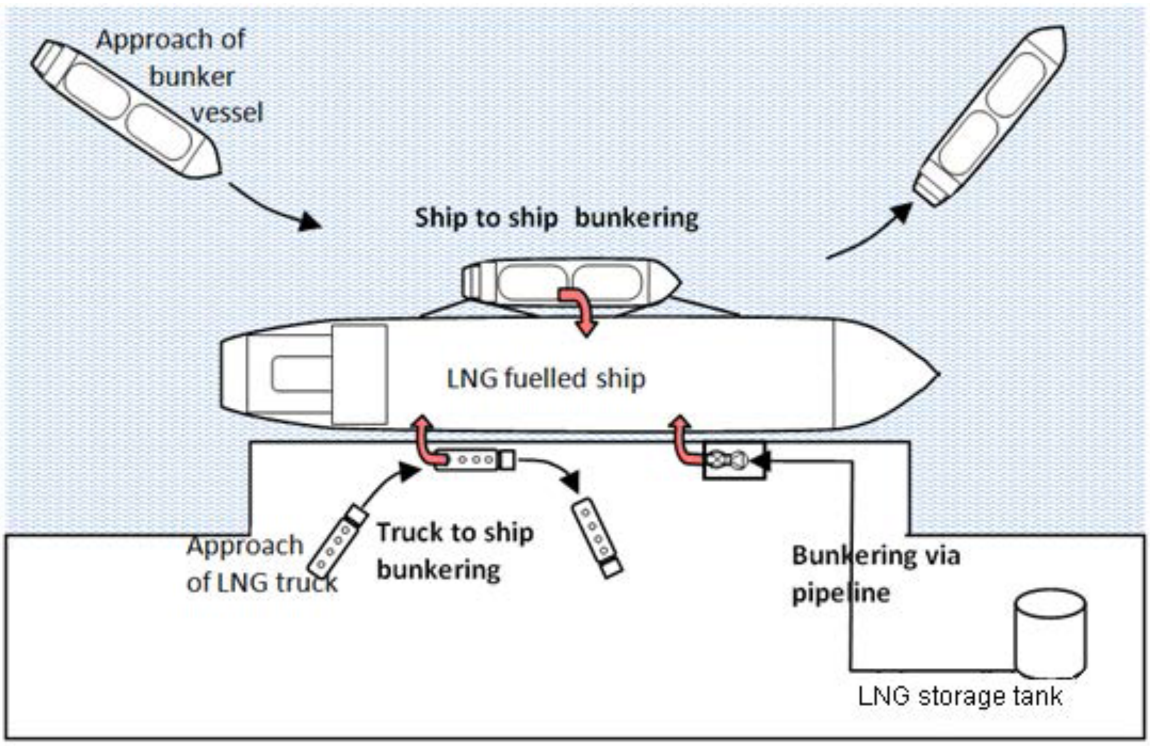

Figure 6. *Three different bunkering methods (Source: DMA, 2012).*

Figure 7. *AGA trucks bunkering Viking Grace: TTS (Source: HHP Insight, 2013).*

Figure 8. *Seagas bunkering Viking Grace: STS (Source: Zerovisiontool, 2013).*

Figure 9. *Bunkering Bit Viking at Risavika Terminal (TPS) Source: (Skangass, 2011).*

Most bunkering of LNG-fuelled vessels has been carried out only in Norway, for the past 13 years. However, this scenario is changing, with the recent introduction of other LNG-fuelled vessels and other bunkering methods. Bunkering the LNG-fuelled vessel Viking Grace, built 2013, was done initially by TTS. The first LNG supply vessel in the world, the Seagas, started operations in 2013, and since then Viking Grace has been bunkered by STS instead, in Stockholm (Gas-Fuelled Ships Conference, 2013).

A typical bunkering sequence onboard a LNG-fuelled vessel follows four distinct moments (DNV, 2012a and 2012b):

1. General
2. Pre-filling
3. Filling
4. Post-filling

In the first step, there is a general exchange of information and communication with the parties involved in the bunkering.

In the pre-filling step, the bunkering lines are made ready for LNG. They need to be cooled down and cannot contain any moisture or oxygen. The low temperature of LNG would cause damage when in contact with warmer lines and cause pressure peak as LNG expands to gas in the contact. As gas is flammable under certain oxygen levels, oxygen must be removed from the lines to render them safe. Consequently, in this step there is a pre-cooling of shore-side lines and pump (in some cases pressure differential is used instead of pumps), connection of bunker hose to the ship (bunkering station), oxygen and water are removed from the ship's lines (inerting, with nitrogen), nitrogen is then pushed out from the line using natural gas (purging).

In the filling step, LNG is transferred from shore-side to vessel, following in a sequential way in order to control the pressure in the ship's tanks.

Bunkering is finalized with the post-filling step in which valves are closed and what is left of LNG in the bunkering line is forced into the ship's tank, using the pressure in the lines. At this point, the lines are full of natural gas, which is removed with nitrogen (inerting), for safety reasons. The bunker hose is disconnected and the bunker operation is finished.

Storage of LNG onboard

LNG properties require cryogenic containment systems and equipment associated with the bunkering and engine operation. Storage onboard consists of tanks that can withstand the low temperature of LNG.

Figure 10. *Bit Viking. LNG fuel tanks on deck (Source: Germanischer Lloyd, 2013)*

2.2. International standards and regulations

This section describes the status on current international training standards and regulations on training of crew on LNG-fuelled vessels.

Training: the human element in risk and safety management

Analysing the properties of LNG and the operational aspects described above, it can be inferred that:

a. Critical features introduced onboard vessels that adopt LNG as marine fuel include LNG properties, gas behaviour related to temperature and pressure, storage tanks and piping and engine systems, inerting techniques, instrumentation, gas detection systems, fire-fighting systems and emergency shutdown procedures and safety procedures specific to LNG as fuel onboard.

b. Competence and training are critical for the safe handling of LNG and for the safe bunkering operations on LNG-fuelled vessels.

Competence and training play an important role in reducing risks and prevention of accidents. As Geir Bjørkeli, Vice-President in Rolls-Royce Marine has put it (MidtSiden, 2013):

> *"LNG er ikkje ufarleg, men kunnskap er nøkkelen til å redusera risikoen. Dette handterast gjennom eit veltrent mannskap og gode prosedyrar, fortel osingen Geir Bjørkeli, salgs- og marknadsdirektør i Rolls Royce)."*
> **That is: LNG is not entirely safe, but competence is the key to reduce the risks. This is achieved by well-trained personnel onboard and right procedures** (author's translation).

Up to 80% of accidents at sea are caused by human error (Hetherington, Flin and Mearns, 2006, and Trucco *et al*, 2008). Training, being an aspect of managing the human element, should then reduce risks and accidents. Trucco *et al* study (2008) supports this connection. Training personnel that will have duties onboard LNG-fuelled vessels, but also a reduction in risk of accidents at sea caused by human errors when handling LNG. LNG in shipping is nothing new. Large cargoes of LNG have been shipped worldwide since the 60's, by specialized vessels dedicated to this segment – LNG-carriers. This trade has a good safety record (NMA, 2013), low in accidents, reflecting the hard work of many years in this segment in maintaining high standards of safety onboard. The introduction of LNG as a new marine fuel in the market will benefit from the excellent safety record of LNG-carriers but shipowners, operators and designers of LNG-fuelled vessels carry the responsibility to preserve it, through training.

This concern was voiced by SIGTTO on IMO's BLG16 session in 2011 (IMO, 2011a). SIGTTO is an organization that has developed a significant amount of standards specific to LNG and best practices in LNG shipping, and works in close relationship with its Members and IMO. SIGTTO's recently created branch Society for

Gas as Marine Fuel (SGMF) focuses on the LNG-fuelled vessel segment.

> *"The LNG and LPG shipping industries have an excellent safety record, which has been achieved and maintained by high standards of training and operational procedures and tried and tested design. Unfortunately, this safety record has led many people to think that these products are intrinsically safe and can be handled with impunity. When attending meetings and conferences pertaining to the use of LNG as ship's fuel we are concerned at the lack of knowledge on the hazards and properties of LNG, particularly those posed by its very low temperature and flashpoint and that it requires only 1/80th of the energy to ignite it compared with marine distillate fuel. Therefore, it is essential that potential designers, owners and operators of LNG-fuelled ships are educated to this effect and supported by a robust regulatory framework, which will likely require a degree of prescription until a greater depth of experience is achieved in the design and operation of these vessels.*
> *(…)*
> *It is apparent from attendance at conferences and meetings that many people who are considering the use of cryogenic and low flash-point fuels have little or no knowledge of their properties and hazards, and it is imperative that crew members responsible for handling these fuels are suitably trained and certificated."*
>
> (SIGTTO, at IMO, 2011a)

One possibility when developing training of personnel in LNG-fuelled vessels is to draw from the long experience of LNG-carrier operations. It is also possible to draw from Norway's experience as pioneers in training their personnel onboard LNG-fuelled ferries and supply vessels for more than ten years.

There are no international mandatory regulations for training requirements of personnel onboard LNG-fuelled vessels

IMO's International Safety Management Code (ISM Code) enforces the training of personnel as part of a company's safety management is enforced by). In this context, the ISM Code ((IMO, 2013, Part A, sections 1.2, 6 and 7) requires companies to:

1. Identify risks,

2. Train the personnel for emergencies and other safety management skills,

3. Give familiarization to personnel with new assignments,

4. Identify training needs, define procedures and instructions (incl. checklists) to ensure safe operations and the safety of the vessel,

5. Train the personnel onboard for emergency (emergency preparedness),

6. Record accidents and hazardous occurrences and use that information to improve safety[1].

IMO's International Code of Safety for Ships using Gases or other low-flash point Fuels (IGF Code) (IMO, 2013d) will regulate vessels using LNG as marine fuel. When studying regulations concerning LNG in shipping, it is important to start by distinguishing two different perspectives:

1. Regulations that apply to tankers carrying LNG as cargo, such as LNG carriers, LNG feeders/barges. These vessels also use gas as fuel but they do not receive LNG bunker: the gas used in their engines is taken from the LNG cargo they carry.

2. Regulations that apply to LNG-fuelled vessels, such as passenger ferries, supply vessels, tankers. These vessels

[1] To improve safety and, subsequently, to improve their training plans (author's note).

receive LNG bunker from, e.g. trucks, barges or by a terminal pipeline.

Until recently, the regular use of natural gas as fuel in shipping was confined to LNG carriers, regulated by IMO's International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). The IGC Code covers requirements on the design, construction and equipment requirements (IMO, 2013d). However, the IGC Code applies only to tankers carrying LNG as cargo (point 1, above). The IGC Code does not apply to LNG-fuelled vessels (point 2, above). There is at the moment no international code with specific regulations for vessels that use LNG as fuel. In fact, the use of fuels with flashpoint lower than 60C (which is the case of natural gas) is not allowed (IMO, 2004, SOLAS II-2 p.163). For this reason, IMO's Sub-Committee on Bulk Liquids and Gases (BLG) has been working on a new code: the International Code of Safety for Ships using Gases or other low-flash point Fuels (IGF Code) (IMO, 2013d). The new IGF Code will apply to LNG-fuelled vessels, and is expected to be adopted in 2014, just before the new SOx requirements enter into force in ECAs in 2015 and the expected expansion in the numbers of LNG-fuelled vessels.

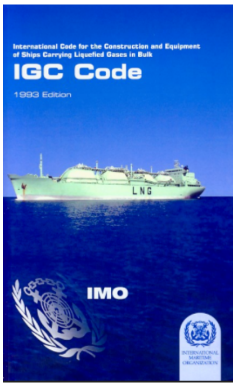

Figure 11.
IMO's IGC Code for LNG-carriers (Source: www.imo.org).

Figure 12. *IMO's IGF Code for LNG-fuelled vessels will be ready in 2014.*

IMO's International Convention on Standards of Training, Certification and Watchkeeping for Seafarers including Manila amendments (the STCW Convention) (IMO, 2011): this Convention has specific requirements for sea personnel working with LNG onboard, namely Regulation V/1-2 (IMO, 2011, p. 44) and Section A-V/1.2 (IMO, 2011, p.198-208). However, these STCW requirements apply only to personnel onboard tankers carrying LNG as cargo; no training requirements for those working onboard LNG-fuelled vessels could be found in this convention either. Such training is still unregulated, at least internationally. The IGF Code or/and the STCW Convention will therefore include new training requirements for personnel on LNG-fuelled vessels, which are being developed by IMO's Sub-Committee on Bulk Liquids and Gases (BLG) in co-operation with IMO's Subcommittee on Standards of Training & Watchkeeping (STW), with inputs from the maritime industry such as the Norwegian Maritime Authority (NMA), Danish Maritime Authority, Den Norske Veritas (DNV), The Society of International Gas Tanker and Terminal Operators (SIGTTO), engine manufacturers and other relevant stakeholders

IMO's Interim Guidelines MSC.285(86), adopted in 2009: are not mandatory but provide at the moment the only available guidance, in the absence of any international mandatory requirements for training of personnel onboard gas-fuelled vessels.

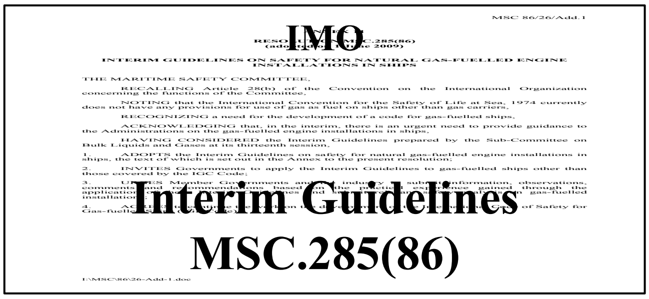

Figure 13.
IMO's Interim Guidelines On Safety for Natural Gas-Fuelled Engine Installations in Ships, Resolution MSC.285(86) adopted on 1 June 2009 (Source: www.imo.org).

The process leading to the development of these guidelines and of the IGF Code was based on the work carried out by the Norwegian Authorities (CNSS, 2013, p.51) and a proposal from Norway in 2004 to develop a gas code (Germanischer Lloyd, 2013b and NMA, 2013). Chapter 8 is dedicated to the training of personnel onboard gas-fuelled vessels. As these guidelines are not mandatory, and therefore each Flag State is free to decide on the training on their fleet of LNG-fuelled vessels. Thus, one cannot expect a great level of harmonization of training standards. For the moment the fleet of LNG-fuelled vessels has been so far confined to Norway but in the near future a significant increase is expected in the number of gas-fuelled vessels, and with it a proliferation of different training standards. It is hoped that a more harmonized high quality in standards will be possible when the IGF Code is in force.

In parallel to the work being carried out by IMO and its Sub-committees BLG and STW, other stakeholders in the maritime industry have been developing guidelines and recommendations about training of personnel on gas-fuelled vessels. The classification society DNV is the classification society of the Norwegian gas-fuelled vessels. Recognizing the need for international standards in training of the personnel onboard LNG-fuelled vessels, DNV published this year their guidelines for such training, in "*Competence Related to the On Board Use of LNG as Fuel"* (DNV, 2013).
The International Organization for Standardization (ISO) is responsible for international standards in industries, developed by its Technical Committees (TCs), composed by several working groups of experts in varied fields (ISO TC 67 WG 10, 2013, pp.26-27). After initiative from Norway in reaction to the lack of LNG bunkering regulations (Germanischer Lloyd, 2013c), ISO established the expert group *ISO Technical Committee 67 Working Group 10*, to develop "Guidelines for systems and installations for supply of LNG as fuel to ships". This document focuses on LNG bunkering operations and the interface terminal-to-ship and ship-to-ship, but it is expected to include also recommendations on training requirements for crew on LNG-fuelled vessels (Germanischer Lloyd, 2013c). Set to be complete by 2014, these Guidelines may still be on time to contribute to further development of the IGF Code and STCW Convention, at IMO.

The European Maritime Safety Agency's (EMSA) study on Standards and Rules for bunkering of gas-fuelled Ships (Germanischer Lloyd, 2013c): This report was published in February 2013 and highlighted gaps in regulations associated with

LNG-fuelled vessels. Identified gaps included training requirements of personnel onboard LNG-fuelled (seagoing)vessels:

- There are at the moment no regulations for such training.
- The IGF Code is still under development at IMO, with inputs from both the BLG and the STW Sub-Committees.

This report makes also reference to SIGTTO's LNG Ship Fuel Advisory Group working group for developing own proposal of training requirements.

Finally, the *Recommendations from the North European LNG Infrastructure project* (DMA, 2012): This project focused on studying what infrastructure is needed for the storage and distribution of LNG as marine fuel. The report was published in May 2012 and it included 22 recommendations, of which, one is about training of sea personnel onboard LNG-fuelled vessels. The report highlighted the safety record of LNG handling, and expressed concern about the lack of specific training for crews on LNG-fuelled vessels and the need to ensure sufficient levels of trained personnel. Consequently, recommendation 15b states that training for LNG-fuelled vessels needs to be developed as soon as possible in order to meet the requirements expected with the introduction of LNG as marine fuel. It also points out the need to assess if adequately trained personnel will be in sufficient numbers at the time they will be needed. IMO, and training institutions were encouraged to assist in overcoming these issues.
Accordingly, IMO's Subcommittee STW was informed by Denmark of recommendation 15b, at the STW's 44th Session in 22 February 2012 (IMO, 2012).

3. The experience of Norway

Norway started using LNG as fuel in ships other than LNG-carriers in the year 2000, accumulating an experience of more than 13 years. The first LNG-fuelled vessel was a passenger vessel called Glutra (2000). Soon after, in 2003, the first LNG-fuelled cargo vessels followed her example. Ten years later, in 2013, the Norwegian fleet of LNG-fuelled vessels had increased to 32 vessels, the majority being passenger vessels (see table below).

Table 1. *Norwegian fleet of LNG-fuelled vessels (based on NMA, 2013)*

Year	Name	Type
2000	Glutra	Ferry
2003	Stril Pioneer	PSV
	Viking Energy	
2006	Bergensfjord	Ferry
2007	Fanafjord	Ferry
	Mastrafjord	
	Raunefjord	
	Stavangerfjord	
2008	Viking Queen	PSV
2009	Viking Lady	PSV
	Tidedronningen	Ferry
	Tidekongen	Ferry
	Tideprins	Ferry
	Barentshav	Cargo
	Moldefjord	Ferry
2010	Bergen	Cargo
	Fannefjord	Ferry
	Romsdalsfjord	Ferry
	Korsfjord	Ferry
	Selbjornsfjord	Ferry
	Sortland	Cargo
2011	Scandigamma	PSV
	Boknafjord	Ferry
	Tresfjord	Ferry
2012	Viking Prince	PSV
	Olympic Energy	PSV
	Høydal	Cargo
	Norman Arctic	PSV
	Landegode	Ferry
	Værøy	Ferry
	Barøy	Ferry
2013	Lødingen	Ferry

The availability of natural gas in Norway and the latest strategies adopted by Norwegian governments may explain the leading position of Norway and this expansion of the fleet.

According to Jevne, Dahle and Sæter (2003), Norway has been a traditional user of hydropower but the use of natural gas in the industry and transport sectors increased in the nineties, albeit gradually. Natural gas was transported by pipeline from the North and Barents Seas to receiving terminals on the Norwegian Coast. Taking into account Norway's topography, it can be inferred that it favors further distribution of natural gas by sea and road (trucks), instead of by pipeline, from small-scale LNG coastal terminals. It can also be inferred that this created early on the conditions for gas-fuelled vessels. Supply of LNG marine fuel is done today from Kollsnes and Karmøy.

More recently, the use of natural gas in shipping, R&D in this area and the development of the necessary LNG-infrastructure in Norway has been clearly encouraged with Norway's maritime strategy (Norwegian Ministry of Trade and Industry, 2007). The financial support made available to the maritime industry through the "Næringslivets NOx-fond" further stimulated shipowners to use LNG as fuel, as stated by the Minister of Trade and Industry of Norway, in an interview quoted in DNV, 2010. 41 ships have been so far granted support for this purpose (Høibye, 2012). In the case of the Norwegian LNG-fuelled ferries, the Minister of Trade and Industry added that specific tender requirements included that they had to use natural gas (DNV, 2010).

With access to LNG and incentives to change fuel or build new LNG-fuelled vessels, the Norwegian fleet using marine LNG fuel expanded from one vessel in 2000 to 32 vessels 13 years later. Bunkering operations usually have dedicated bunkering arrangements. Vessels are bunkered either by truck to ship (TTS) or from a storage tank ashore to ship (TPS), most often by truck, from a dedicated station along the Norwegian coast: Tjeldbergodden (Glutra, since 2000) and Ågotnes (PSVs) (Jevne, Dahle and Sæter, 2003), but also at Halhjem, Risavika, Fredrikstad, Lødingen, Moskenes and Bodø (NMA, 2013). It is not allowed to carry LNG-bunkering of ferries with passengers onboard (NMA, 2013).

In 13 years of operations, no accidents on handling of LNG as fuel in Norway have been reported or recorded (SSPA, 2010, p. 35 and NMA, 2013), with the exception of two small leaks during ship LNG-bunkering operations (NMA, 2013). Based on their experience, the Norwegian Maritime Authority concluded recently:

> *"The safety of the LNG fuelled ships is good, but notes that most LNG shipping operations today are focused with dedicated bunkering arrangement. A general increase LNG shipping activity may require further development of safety culture and standard solutions which can be utilized by "any" LNG ship"*
>
> *(NMA, 2013).*

Norway’s experience in this area is brought to IMO as recommendations at the meetings for developing the future requirements for training in the IGF Code (Appendix A, IMO 2013e).

Based on these facts, Norway’s know-how on operating and bunkering LNG-fuelled vessels is undeniable and has been lately much sought after internationally, from other stakeholders that are considering LNG as marine fuel. This is evidenced by the recent visit by a delegation from the New York Fire Department and the Staten Island Ferry Company to the Haljem LNG-terminal in Norway (Bergen region), as reported by MidtSiden (2013). The purpose of this visit was to eyewitness that it is possible to operate and bunker LNG-fuelled vessels safely, and to draw from the experience of Fjord1, engine manufacturer Rolls-Royce, Port Authorities and the Fire Brigade on best practices for bunkering and safe handling of LNG as marine fuel (MidtSiden, 2013).

PART III – METHODOLOGY

This section describes the design and methods that guided this research.

1. Why a case study?

Definition and terminology

According to Patton, "case study can refer to the process of analysis or the product of analysis, or both" (2002, p.447). This case study is both. As a process, it covers methods to collect data and to analyze it afterwards. As a product, it is the result of the analysis. Case studies can be layered or nested (Patton, p.447). This case study is nested. With nested it is meant that it incorporates studies of individual 'sub-cases', namely companies and organizations that are directly relevant for the training in LNG-fuelled vessels in Norway. The reason for this structure is that it facilitates going in-depth and comparing, the quality of the study depending in the quality of each 'sub-case' (Patton, 2002, pp.447-452). The findings for each 'sub-case- are then compared by cross-case analysis according to the purpose of the study. According to Patton ""lessons learned" and "best practices" have become popular practices of cross-case analysis (...) in studies (...) that aim to build knowledge comparatively. Rather than (...) empiric generalizations, lessons learned more often take the form of *principles of practice* that must be adapted to particular settings in which the principle is to be applied" (2002, p.564).

Is case study the adequate approach? Why? What are the advantages or disadvantages?

Case study is an adequate approach for this study because the situation of Norway is unique, the study's purpose benefits from purposeful sampling, its exploratory character benefits from a flexible design and from in-depth data rather than shallow and broad data.

One of the criticisms of studying unique cases is that its results are not generalizable. However, it was already defended in the text above how case studies' findings may include principles that are dissociated from context, and that these may be analytically generalized.

2. Methodology framework and definitions

According to Patton, qualitative research is a suitable approach for exploratory studies (2002, p. 55) and studies that aim for in-depth knowledge (2002, p.14). Patton describes 12 different themes for strategic frameworks in qualitative studies (2002, pp. 39-73). They give an overall direction and cohesion to the various elements of research, serving as a thread through the study. From the themes presented (Patton, 2002, exhibit 2.1 in page 40), purposeful sampling, qualitative data and content analysis, were the most suitable for this case study regarding design, data collection and analysis, respectively.

Design: Purposeful sampling and analytical generalization

Purposeful sampling in quality research can perhaps be better understood when put in stark contrast to the well-known probability sampling in quantitative research (Patton, 2002, p.46). It is important to appreciate the differences between these two concepts because they lead to two very different ways of generalizing the findings of a study. On the latter, samples are usually larger and representative of a population to which the findings may be statistically generalized, whereas on the former, sampling is irrelevant. In fact, research can be concentrated on a single case (Patton 2002, p.46), such as in case studies. The focus is, instead, on gaining deep knowledge of the singularity studied (Patton, 2002, p.46), and in generalizing findings analytically instead of statistically (Yin, 2009, p.38). Analytical generalization involves comparing case study findings against a previously developed theory (Yin, 2009, pp.38-39).

Patton (2002, p.40) defends that purposeful sampling is suitable for case studies. Yin (2009, p.39) defends that analytical generalization can and should be used in case studies, even those involving a single-case. This line of thought guided the work plan of this research: the chosen case study subject was of significant interest, theoretical framework needed to be developed, and findings had to be analyzed against this theory.

Data analysis: Content analysis

According to Patton, content analysis of the data collected suits the exploratory character of qualitative studies, and of case studies in particular (Patton, 2002, p.55-57). With content analysis (or inductive analysis) it is meant to analyze data collected aiming at detecting important patterns and relationships, and end up with a synthesis of the findings (Patton, 2002, pp.56-57). This process fits well in the explorative nature of the research questions.

Guided by these concepts, data was grouped according to two different analysis purposes:

1. Data that helped build the theoretical framework on the subject, and describe how it is today. This data was the base for the chapter on Theory.
2. Information that was specific to the Norwegian case, focusing on past events, and presented question by question. This data was the base for the chapter Results.

The analysis was carried out in the chapter Discussion, where a summary of findings about the Norwegian case was compiled and interpreted, and patterns/relations/turning points identified after cross-analyzing the information. This analysis would lead to the answer to the first research question. The summary of findings was then analyzed against the theoretical frame, leading to the answer of the second research question, and an attempt to an analytical generalization of the findings.

Data collection: *qualitative data*

Qualitative data can be used in case studies, to capture the much sought-after in-depth knowledge of the subject studied (Patton, 2002, p.40). This study collected data from three sources:

Primary data was obtained from a questionnaire sent to selected participants followed by open-ended interviews to supplement information from the questionnaires, and secondary data was obtained from documents.

Data collection started with secondary sources, at a very early stage, even before research questions had been formulated. The selection of documentary sources was based on these parameters: information had to have quality; publication should be recent, information should be relevant to this study and accessible. Reliable sources were selected, from established groups with proven experience on this particular field to current research and development work, industry publications, conference paper from a conference that was attended, and articles. The section about LNG handling (chapter: Theory) was based on an LNG course attended by the author at Chalmers University of Technology, Sweden, in 2009. The purpose was to develop a theoretical framework from **in-depth knowledge** of the gas-fuelled technology and operations, understand **research and development** that is currently made in this field, and **identify issues** that needed to be addressed regarding gas-fuelled vessels and associated training

Specialized news sources were also used, although to a much lesser extent. Its function was mainly to illustrate a given point.

Primary sources were used at a later stage, and they consisted of a questionnaire with a set of comparable standard questions, and open-ended interviews by phone or mail. A two-day conference was attended more or less half way into this work. The purpose of attending this conference was to hear about **research and development** that is currently being made in this field. Moreover, since this conference was held on a gas-fuelled vessel, the organizers had arranged for the participants to observe a guided bunkering operation of the vessel with LNG, as well as guided visits to the bridge and engine room. This helped to have a hands-on understanding of handling this fuel, the risks associated with it, and to have insight of training needs for officers and crew.

Questionnaire and Interviews were not done until this subject was better understood. So, they came at a later stage.

Organization of the questionnaires and interviews for this study

For the purpose of capturing in-depth information about how the training was developed in Norway, this study developed a questionnaire that was be sent to a selection of relevant stakeholders in Norway, supplemented by interviews to clarify some points or/and explore a particular detail. Three respondents participated in the questionnaires and interviews.

Selection of respondents

The selection of respondents was done in two steps:

1. Selection of companies: the main target was shipping companies that operate/own LNG-fuelled vessel since the early days when LNG as marine fuel was introduced in Norway. In order to capture additional perspectives from the object studied, it was attempted to include also other stakeholders that, not being shipping companies, have also participated in the development of the gas training, such as classification companies, suppliers or administration. Based on these criteria, three shipping companies were contacted for possible participation in this study. Of these, two were available for interviews and questionnaire. A third company - a supplier of gas training - was also available for the questionnaire and interview. The Norwegian Maritime Authority participated in providing contacts. Finally, a classification society was also contacted for possible participation in the questionnaire and/or interview but their involvement was limited based on that the respondent did not have knowledge on earlier training schemes of gas training in Norway.

2. Then, each company designated one respondent within their organization with adequate experience to participate in the questionnaire and interview. A total of three respondents participated in this study.

Biography of the three respondents

Two respondents are active senior maritime professionals with more than ten years experience on LNG-fuelled ships and the gas training of crew, including involvement on the building process of an LNG-fuelled vessel and sailing on LNG-fuelled vessels. The third respondent is an instructor of crew training on LNG-fuelled vessels, with 14 years operational experience in fire-fighting and emergency preparedness and as a training instructor at safety centers, with solid competence on gas technology and fire-technology, and has also been active in consultancy services for fire and gas technologies to varied Norwegian industries.

Questionnaires and Interviews

The questionnaires were prepared and sent by e-mail together with a formal introduction of this study and the document "Informed consent" advising the participants of the conditions of participation in this study (see Appendix F). Follow-up interviews were made two weeks after receiving the answered questionnaires, for clarifying some of the answers or get more information. The three respondents were based in different places in Norway and so physical interviews were not practical. Therefore, they were made by phone and/or e-mail.

Preparation of the questionnaires and interviews

It was necessary to identify what major changes, regarding training needs, those working onboard when LNG was introduced as a new fuel really experienced. Most of the data was collected through literature study. But data from companies about 'real' experiences on training needs on LNG-fuelled vessels was needed. This information was obtained through a questionnaire, and was analyzed by content analysis i.e. identify main emerging themes (Bartram & Gibson, 2000) through data reduction. This strategy would facilitate the identification of themes emerging more often from the data obtained through questionnaires. Questionnaire would also allow capturing some of the information needed for this study in relatively short time, from respondents that were geographically distant from the researcher. Subsequent interviews to the respondents of the questionnaires would supplement the information obtained in the questionnaires or clarify any detail. Reflections for the development of the questionnaire included what questions it should contain, what structure to follow, and what consequences such choices would have in analyzing its data. The idea of creating a questionnaire in an unsystematic way was not appealing. Therefore, in order to increase the quality of the data obtained through the questionnaire, it was decided to develop the questionnaire based on an existing model that has been created specifically for analyzing training needs in organizations, namely the “Training needs analysis Toolkit” (TNA) (Bartram & Gibson, 2000). Due to limitations of this study, the model could not be fully applied but the questionnaire’s development and structure were adapted from concepts in the model. This was sufficient to reach the purpose set out with the questionnaire, which was to identify the major changes experienced by those onboard with more rigor through a questionnaire developed in a more systematic way.

The questionnaire was developed based on the training needs analysis toolkit (TNA) (Bartram & Gibson, 2000) and on the following assumptions:

1. The introduction of LNG as marine fuel triggered changes onboard and changes to tasks onboard.
2. Deck officers, engine officers and crew are the groups likely to be affected onboard by these changes.
3. A training needs questionnaire is an adequate instrument for identifying what skills are needed for new tasks and who needs to develop them.
4. Data collected by a training needs questionnaire from few respondents is suitable for content analysis, in which responses are reduced to a summary of topics emerging more often and then analyzed.
5. Recognize that not all changes generate training needs.

The resulting questionnaire had the following structure and question topics:

A. Identify training needs:

1. Does the introduction of LNG as fuel implies new equipment, systems or procedures? Identify what impact the change to LNG had onboard.
2. Does the introduction of LNG as fuel imply new/revised tasks, knowledge and skills? Identify what impact the change to LNG had on people's tasks onboard

B. Identify training strategies:

3. Identify what training was provided to meet the new tasks
4. Identify how this training was delivered to the officers and crew
5. Identify when was the training developed
6. Identify who developed the training
7. Identify how the training was developed
8. Explore if the company had to make changes to the courses
9. Describe the elements of a typical training scheme.

The researcher considered including one last question in this questionnaire, asking the respondent how can the respondent know that the training has been correctly developed i.e. that it is effective and successful in the handling of LNG as fuel. The question is relevant because, while Norwegian LNG-fuelled passenger ferries are obliged to have their training courses/plans approved, the training plans/courses of Norwegian cargo vessels using LNG as fuel do not need to be assessed nor approved by the Norwegian Maritime Authorities. The researcher opted therefore to drop this question from the questionnaire and include it in a follow-up interview instead.

Questionnaire's responses were *content analyzed*, which is *consistent with the content analysis used on the remaining data analysis of the case study.* Thus, responses were reduced to a summary of those topics emerging more often. These are presented in the Results section of this study. Analysis and discussion of these results, together with other findings obtained from literature study and interviews, were presented in the Discussion section of this study.

PART IV – RESULTS

1. Regulations in Norway

Norway has regulations with mandatory requirements for training officers and crew of LNG-fuelled vessels. National regulation in force in Norway on the training of officers and crew of gas-fuelled vessels are as follows:

- *The Regulation of 17.June 2002 No. 644 concerning cargo ships with natural gas fuelled combustion engines.*

- *Regulation of 9.September 2005 No.1218 concerning construction and operation of gas-fuelled passenger vessels.*

→ **Norwegian regulation of 17 June 2002 No. 664, concerning cargo ships with natural gas-fuelled internal combustion engines**: This regulation applies to Norwegian cargo ships that use natural gas as fuel. It entered into force in 2002, the year before the first gas-fuelled cargo vessels started operating. Training requirements for sea personnel are ship specific and are divided into two levels:

1. The whole crew, prior to joining the vessel: a basic in-depth training on gas-related safety, operations and maintenance;
2. For those with direct responsibility for the operation of gas-related equipment onboard: additional training.

Gas-related drills should be conducted regularly. The company is required to develop a training manual and training plan and to ensure that sea personnel maintain their gas knowledge at all times. There is no requirement for the approval of the courses/plan by the Norwegian Maritime Authorities. An extract of this regulation can be consulted on Appendix C, at the end of this report.

→ **Norwegian regulation of 9 September 2005 No. 1218, concerning the construction and operation of gas-fuelled passenger ships:** This regulation applies to Norwegian passenger vessels that use gas as fuel. It entered into force in 2005, five years after the then only gas-fuelled passenger vessel started operating. Training requirements for sea personnel are ship-specific, and are divided into three groups and an additional internal refresher course. The Norwegian Maritime Administration must approve training plan/curriculum. Training plan shall be evaluated regularly. A summary follows, based on this regulation and on information from the Norwegian Maritime Authority (2013):

Category A - All crewmembers part of the minimum safe manning (prior to joining the vessel):
General basic training on gas-related safety, operation and maintenance, based on the assumption that the crew does not have any prior knowledge of gas, gas engines and gas systems.
Instructors: gas equipment/systems' suppliers/specialists.
Course includes theoretical and practical moments.
Theoretical part (details provided by NMA, 2013):

- Basic knowledge of gas
- Thermodynamic properties of natural gas
- Liquid Cryogenic gases and phase transition
- Explosion levels UEL/LEL
- Control and monitoring of gas, barriers
- Principe of RISK-assessment
- Probability- and consequence reduction
- Simplified analysis of risks
- Risk events; leakage, explosion and fires
- Emergency preparedness
- TQM – total quality management
- Safe work analyses, hot and cold work permit
- Regulations

Practical part (details provided by NMA, 2013):

- Control of gas fires
- Flash point and auto ignition temperatures
- Different extinguish ant - benefits/disadvantages
- Fire in gas and liquids
- Ignition energy and combustible mixture UEL/LEL
- Personal protective equipment gas/LNG
- Gas detection with test gas
- ESD of gas system and engine
- EX areas, entering procedures and equipment
- Practical extinguishing gas fires at an approved center.
- Personal protection when handling liquid/compressed gas.

Course duration: 1,5 to 2,5 days (NMA 2013).

Category B - Deck officers:
This training is supplementary to the basic training. The company and the Master determine what comes under deck operations and what comes under engine operations.
Instructors: gas equipment/systems' suppliers/specialists.
The course is based on the ship's maintenance manual, gas supply system manual and manual for electrical equipment in explosion hazardous spaces, and covers this Regulation, Appendices concerning risk analysis and hot/cold work permits.
This additional theoretical training includes (details provided by NMA, 2013):

– Gas/LNG system review
– Power supply system
– Monitoring and supervision
– Bunkering
– Gas fire hazards and damage
– Shutdown gas engines
– Shutdown gas system
– Set of exercises

If the vessel's own crew will be performing technical maintenance of gas equipment, the training for this type of work shall be documented.
Course duration: an additional 0,5 day (NMA (2013).

Category C - Engine officers:
This training is supplementary to the basic training. The company and the Master determine what comes under deck operations and engine operations.
Instructors: gas equipment/systems' suppliers/specialists.
The course is based on the ship's maintenance manual, gas supply system manual and manual for electrical equipment in explosion hazardous spaces, and covers this Regulation, Appendices concerning risk analysis and hot/cold work permits.
This additional theoretical training includes (details provided by NMA, 2013):

– Purging and gas freeing
– Quality of gas / Methane number
– Heat value of Methane
– Ignition failure/knocking

– Maintenance of gas/LNG system
– EX equipment
– Electrical installations in cold box and engine room
– Gas pipe system/ double wall piping
– LNG evaporator
– Principle of gas engines
– Shutdown of gas engine/gas supply

Course duration: an additional 0,5 day (NMA (2013).

Internal refresher course (prior to joining the vessel):
Specially arranged course for crew that has been away from the ship more than six months in one go.
An extract of this regulation can be consulted on Appendix D, at the end of this report.

2. Training developed in Norway

Summarized results of the questionnaires and interviews:

Q1. When asked what impact did the introduction of LNG as fuel in 2003 have onboard:
Equipment: Dual fuel engines was new technology at the time and very little tested onboard before, more complex operation with dual fuel; new LNG tank; new personal protection equipment (PPE) for extreme low temperatures; ex-proof electric equipment Systems: the complete gas system was new, from the bunkering station to the gas engine; more sophisticated software on the engine automation; more complex fuel systems (dual fuel); gas detection system, emergency shutdown system (ESD) Procedures: new bunkering procedures; new checklists for bunkering and operations; new bunkering procedures affect both the engineers and the deck officers. One respondent added that the operation of the vessel was different compared with a diesel-powered vessel. The reaction times for the motors are slower in gas mode, what takes 15 seconds in diesel mode takes 40 seconds in gas mode. This meant that crew had to be much more aware during all operations and plan further ahead.

Q2. When asked what impacts did the change from fuel oils to LNG-as fuel have on people’s tasks onboard:
All groups gained a lot of new tasks onboard for the daily operation of the gas-system (Deck, Engine and Crew) Engine officers: bunkering, maintenance gas-related equipment, understanding the complete gas system, complicated new engine control system took time to learn. Deck officers: new limitations about maneuvering the vessel in gas mode, since gas engines need to be operated a bit slower than diesel engines. Specific Crew: new tasks when bunkering LNG (valve operation on deck) One respondent added that with this change, Engine officers have to run a process plant onboard.

Q3. When asked to describe what training officers and crew were provided for meeting the new tasks, knowledge and skills needed:	
Engine officers →	Course based on lectures from the ship owner and suppliers, with focus on safety and technical issues
	External course provided by engine supplier for engineers and electrician + One internal two-day course in operation of gas powered vessels + Internal in-depth course
Deck officers →	Course based on lectures from the ship owner and suppliers, with focus on safety and technical issues
	One internal two-day course in operation of gas powered vessels + Internal in-depth course
Crew →	Course based on lectures from the ship owner and suppliers, with focus on safety and technical issues, but without the advanced technical part.
	One internal two-day course in operation of gas powered vessels + **Internal basic course**

Q4. When asked how has the training been provided to the officers and crew:
Internal courses: two respondents provide internal courses to all groups onboard. Note that according to Regulation of 9 September 2005 No. 1218 gas-fuelled passenger ships are required to provide an internal refresher course to those who have not been in the vessel > 6 months. For cargo ships it is required that knowledge is maintained at all times. External courses: one respondent uses also external course provider. Courses onboard: gas-related drills, carried out onboard. One respondent added that no formal **monitoring** of training is done on a regular basis by the office. Every time a new person is coming onboard it is the captain who monitors what type of training is required. This is based on which position onboard the new crewmember will enter. A training certificate is issued on completion of the training course onboard and a copy of the certificate is filed onboard. Another respondent added that, about **monitoring**, company arranges one or two course before delivery of each vessel, after that the chief engineer on each vessel have a course on board for each new employer.

Q5. When asked how early did company start working on the training needs of their onboard personnel:
One respondent stated: about six months before manning of vessel. Another respondent stated: training plan was developed in connection with **newbuilding project**, so training plan started about about 1,5 year before newbuilding was delivered. Training plan was developed in **collaboration** with a competitor shipping company.

Q6. When asked who has normally been developing their training courses:
Respondents stated: course development resulted from **collaboration** between **shipowners** in the same situation, and between **shipowners and suppliers**. One respondent specified that experienced **sailors** from existing LNG-carriers, experienced people from **shore** organization and suppliers develop each course. One respondent added that until 2010 it was **up to the ship owners** to develop and deliver training to their own officers and crews.

Q7. When asked how their training schemes were developed when LNG as fuel was introduced in their fleet (2002/2003):
One respondent answered that the rules did not specify what kind of training to be given, so it is up to the ship owner to find suitable training for the crew. The course is **specific for each vessel**. Another respondent described that a classification society made "a construction risk analysis" of their LNG-fuelled vessel when she was being built and this risk analysis formed the background for how the training was developed. The Norwegian Authorities had at that time no requirements or guidelines for training in operation of LNG fuelled supply vessels.

Q8. When asked if the company had to make changes to any training:
One respondent answered that vessels in their LNG-fuelled fleet **have changed** during the years and, consequently, the **courses have also been changed to be specific to each vessel**. Another respondent stated that **no changes** have been made to the training.

Q9. Describe the elements of a typical training scheme for Officers and Crew on your gas-fuelled vessels
Two respondents made their training scheme available. One of them is available on Appendix E, for illustrative purposes to exemplify what typical items are covered by the training.

What respondents added in subsequent contacts:

"The courses used are all organized and set up by own shipping company, but we had a supplier as a guest lecturer on the first courses. We are no longer using a supplier for this purpose, because we have **built our own experience**, but we follow more or less the same model."

"The time between bunkering **varies from ship to ship** and also which bunkering port which is used. In some places ships use trucks for LNG delivery and somewhere they have fixed facility on shore."

"The ships with the highest activity normally <u>bunker once a week</u>, and for the others up to <u>every second week</u>. "

For another respondent, <u>bunkering is carried out once a week,</u> from terminal's tank in a single **fixed arrangement**.

The respondent was asked if their training courses/plan was approved, to which the respondent answered that their courses are **not approved/assessed** by the Norwegian Maritime Authority. However, the respondent added, representatives both from their **classification society** and from the **Norwegian Maritime Authority** have been on their courses, and respondent have also had one course in their head office.

The respondent's company has been managing gas-related training for more than ten years, with expertise from suppliers, experienced shore people and experienced sailors from existing LNG vessels, which is an **intrinsic sign of quality.** Nonetheless, the respondent was asked how can the respondent **be sure that the right training has been given all this time**?, to which the respondent answered "I am sure we are giving the right training because the course is **vessel specific** on all the technical part. We have high focus on all the **built-in safety barriers** for the gas system."

The other respondent was also asked how can the respondent **be sure that the right training has been given all this time**?, to which the respondent answered that "the training from the supplier has been successful, measured by the **lack of gas-related accidents** onboard since the start of the vessel in 2003."

One respondent stated that: "We do not have regular **gas-related drills**, but this is a normal part of a regular fire-drill. "

For another respondent: "**Gas-related emergency** preparedness drills are carried out regularly onboard, every <u>three months</u>."

Another respondent, that uses external course providers, gave more details: "All the training for the company and the crew onboard has been provided and developed by a supplier. Training was provided before the gas-fuelled vessel started operation. This supplier delivers the training since the beginning in 2003 and until today. In addition, another supplier also has been giving training on gas-engine system. Crew and officers that join the LNG-fuelled vessel for the first time receive the relevant gas course(s) and a certificate is issued, to document the training. "

Noticing a gap in the data studie,d between the date of national regulation for Norwegian passenger vessels that use LNG as fuel, and the date when the first LNG-fuelled passenger vessel started operating, one respondent was asked the following:

Regulation of 9 September 2005 No.1218 entered into force in 2005. However, the first gas-fuelled vessel passenger ferry started to operate five years before that, in 2000 (MV Glutra). What regulations existed for gas-fuelled passenger ships in the period 2000-2005? The respondent explained that this regulation was indeed the first national regulation for gas-fuelled passenger vessels. They were developed at the same time as the passenger ferry MV Glutra was being built but, for the period after that, the respondent did not have more information.

The researcher tried to find this information but the search was not successful.

PART V – DISCUSSION

1. Discussion about the findings

Reflecting on the various research projects mentioned in the first part of this study, it seems very likely that we are moving toward a generalized use of LNG as fuel in shipping. Furthermore, studies analysing such scenario suggested that the number of vessels using LNG as fuel could increase quite rapidly.

Technical documentation studied during this research revealed the critical moments and risks associated with LNG as marine fuel: handling, bunkering operation and storage solutions onboard carry a risk caused by LNG's cryogenic properties, being low-flashpoint and flammable.

Critical moments include bunkering and associated operations, namely inerting and venting.

Despite the risk, documentation shows that LNG shipping industry have managed to keep an excellent safety record with high training standards. In order to keep this record, one must continue to invest in training, now also with LNG as fuel.

When Norway started to use LNG as fuel in 2000, there were no regulations about training the crew. And yet, 13 years on, LNG fuel experience in Norway is very positive and safe, with no reported gas-related accidents as reported previously in this study. How did Norway reach this success story? The answer seems to lay in the training given to their sea-personnel and how this training was developed.

An analysis of the questionnaires and interviews show that many new tasks and new equipment emerged onboard with the introduction of LNG as fuel. Research show it was recognized that gas-related training was needed for all the functional groups onboard in order to meet the new tasks, understand the new fuel and the new equipment. Many new systems were installed onboard LNG-fuelled vessels: a complete gas engine, with insulated piping and LNG tanks, gas detection system, and a demanding engine control system and automation. Respondents also highlighted many new procedures and checklists.

Comparing the results, several similarities emerge about the way training was developed to meet this needs, possibly explaining the success of the experience in Norway.

Firstly, training started to be developed at least six months before the gas-fuelled vessel started operation. Secondly, several sources mention collaboration between ship owners and between ship owners and suppliers of the equipment for exchanging gas-related knowledge, both technical and from a safety perspective, and for the development of adequate training courses. There are references that this collaboration extended also to a classification society with expertise in LNG, to seafarers with long LNG experience. It could very well be that this collaboration was a decisive contribute for the successful training delivered to the officers and crew. The number of gas-fuelled vessels was still very limited then but was gradually increasing. There are references in the data that bunkering arrangements where rather fixed, which might favour safe bunkering operations in that a repeated operation becomes routine and easier to handle. One other aspect highlighted by the data is that training was ship specific. A possible explanation is that different vessels may have different equipment, and although LNG handling principles are the same, differences in equipment and design can be significant aspect in maintaining safety. This was possible since the fleet of LNG-fuelled vessels is rather small, but nowadays this is still done that way, as it has become mandatory requirement. Finally, one last factor to consider in the study of how training was developed in Norway for LNG fuelled vessels, is the national regulation. The regulations were prepared, one applicable for cargo and the other applicable for passenger vessels. The differences between them have already been explored in this report. One last consideration about the national regulations is that the first one of the two i.e. the one for LNG-fuelled vessels, was developed in parallel with the construction of the first gas-fuelled passenger vessel, most likely in collaboration and with the inputs of experts and stakeholders involved directly on LNG operations. It was then decided that the regulation would require training differentiated into three categories/two levels according to the functional demands of the crew onboard.

Comparative analysis between the national regulations for Norwegian gas-fuelled cargo vessels (Appendix C) and Norwegian gas-fuelled passenger vessels (Appendix D) and IMO's Interim Guidelines Res. MSC.285 (86).

Gas-fuelled cargo vessels	**Gas-fuelled passenger vessels**
Norwegian regulation of 17 June 2002 No. 664 concerning cargo ships with natural gas-fuelled internal combustion engines	*Norwegian regulation of 9 September 2005 No. 1218 concerning the construction and operation of gas-fuelled passenger ships*
Entered into force in 2002	Entered into force in 2005
Regulation entered into force before the first gas-fuelled cargo vessels started to operate	Regulation entered into force five years after the first gas-fuelled passenger vessel started to operate
Two levels	Three categories
Gas knowledge to be maintained	(*) Internal refresher course for those that have been at least six months away from the ship
Training to be given prior to joining the vessel to: - All	Training to be given prior to joining the vessel to: - All minimum safe manning (*)- Refresher internal course
Training is ship specific (re-training needed if changing to a new ship)	**Training is ship specific (re-training needed if changing to a new ship)**
Not specified	Theoretical and practical training requirements
Regular gas-related drills	Requires training on gas-fire extinguishing, at an approved safety centre.
Rules include no guidance, no details; Shipowner free to develop the training plan/courses.	Rules are detailed. (*) Guidance is mandatory.
Training plan/courses don't need approval from the Norwegian Maritime Authority, they are the responsibility of the shipowner	(*) **The training plan/courses must be approved by the Norwegian Maritime Authoritiy.** Training plan/course evaluated regularly.
Identical to the not mandatory *"8.1. Operational requirements"* of Interim Guidelines Res. MSC.285(86) adopted in 2009	**Corresponds to the not mandatory *"8.2 Gas related training"* of the Interim Guidelines Res. MSC.285(86) adopted in 2009,** except those marked (*)

(*) *IMO's Interim Guidelines Resolution MSC.285 (86) are not mandatory, don't mention internal refresher courses, do not require the training plan/courses to be approved by the Flag State (it is up to the ship owner to develop them, as for cargo vessels).*

Finally, results show that the Norwegian Maritime Authority already contributed with their experience, acquired during the development of their own national regulations on LNG-fuelled vessels, to the drafting of IMO's Interim Guidelines of 2009. IMO's Interim Guidelines MSC. 285 (86) provide the only available international guidelines for the training of personnel onboard gas-fuelled vessels during the absence of any international mandatory requirements. The guidelines leave to each Administration to decide on how their vessels implement them. This implies that training might not be equal throughout different Flag states. In practice, this has not been a problem since the fleet of LNG-fuelled vessels has been confined to Norway until recently, but trends indicate that the fleet of LNG-fuelled vessels will expand quickly in the near future and mandatory international standards can prevent proliferation of different training standards. This concern was voiced by Norway (IMO, 2013e). Taking into account the properties of LNG and the risks involved with handling it, and that the record of accidents with LNG must be kept, it is desirable that the knowledge and implementation is of high quality and implemented uniformly by different Flag States.

More recently, based on the discussions at IMO's BLG and STW committee already referred to in this report, it is apparent that the Norwegian experience on training of crews on LNG fuelled will provide guidance to the drafting of IMO's new IGF Code. Norway pointed out their good track record on gas-related safety but has also highlighted some concerns:

- Although requiring ship specific training has apparently not constituted a problem so far in Norway, the same may not apply to the rest of Europe in the future, in particular bearing in mind the possible scenario of a rapid increase in the LNG fuelled fleet in Europe (IMO 2013e, Appendix A).

- The Norwegian model of three training categories/two levels, is also at the base of the recommendations at IMO meetings, indicating that it has been also a contributive factor in the successful experience.

2. Discussion about the methodology

A lot of effort was put in designing this qualitative case study, bearing in mind that, in general, qualitative research's credibility is often challenged.

Literature about qualitative studies was reviewed for developing a methodological framework adequate for case studies and the working plan for this research, and to define appropriate data collection methods and analysis methods.

In order to decide on the data collection methods, it was necessary to take into account what resources were available (time and funds of the researcher, but also time from respondents), and to consider the good quality level wished for this research, incorporating aspects such as multi methods and multi data sources.

The following describes what was done to produce a high quality and ethically correct research (Patton, 2002, p.51):

Quality data sources
Throughout the study, there was a conscious effort to utilize sources of good quality. Printed literature and Internet sources of potential interest were scanned on first contact to assess its general quality. Online tutorials from libraries (e.g. Place et al, 2006) helped with the task of assessing online information sources. With good quality it is meant that information was accurate (e.g. no mistakes detected, citations correct), with evidence of research back up (e.g. citations, reference list), was from authoritative sources (e.g. from research groups, academic publications, maritime authorities, classification societies). Furthermore, particularly on interviews, the information gathered was as recent as possible, and covered different perspectives on the subject (from a shipping company, from a classification society and a maritime authority).

Triangulation

Triangulation was done in two different ways:

1. Combining different data collection methods: questionnaire, follow-up interviews and documentary analysis.
2. Combining different data sources (e.g. two different respondents, two different articles of the same thing);

Potential sources of bias

When undertaking this study, the researcher tried to be as truthful to the facts as possible and used triangulation for minimizing bias, but agrees with Patton that subjectivity cannot be eliminated completely in qualitative studies (2002, p.51 and p.65). Acknowledging this limitation, the researcher reflected on potential sources of bias and could not find any significant. In any case, having this report peer-reviewed should minimize effects of any eventual bias.

Ethical aspects were observed

A research project planning letter, introducing the subject covered in this case study, its significance for current developments, the research questions, and the aim of the research was prepared and sent to the potential informants, inviting to participate in this research in the form of an interview. In addition, respondents were requested their informed consent, and were informed that they could give-up at any moment without the need of explaining why. Letter of Informed Consent on Appendix F._ For ethical reasons, it must be informed that the two-day conference attended during the production of this study, was partly sponsored by the British company Mercatormedia, at the request of the researcher. Mercatormedia were the organizers of this event and the researcher assures that their sponsorship did not bias the conclusions of this report in any way.

3. Recommendation for further studies

While carrying out this research, there was evidence that office personnel of shipping companies would benefit from training on LNG as fuel, adjusted to their functions. Thus I would recommend a study focusing on this subject.

PART VI – CONCLUSION

Reflecting on the research questions proposed for this study, and on its findings, this report concludes with the following:

a) What training was needed for officers and crew of LNG-fuelled vessels, and how training was developed in Norway to meet those needs.

- The training needed encompassed the critical properties of natural gas and LNG (cryogenic, low flashpoint and flammable), and the critical moments in LNG operation: handling of LNG and bunkering operation. The training extended to all new gas engine systems onboard, and other associated systems, and new procedures. The level of training depended on the function of the crewmember onboard.

- How the training was developed:

  - Trainings needs were recognized early on.
  - Training plans developed early on.
  - Collaboration between stakeholders with expertise and experience in LNG, often suppliers of the technical equipment and systems, to develop training plans.
  - Internal courses/External courses.
  - Training levels was differentiated based on functional requirements of the crew onboard, and a model based on two levels/three categories was developed.
  - Ship specific training

b) To find out if there are any lessons to be learned from that experience:

- Norway enjoys a good track record on gas-related safety, indicating that its training solutions may set the example.

- The model with two levels/three categories for differentiation training levels could be used in the future even internationally.

- Ship specific training is required in Norway but could it have negative impacts if applied in the same way in the event of a rapid expansion of the gas-fuelled fleet?

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APPENDIX A

Comments submitted by Norway at IMO's subcommittee STW 44th session 22.Feb.2013, illustrates aspects of their experience, the need for creating mandatory international requirements, and discussion on future training model of crews/officers on LNG-fuelled vessels.

INTERNATIONAL MARITIME ORGANIZATION

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SUB-COMMITTEE ON STANDARDS OF TRAINING AND WATCHKEEPING
44th session
Agenda item 17

STW 44/17/3
22 February 2013
Original: ENGLISH

ANY OTHER BUSINESS

Training requirements for officers and crew on board ships using low flash-point fuels

Submitted by Norway

SUMMARY

Executive summary:	BLG 16 referred the question on training for officers and crew on board ships using low flash-point fuels to the STW Sub-Committee. This document provides information related to training requirements for officers and crew on board ships using low flash-point fuels, and proposes to amend the STCW Convention and Code accordingly
Strategic direction:	5.2
High-level action:	5.2.1
Planned output:	5.2.1.3
Action to be taken:	Paragraph 9
Related documents:	BLG 16/WP.5, BLG 16/16, section 6.18 and STW 44/INF.4

Background

1 BLG 16 decided to refer the question on training for officers and crew on board ships using low flash-point fuels to the STW Sub-Committee. STW 43 briefly discussed the matter and invited Member Governments and international organizations to consider the matter in detail and submit comments and proposals to STW 44. This submission is a response to that request.

Discussion

2 Currently there are no mandatory training requirements for personnel serving on board ships using low flash-point fuel. Resolution MSC.285(86) *Interim guidelines on safety for natural gas-fuelled engines* include provisions for training, however how to implement these provisions is left to the Administration to decide.

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3 As long as the number of ships using low flash-point fuels was limited and no mandatory requirements for the design and operation of the machinery installations existed, it was deemed sufficient to have national requirements. However, as new regulations on emission control areas (ECA) enter into force in January 2015, a rapid increase in the fleet of ships utilizing new technical solutions and fuels is foreseen. For the time being methane gas stored as liquefied natural gas (LNG) seems to be one of the preferred fuels on new buildings and for conversions. This may significantly increase the number of LNG-fuelled ships. The use of other low flash-point fuels is currently also increasing. In particular, colour and odourless gases which are stored as cryogenic liquids represent a paradigm shift. A new safety culture is needed and a sharp focus on the differences compared to traditional fuels will be essential for safety.

4 Norway is of the opinion that the time has come to develop mandatory training requirements for personnel operating on ships using low flash-point fuels. The STCW Convention and Code should contain "all" of the global standards for seafarer training, certification and watchkeeping, including specialized training and is in our view the correct location for such training requirements.

5 All personnel forming part of a ship's minimum safe manning should have some kind of additional training. However it is recognized that there may be different levels of training based on the responsibilities inherent in a specific position on board. The interim guidelines contain three levels of training and up until now, Norway has implemented these three levels for personnel on LNG-fuelled ships, but the training has been very ship specific. Hence when changing to a new ship, all the training often has to be repeated.

6 Furthermore, a more generic training regime should be implemented for personnel on ships using low flash-point fuels. Based on the experience gained with training for personnel on LNG-fuelled ships and recognizing that new low flash-point fuels may be in the pipeline we are currently in a process of reviewing these training requirements in Norwegian legislation. One of the conclusions we have reached is that two levels, basic and advanced, should be sufficient with the addition of familiarization.

7 In order to assist the work, should the Sub-Committee agree to include training requirements for personnel on ships using low flash-point fuels in the STCW Convention and Code, Norway has also submitted document STW 44/INF.4 which could serve as a starting-point for discussions.

8 If so decided, in developing these training requirements, it should be considered if they should form part of the basic training and as such be located in chapters II and III of the Convention and Code or it should be considered as specialized training and be included in chapter V of the Convention and Code. One possibility could be to include them in chapter V first and include them in chapters II and III at a later stage when the use of alternative fuels becomes more common.

Action requested of the Sub-Committee

9 The Sub-Committee is invited to consider the information above and take action, as appropriate.

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INTERNATIONAL MARITIME ORGANIZATION

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SUB-COMMITTEE ON STANDARDS OF TRAINING AND WATCHKEEPING
44th session
Agenda item 17

STW 44/INF.4
22 February 2013
ENGLISH ONLY

ANY OTHER BUSINESS

Training requirements for officers and crew on board ships using low-flashpoint fuels

Submitted by Norway

SUMMARY	
Executive summary:	This document provides information on proposed amendments to the STCW Convention and Code related to training requirements for officers and crew on board ships using low-flashpoint fuels
Strategic direction:	5.2
High-level action:	5.2.1
Planned output:	5.2.1.3
Action to be taken:	Paragraph 17
Related documents:	BLG 16/WP5, BLG 16/16, section 6.18 and STW 44/17/3

Background

1 In document STW 44/17/3, Norway discusses the issue of developing mandatory training requirements for personnel on board ships using low-flashpoint fuels. Without pre-empting the outcome of that discussion, but in order to save time, should the Sub-Committee agree, Norway has developed a proposal for tables of competence on basic training and on advanced training for personnel on board ships using low-flashpoint fuels, to be included in part A of the STCW Convention, as set out in the annex. It is recognized that amendments to the Convention itself also need to be developed. Given below are some additional comments and explanations related to the proposed competency tables.

2 As informed, Norway is currently updating its training programmes for personnel on ships other than gas-carriers using low-flashpoint fuels like methane gas stored as LNG.

3 Current Norwegian regulation on training for personnel on gas-fuelled ships is principally based on training for a specific ship. In the future, this may not be convenient as a growing number of ships fuelled with low-flashpoint fuels will require an increased number of seafarers qualified to handle the new fuels.

Safety strategy on training

Add-on training

4 The basis for safety is that officers and ratings assigned as part of a low-flashpoint-fuelled ship's minimum safe manning, other than liquefied gas tankers, should have passed the related tests and hold the relevant certificates in basic or advanced training.

5 Every candidate, officers as well as ratings, undergoing training for a certificate in basic or advanced training, should be qualified in accordance with the STCW Convention and Code to be assigned to a conventional diesel-fuelled ship of the same type, size and trade.

Generic basic training and ship specific familiarization

6 Currently, the owner has to develop a specific training programme for each ship and the crew will more or less need completely new training if they transfer to another ship. To adapt to the growing number of low-flashpoint-fuelled ships, the related training will be divided into general generic training and ship specific familiarization. The purpose of the division into generic training and ship specific familiarization is to allow an increase in numbers of seafarers that may be able to be assigned to gas-fuelled (IGF-Code) ships and to provide flexibility.

7 Existing Norwegian training regulations have been divided into three levels. For the future, Norway has decided to change to only two levels: generic basic training and generic advanced training. Generic basic training would be the same for all crew. Generic advanced training for deck and engine officers and other crew who shall participate in low-flashpoint fuel operations or maintenance shall be the same. The common training programme will give the crew with direct responsibility for the operation of gas-related equipment on board, the same competence and communication platform. This will enhance the efficiency both in normal operations and in any emergency situation.

Retraining

8 The development of low-flashpoint-fuelled shipping is at its incipient stage, even if some valuable experience can be taken from the past 50 years of LNG-tanker operation where vapour gases have been used as fuel. Furthermore, the experience in Norway from 13 years of gas/LNG-fuelled ferries and supply ships is absolutely good and with a clean safety record. However, the expected increase in low-flashpoint fuel ships may introduce rapid development of the technology and provide new experience. To secure the maintenance of the low-flashpoint fuel safety culture and to keep up with experience and technological developments, a retraining scheme should be introduced.

Structure for low-flashpoint fuel training

Generic training

9 The purpose of the generic training programme is to give seafarers knowledge of the typical characteristics of low-flashpoint-fuelled ships and the related techniques and systems utilized to ensure safe operation. The generic training programme should also cover the properties of actual low-flashpoint fuels and fuels stored as cryogenic liquids in comparison to traditional fuels. The special hazards that may arise in conjunction with use of low-flashpoint fuels should be addressed. The generic training programme should include

safety standards regarding low-flashpoint fuel fire fighting, cryogenic liquid handling, emergency preparedness, emergency handling, occupational safety, security and medical care and survival functions. The generic training should have two levels:

Level 1 - Basic generic training for all crew with safety duties; and
Level 2 - Advanced generic training for all officers and other crew with direct responsibility for low-flashpoint fuel operations.

Ship-specific familiarization

10 As part of the already required familiarization, the ship-specific training should include all needed detailed competence to allow the crew to perform their work and leisure activities on board safely. The arrangement of the ships' low-flashpoint fuel systems including hazardous zones, operation, control and safety systems, related procedures and implemented safety culture should be reviewed. The ship-specific training should meet with provisions of regulation I/14 of the STCW Convention and the ISM Code.

Retraining

11 In our view, the specification of minimum standards of competence for retraining for the minimum safe manning should be the same as initial training.

Qualification of trainers/instructors

Generic training level 1 and 2

12 The instructors shall be specialists with in-depth knowledge of low-flashpoint fuels and the design basis for all type of related fuel systems and installations. Instructors shall have in-depth knowledge of particulars regarding low-flashpoint fuel safety culture, hazards and emergency management as well as fire fighting and rescue operations. Instructors should preferably have documented competence from the leading designers and suppliers. Experience from operation and maintenance of LNG IGC-Code tankers fuelled with vapour gas would normally not be sufficient as systems may deviate and the third-party risk would be on a different level.

Ship-specific training and familiarization

13 The instructors should be the master, chief engineer or specialist with in-depth knowledge of low-flashpoint fuels in question and the design basis for the related systems and installations for the specific ship. Instructors should preferably have documented competence from the leading designers, builders and suppliers and experience from control, start-up and testing of the actual ship. The instructors should know the ship-specific procedures for safe operation and bunkering, the emergency preparedness and operation, the manual for maintenance and electrical equipment in explosion-hazardous spaces and zones.

Evidence of training

14 A certificate of proficiency should be issued to seafarers who have passed the relevant tests and are qualified in accordance with the proposed generic gas training for low-flashpoint-fuelled (IGF-Code) ships. The certificate of proficiency should be valid if endorsed every five years following retraining.

Source: IMO, 2013e.

APPENDIX B

Extract of IMO's Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations on Ships – Resolution MSC.285(86) adopted on 1 June 2009

CHAPTER 8

OPERATIONAL AND TRAINING REQUIREMENTS

8.1 Operational requirement

8.1.1 The whole operational crew of a gas-fuelled cargo and a passenger ship should have necessary training in gas-related safety, operation and maintenance prior to the commencement of work on board.

8.1.2 Additionally, crew members with a direct responsibility for the operation of gas-related equipment on board should receive special training. The company should document that the personnel have acquired the necessary knowledge and that this knowledge is maintained at all times.

8.1.3 Gas-related emergency exercises should be conducted at regular intervals. Safety and response systems for the handling of defined hazards and accidents should be reviewed and tested.

8.1.4 A training manual should be developed and a training programme and exercises should be specially designed for each individual vessel and its gas installations.

8.2 Gas-related training

8.2.1 *Training in general*

The training on gas-fuelled ships is divided into the following categories:

.1 category A: Basic training for the basic safety crew;
.2 category B: Supplementary training for deck officers; and
.3 category C: Supplementary training for engineer officers.

8.2.1.1 *Category A training*

.1 The goal of the category A training should provide the basic safety crew with a basic understanding of the gas in question as a fuel, the technical properties of liquid and compressed gas, explosion limits, ignition sources, risk reducing and consequence reducing measures, and the rules and procedures that must be followed during normal operation and in emergency situations.

.2 The general basic training required for the basic safety crew is based on the assumption that the crew does not have any prior knowledge of gas, gas engines and gas systems. The instructors should include one or more of the suppliers of the technical gas equipment or gas systems, alternatively other specialists with in-depth knowledge of the gas in question and the technical gas systems that are installed on board.

.3 The training should consist of both theoretical and practical exercises that involve gas and the relevant systems, as well as personal protection while handling liquid and compressed gas. Practical extinguishing of gas fires should form part of the training, and should take place at an approved safety centre.

8.2.1.2 *Categories B and C training*

.1 Deck and engineer officers should have gas training beyond the general basic training. Category B and category C training should be divided technically between deck and engineer officers. The company's training manager and the master should determine what comes under deck operations and what comes under engineering.

.2 Those ordinary crew members who are to participate in the actual bunkering work, as well as gas purging, or are to perform work on gas engines or gas installations, etc., should participate in all or parts of the training for category B/C. The company and the master are responsible for arranging such training based on an evaluation of the concerned crew member's job instructions/area of responsibility on board.

.3 The instructors used for such supplementary training should be the same as outlined for category A.

.4 All gas-related systems on board should be reviewed. The ship's maintenance manual, gas supply system manual and manual for electrical equipment in explosion hazardous spaces and zones should be used as a basis for this part of the training.

.5 This regulation should be regularly reviewed by the company and onboard senior management team as part of the SMS system. Risk analysis should be emphasized, and any risk analysis and sub-analyses performed should be available to course participants during training.

.6 If the ship's own crew will be performing technical maintenance of gas equipment, the training for this type of work should be documented.

.7 The master and the chief engineer officer should give the basic safety crew on board their final clearance prior to the entry into service of the ship. The clearance document should only apply to gas-related training, and it should be signed by both the master/chief engineer officer and the course participant. The clearance document for gas-related training may be integrated in the ship's general training programme, but it should be clearly evident what is regarded as gas-related training and what is regarded as other training.

.8 The training requirements related to the gas system should be evaluated in the same manner as other training requirements on board at least once a year. The training plan should be evaluated at regular intervals.

8.3 Maintenance

8.3.1 A special maintenance manual should be prepared for the gas supply system on board.

8.3.2 The manual should include maintenance procedures for all technical gas-related installations, and should comply with the recommendations of the suppliers of the equipment. The intervals for, and the extent of, the replacement/approval of gas valves should be established. The maintenance procedure should specify who is qualified to carry out maintenance.

8.3.3 A special maintenance manual should be prepared for electrical equipment that is installed in explosion hazardous spaces and areas. The inspection and maintenance of electrical installations in explosion hazardous spaces should be performed in accordance with a recognized standard.[18]

8.3.4 Any personnel that should carry out inspections and maintenance of electrical installations in explosion hazardous spaces should be qualified pursuant to IEC 60079-17, item 4.2.

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[18] Refer to IEC 60079-17:2007 Explosive atmospheres – Part 17: Electrical installations inspection and maintenance.

Source: IMO, 2009.

APPENDIX C

Extract of the Norwegian regulation of 17 June 2002 No. 664 concerning cargo ships with natural gas-fuelled internal combustion engines

Regulation of 17 June 2002 No. 644 concerning cargo ships with natural gas fuelled internal combustion engines

Laid down by the Norwegian Maritime Directorate on 17 June 2002 pursuant to the Act of 9 June 1903 No. 7 relating to Public Control of the Seaworthiness of Ships, etc. Legal basis amended to Act of 16 February 2007 No. 9 relating to Ship Safety and Security (the Ship Safety and Security Act) sections 2, 6, 9, 11, 16, 21, 22, 30 and 43, cf. Formal Delegation of 16 February 2007 No. 171 and Formal Delegation of 31 May 2007 No. 590 by the Ministry of Trade and Industry. Amended 29 June 2007 No. 1006 (i.a. legal basis).

Chapter 1
General provisions

§ 1
Scope of application

(1) This Regulation applies to the following Norwegian cargo ships:

a) cargo ships with an internal combustion engine installation fuelled by liquefied natural gas (LNG);

b) cargo ships with a gas plant in which the pressure does not exceed 10 bars and arrangement for dual fuel or gas-only operation; and

c) cargo ships in which the principle of ESD-protected gas engine-rooms is applied.

(2) The Regulation may, insofar as it is appropriate and for matters not regulated by any international body of rules, also be made applicable to LNG carriers where the cargo is used as bunker fuel.

Amended by Regulation of 29 June 2007 No. 1006 (in force on 1 July 2007).

§ 12
Training

(1) The whole operational crew of a gas-fuelled cargo ship shall have necessary training in gas-related safety, operation and maintenance prior to the commencement of work on board.

(2) Additionally, crew members with a direct responsibility for the operation of gas-related equipment on board shall receive special training. The company shall document that the personnel have acquired the necessary knowledge and that this knowledge is maintained at all times.

(3) Gas-related emergency exercises shall be conducted at regular intervals. Safety and response systems for the handling of defined hazards and accidents shall be reviewed and tested.

(4) A training manual shall be developed and a training programme and exercises shall be specially designed for each individual vessel and its gas installations.

Chapter 5
Concluding provisions

§ 13
Entry into force

This Regulation enters into force on 1 July 2002 for new ships and existing ships that are converted for gas-fuelled operation after the entry into force.

Source: UiO.no (n.d.)

APPENDIX D

Extract of the Norwegian regulation of 9 September 2005 No. 1218 concerning the construction and operation of gas-fuelled passenger ships

Regulation of 9 September 2005 No. 1218 concerning the construction and operation of gas-fuelled passenger ships

Laid down by the Norwegian Maritime Directorate on 9 September 2005 pursuant to the Act of 9 June 1903 No. 7 relating to Public Control of the Seaworthiness of Ships, etc. Legal basis amended to Act of 16 February 2007 No. 9 relating to Ship Safety and Security (the Ship Safety and Security Act) sections 2, 7, 8, 9, 11, 16, 21, 22 and 47, cf. Royal Decree of 16 February 2007 No. 171 and Formal Delegation of 31 May 2007 No. 590, and Act of 17 December 2004 No. 101 on European notification of technical rules (the EEA Hearing Act). Cf. the EEA Agreement, Annex II, Chapter XIX paragraph 1 (Directive 98/34/EC as amended by Directive 98/48/EC). Amended 29 June 2007 No. 1006 (i.a. legal basis).

Chapter 1
General provisions

§ 1
Scope of application

(1) This Regulation and its appendices apply to Norwegian-registered, gas-fuelled passenger ships built on the date of or after the entry into force of this Regulation, and pursuant to:

a) Regulation of 15 September 1992 No. 695 concerning the construction of passenger ships, cargo ships and barges; or
b) Regulations of 28 March 2000 No. 305 concerning surveys, construction and equipment of passenger ships engaged on domestic voyages; or
c) Regulations of 5 January 1998 No. 6 concerning the construction, equipment and operation of high-speed craft used as passenger craft or cargo craft.

(2) This Regulation also applies to ships that are converted to gas-fuelled passenger ships.

(3) For gas-related matters that are not regulated in this Regulation, the following shall apply:

a) Classified ships shall comply with the DNV rules currently in force for gas-fuelled engine installations or the equivalent rules of another recognized classification society.
b) Unclassified ships shall comply with the DNV rules currently in force for gas-fuelled engine installations.

Amended by regulation of 29 June 2007 No. 1006 (in force on 1 July 2007).

Chapter 4
Training

§ 28
Training

(1) The training described in this Section comes in addition to other training that is required in order to serve on board passenger ships.

(2) The training shall comply with the guidance currently in force prepared by the Norwegian Maritime Directorate.

(3) All crew members constituting the minimum safe manning on a gas-fuelled passenger ship shall have completed the general basic training, Category A, for gas-related safety, operation and maintenance, before assuming duties on board.

(4) The part of the crew that are directly responsible for the operation of gas-related equipment on board shall also receive special training, deck officers, Category B, and engineer officers, Category C.

(5) The training plan/curriculum shall include all three categories (A, B and C), and shall be approved by the Norwegian Maritime Directorate.

(6) Documentation of completed training shall be kept on board.

(7) Crew members who have been away from the ship for a continuous period of more than six months shall complete a specially arranged internal refresher course before they assume duties on board. Documentation of completed internal courses shall be kept on board.

4. PERMIT FOR HOT AND COLD WORK IN EXPLOSION HAZARDOUS SPACES AND AREAS

Ship's name and call signal ____
Company/management company ____
Shipyard/place where the work shall be performed _____________________________________

Permit applies to hot/cold (delete as appropriate) work in the following space/area: ______________________________

This permit for hot/cold work requires the following documents to be provided and signed:

Check box

a) Checklist for purging of gas
b) Gas measurement results (shall not exceed 1% of the LEL)
c) Checklist for equipment and emergency preparedness

NOTE: If this permit is issued without the bunker tanks and associated gas piping systems having been emptied and purged of gas, the validity of this permit shall be restricted to the time available before the opening pressure is reached for the bunker tanks' safety valves.

Safety valve opening pressure: _____ Time available _____
Permit is valid for:__________ hours from date __________ time __________

Comments:

Place/date	Master	Chief engineer officer
________________	________________	________________

When the purging of gas is performed at a shipyard, the shipyard's operations/safety manager shall be familiar with and sign this permit.

Place/date	Shipyard's manager
________________	________________

GUIDELINES

Training of crews on gas-fuelled passenger ships

Gas-related training

1. *Training in general*
   The training on gas-fuelled passenger ships is divided into the following categories:
   Category A: Basic training for crew members constituting the minimum safe manning
   Category B: Supplementary training for deck officers
   Category C: Supplementary training for engineer officers
2. *Category A*

The goal of the Category A training is to provide crew members constituting the minimum safe manning with a basic understanding of the gas in question as a fuel, the technical properties of liquid and compressed gas, explosion limits, ignition sources, risk reducing and consequence reducing measures, and the rules and procedures that must be followed during normal operation and in emergency situations.

The general basic training required for the basic safety crew is based on the assumption that the crew does not have any prior knowledge of gas, gas engines and gas systems.

The instructors should include one or more of the suppliers of the technical gas equipment or gas systems, alternatively other specialists with in-depth knowledge of the gas in question and the technical gas systems that are installed on board.

The training shall consist of both theoretical and practical exercises that involve gas and the relevant systems, as well as personal protection while handling liquid and compressed gas.

Practical extinguishing of gas fires shall form part of the training, and shall take place at an approved safety centre.

3. *Categories B and C*

Deck and engineer officers shall have gas training beyond the general basic training. Category B and Category C training shall be divided technically between deck and engineer officers. The company's training manager and the master shall determine what comes under deck operations and what comes under engineering. This must appear from the curriculum, which shall be approved by the Norwegian Maritime Directorate, as mentioned in § 28 of this Regulation.

Those ordinary crew members who are to participate in the actual bunkering work, as well as gas purging, or are to perform work on gas engines or gas installations, etc., shall participate in all or parts of the training for Category B/C.

The company and the master are responsible for arranging such training based on an evaluation of the concerned crew member's job instructions / area of responsibility on board.

The instructors used for such supplementary training should be the same as outlined for Category A.

All gas-related systems on board shall be reviewed. The ship's maintenance manual, gas supply system manual and manual for electrical equipment in explosion hazardous spaces and zones, as mentioned in § 29 of this Regulation, shall be used as a basis for this part of the training.

This Regulation and Appendices 1 and 2 shall be reviewed. Appendix 1 concerning risk analysis shall be emphasized, and the risk analysis and sub-analyses shall be available to course participants during training.

If the ship's own crew will be performing technical maintenance of gas equipment, the training for this type of work shall be documented.

The master and the chief engineer officer shall give crew members constituting the minimum safe manning on board their final clearance prior to the entry into service of the ship. The clearance document shall only apply to gas-related training, and it must be signed by both the master/chief engineer officer and the course participant.

The clearance document for gas-related training may be integrated in the ship's general training programme, but it must be clearly evident what is regarded as gas-related training and what is regarded as other training.

The training requirements related to the gas system shall be evaluated in the same manner as other training requirements on board at least once a year. The training plan shall be evaluated at regular intervals.

Source: UiO.no (n.d.)

APPENDIX E

Example of a training scheme, provided by one of the respondents in the questionnaire

Q9. Describe the elements of a typical training scheme for Officers and Crew on your gas-fuelled vessels
The training is divided in two levels, basic and depth. Basic course consists off: - Review of all presentations in the training course - Review of picture-material - Tour around the vessel Depth course consists off: - Review of all presentations in the training course - Review of drawings - Review of AGA manual - Thorough introduction in the operation of the gas-system via computer screens - Tour around the vessel The training to be documented. The tour around the vessel shall at least cover; - PPE, placed and proper use - LNG bunkering-station in stbd cargo rail - Emergency stops and warning equipment, alarms - Explosion hatches in ventilation ducts - Reinforced area i the cargo-deck - Hatches for ventilation-ducts to the accommodation area - Electric component on deck and in cargo rail which shall be shut down before start of bunkering - Ventilation outlets from gas dangerous zones - Escape routes from generator- and engine rooms - Access to “Cold box”/gas tank. Study checklist for access to these areas - Valve room with gas-ramps, gas detection system - Generator room with gas pipes and gas detection equipment - Foam fire extinguishing system in generator room - Engine control room with monitor pictures of the gas system - Documentation and drawing archive

APPENDIX F

Ethics: copy of the document "Informed Consent" sent to the respondents.

Page 1 of 1

INFORMED CONSENT

Description of the study
This study is a thesis for obtaining a degree on Master of Sciences in Maritime Management at Chalmers University of Technology, Sweden.
It is a case study about how Norway dealt with the training of officers and crew when Norwegian vessels started to use liquefied natural gas (LNG) instead of heavy oils as fuel. The purpose is to study what new training needs emerged, and what training was developed to meet those needs. As Norway had a pioneer role in this subject, the purpose is also to explore what can be learned from the Norwegian experience.

Conditions for participation
Data will be collected about training needs and training solutions, from documents and interviews, and analysed for the purposes stated above. Your participation in this study, by providing data in the form of documents and/or interviews, is voluntary.
This case study will result in a report that will be published and made available to the public by December 2013. You will be offered to read the result section prior to its publication if you indicate you wish to do so. You may withdraw your participation in this study any time prior to its publication, without having to give any reasons. In this event, all data you provided will be removed from the study and destroyed with immediate effect.

Confidentiality
The researcher's interest is on the training needs, the solutions created to meet those needs, and in lessons learned. The data you provided will be separated from your identity and that of your company.
Questions or comments may be sent to the researcher:
Name:
E-mails:

Informed consent
The participant is kindly requested to read and sign the form below, and send it to the researcher by return e-mail.

Participant's consent
I have been informed about the purposes of this case study, the conditions for participation and confidentiality, and that the resulting report will be published.
I, ____ (texted name)

participate voluntarily in this study.

Please indicate:

- ☐ I want to read to read the result section prior to its publication.
- ☐ I do not want to read the result section prior to its publication.

Date: ___________ Signature: _________________________________