

A-095

The Norwegian LNG Ferry

Per Magne Einang*

Norwegian Marine Technology Research Institute (MARINTEK)

Konrad Magnus Haavik

Norwegian Maritime Directorate

ABSTRACT

Financed by the Norwegian Directorate of Public Roads, a car ferry with a capacity of 100 private cars was designed for operation on natural gas, based on a new set of Norwegian safety standards for gas fuelled passenger ships. The ferry is propelled by four gas engine generator sets giving power to two electric driven compass thrusters, one in each end of the ship. Liquid Natural Gas (LNG) is stored in two LNG tanks under the main deck. This paper will describe the design and safety philosophy for this ferry. Further, the LNG production, transportation and filling system will be presented.

The ferry has been in operation since February 2000, crossing a fjord close to the city of Molde at the west coast of Norway. The experience so far is very good considering that the ferry has been running 19 hours a day 7 days a week, without any kind of interruptions. Design of a second ferry of the same size is in process. Further more this paper gives a short overview of the international experience on natural gas fuelled ships.

INTRODUCTION

The transportation sector is responsible for more than 22% of all oil products consumed world wide, and is the fastest growing oil demanding sector and the fastest growing source of emissions. However, water bound transportation is one of the most environmentally friendly means of transportation. By employing natural gas as fuel, the potential pollution to water and harmful exhaust emissions could be substantially reduced, making the water bound transportation even more environmentally friendly.

This paper is dealing with the technical challenges and the safety aspects related to introducing natural gas as fuel in passenger ships.

INTERNATIONAL EXPERIENCE /1/

LNG carriers have used the boil off gas as fuel since the first ship was put into operation in 1964. Numerous LNG carriers have long and good experiences with natural gas as fuel for the propulsion machinery, mainly steam turbines. The experiences from the LNG ships are of course relevant but this paper is dealing with vessels using natural gas as bunker fuel.

Until today, just a handful of vessels are using natural gas as fuel, and the list in Table 1 is covering most of them. In addition there has been some preliminary studies and pre-engineering of natural gas powered passenger ships. Among them is BC ferries study of a large and a medium sized car/passenger ferry using CNG storage, a passenger ship in Germany /2/ and a catamaran fast ferry in England using LNG /3/.

Type of vessel	Location	Year	Engine	Storage
"Accolade II" Bulk carrier	Adelaide, Australia	1982	Dual Fuel 2 engines	CNG
"Klatawa" Car/passenger ferry, 26 cars, 146 passengers	Vancouver, Canada	1985	Dual Fuel 2 engines	CNG
"Kulleet" Car/passenger ferry 26 cars, 146 passengers	Vancouver, Canada	1988	Dual Fuel 2 engines	CNG
Canal boat	Amsterdam, Netherlands	1992	Dual Fuel 1 engine	CNG
Canal boat	Amsterdam, Netherlands	1994	Dual Fuel 1 engine	CNG
Tourist boat	St. Petersburg, Russia	1994	Dual Fuel 2 engine	CNG
	Moscow	1999	Dual Fuel 2 engines	CNG
"Elisabeth River I", Passenger ferry, 149 passengers	Norfolk, Virginia, USA	1995	Gas engine 2 engines	CNG
"Glutra" Car/passenger 100 cars, 300 passengers	Molde, Norway	2000	Gas engine 4 gen. sets	LNG

Table 1. Some ships and boats that are in operation powered by natural gas

From this list we like to share some relevant information from the car ferries in Canada which have accumulated about 15 years of experience.

MV "Klatawa" and "Kulleet" /4/

The Ministry of Transport and Highways in British Columbia, Canada, operates MV Klatawa and its sister ship MV Kulleet. The two ferries have a capacity of 26 cars and 146 passengers, and operate on the Fraser River between Albion and Fort Langley, close to Vancouver.

Klatawa was built in 1982 and converted to natural gas operation in 1985. The two deck-mounted Caterpillar 3406-B engines, located in diagonally opposite corners of the ship, were converted to dual fuel operation. Eight aluminium, hoop wrapped CNG cylinders were mounted on the main deck in two compartments, completely separated, one for each engine. Putting the gas storage, piping and the engines on the main deck, assure no gas below main deck, which is the main safety feature of the ship.

The ship is refuelled twice a day using about 3-4 minutes each time. The on-shore compressor station store the gas at 250 bar, filling the on board storage to about 160 bar.

After 4 years of operation, calculations showed net savings per year giving payback of investments of about 8 years. Further, the engine maintenance cost is reduced due to increased lifetime of the engines.

MV Kulleet was converted to natural gas operation in 1988. The benefit from the experience of Klatawa and using 4 less expensive CNG cylinders made of steel, reduced the investment costs. The payback of investments for Kulleet is calculated to about 5 years.

Exhaust emissions have not been in focus in the project and no figures are therefore reported.

SAFETY ASPECTS

Since 1964 a number of LNG carriers have been in operation using boil off gas as fuel for the propulsion machinery. No accident related to the use of natural gas as fuel has been reported, which is an indication of natural gas being a safe fuel. Safety for the LNG carriers is regulated by an international standard, the International Code for the Construction of Equipment of Ships Carrying Liquefied Gases in Bulk (IGC-Code). Today this is the only international safety standard for using gas as fuel for ships.

The IGC-Code will not be suitable related safety for other kind of ships then gas freighters. Some of the classification societies, however, have worked out requirements for the use of gas as fuel in ships based on this code. For instance, the Norwegian classification society, DNV, Rules for Classification of ships, has launched the rule proposal "Gas Fuelled Engine Installation" /5/. This means that in near future there will be classification rules to which you can design a gas-fuelled ship.

In Norway several studies of natural gas fuelled ferries have been carried out, the first one in 1989. All studies concluded negative mainly due to high costs. In 1997 LNG became available at the west coast of Norway at an acceptable cost level. Funding to build a new ferry driven by natural gas was at the same time granted by the government.

The Norwegian Maritime Directorate (MD) is the regulatory body responsible for safety of ships and passengers. The attitude of the MD regarding natural gas powered passenger ships, was that natural gas as fuel will not be allowed if the consequences of an accident are unacceptable. That is the risk for life of passengers, even if the probability for the accident is low. At the beginning of the discussions of building a gas ferry, MD was reluctant. After some studies and calculations showing it was possible to reduce the consequences of any possible accident to an acceptable level, the process of developing a set of regulation for gas fuelled passenger ships, could start.

To write the regulations with respect to gas related equipment and procedures, a task force was established with representatives from:

- Maritime Directorate (MD)
- Directorate of Public Roads
- Directorate of Fire and Explosion prevention
- MRF- Ferry operator
- RT-Ferry operator
- MARINTEK advisor, gas engine applications
- Kvaerne, advisor, LNG applications

In discussion of special subjects, other institutions were consulted, like the Labour Inspection Offices, the Norwegian classification society DNV.

Bringing all these people, representing concerned institutions and expertise in gas applications, around the same table, was a sound and efficient way of developing the regulation for gas fuelled passenger ships. In parallel to this work, the first LNG ferry was designed and built. We believe that developing

the regulations and co-operatively designing and building a ship according to the same regulations is unique. After operating the ferry for some time, there have been revisions of the regulations based on the experiences. The regulations were finalised in August 2000, about three years after starting the work.

Some of the main requirements in the regulations of gas fuelled passenger ships are:

- Generally by design reduce the risk of explosion; limiting area of gas in place, small engine rooms.
- Redundancy of fuel storage, power generation, transmission and propellers.
- Separation of engines in at least two engine rooms, separation of fuel supply.
- Double piping of all gas pipes inside the ship.
- If a fire or explosion should occur, the result should not harm the ship or endanger passenger's life. And the ship should still be able to manoeuvre and get safely to port.
- Detection of gas leakage in all areas where gas in place. Alarms of 20% Lower Explosion Limit (LEL), automatic shut down at 60% LEL based on voting 2 out of 3.

THE LNG FERRY

The ferry is double-ended car/passenger ferry with a capacity of 100 private cars, and was built at Langsten Yard in Norway, part of the Aker Yards group, The ferry was named "Glutra" and put in operation February 2000. The ferry was delivered according to contract after a building time of one year. The total cost was 30% higher compared to similar diesel powered ferry. This is regarded as acceptable taking into account this being the first one, and introducing new techniques for the yard and the ferry operator.

Glutra is operating at the ferry service Solsnes –Aarnes close to the city of Molde at the West Coast of Norway. A roundtrip takes 35 minutes.

General arrangement of the ferry and some pictures are shown in Page 6, 7 and 8.

LNG FUEL SYSTEM

The LNG fuel system was sealed off under main deck in two separate compartments containing one LNG tank and evaporator each. Evaporated gas is fed in double piping to the engine room at about 4 bar.

The size of the LNG tanks is 32 m² each having enough capacity to take a full truck load. Refuelling every 4th or 5th day. Having this storage capacity onboard, storage at the ferry berth was not necessary. This cut down on investment costs and provided some freedom regarding where to put the ferry in service.

The refuelling takes place when the ferry is docked for the night and no passengers are onboard. Refuelling time is about one hour for a truckload of 40 m² of LNG. The truck connects to the filling station through a hatch at the shipside.

GAS ENGINES

The ferry company, MRF, is in favour of using electric transmission for the small ferries at short distances. This is also the case of Glutra. When choosing gas engines, only gas engine generator sets for power production were available at the power range of 500-800 kW per unit. A final argument for choosing electric transmission was the freedom of putting the generator sets at different locations onboard the ferry.

Four generator sets, 675 kW each, were put in separate engine rooms above the main deck. This was at the same time an elegant way to meet the strict requirement regarding consequences of an explosion in the engine room. An explosion analysis showed that in the worst case the two-sashed door of the engine room would burst and immediately release the pressure without affect the other engine rooms. The engine room are arranged two and two, with the main switchboard for the electric power, separating them.

In normal operation two engines gives sufficient power for propulsion and other energy consumers. The third generator set is backup or may be added to increase speed or higher energy demand due to weather conditions. The fourth generator set could then be available for maintenance. By this arrangement the ferry could be in operation 365 days a year in a period of 2-3 years.

Glutra has been in operation for more than half a year without any kind of interruptions. The ferry company is satisfied in all respect.

Table 2. Specifications of the LNG ferry M/F Glutra

Main dimensions	
Length	94.80 m
Bredth	15.70 m
Depth	5.15 m
Dead weight	640 ton
Service speed	12 knots
Capacities	
Private cars	100
Passengers	300
Engines	
4 Mitsubishi GS12R-PTK, 12 cylinder V Lean Burn Pre-chamber spark ignited gas engine	675 kW per unit
LNG fuel system	
2 AGA CRYO vacuum insulated cryogenic tanks	32m ² per unit
Propellers	
2 Schottle Twin propeller STP 1010	1000 kW
Propeller diameter	2.15 m
Electric transmission	
24- Pulse Siemens system	
Electric installation/alarms	
ABB	

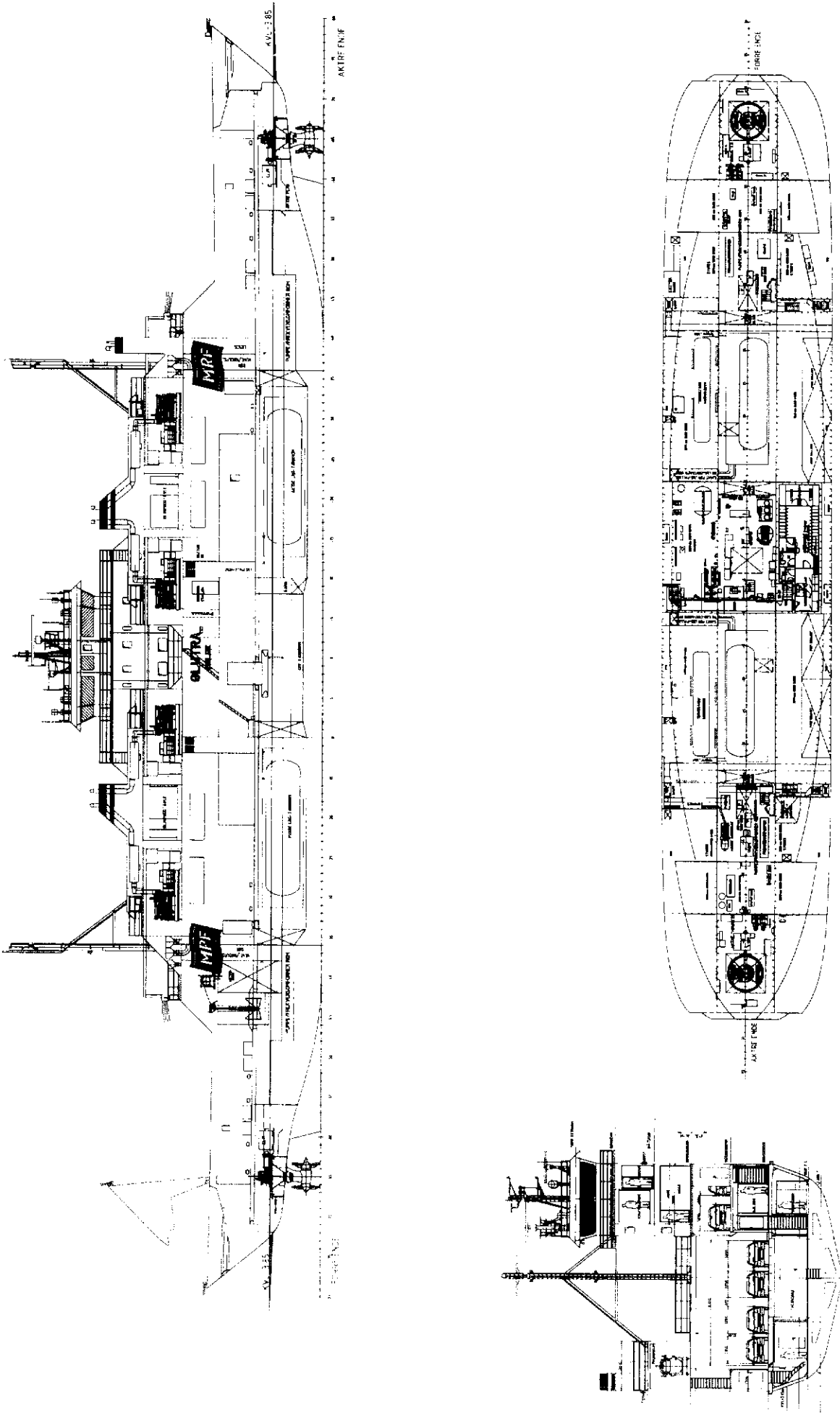


Figure 1. LNG ferry Glutra - General arrangement

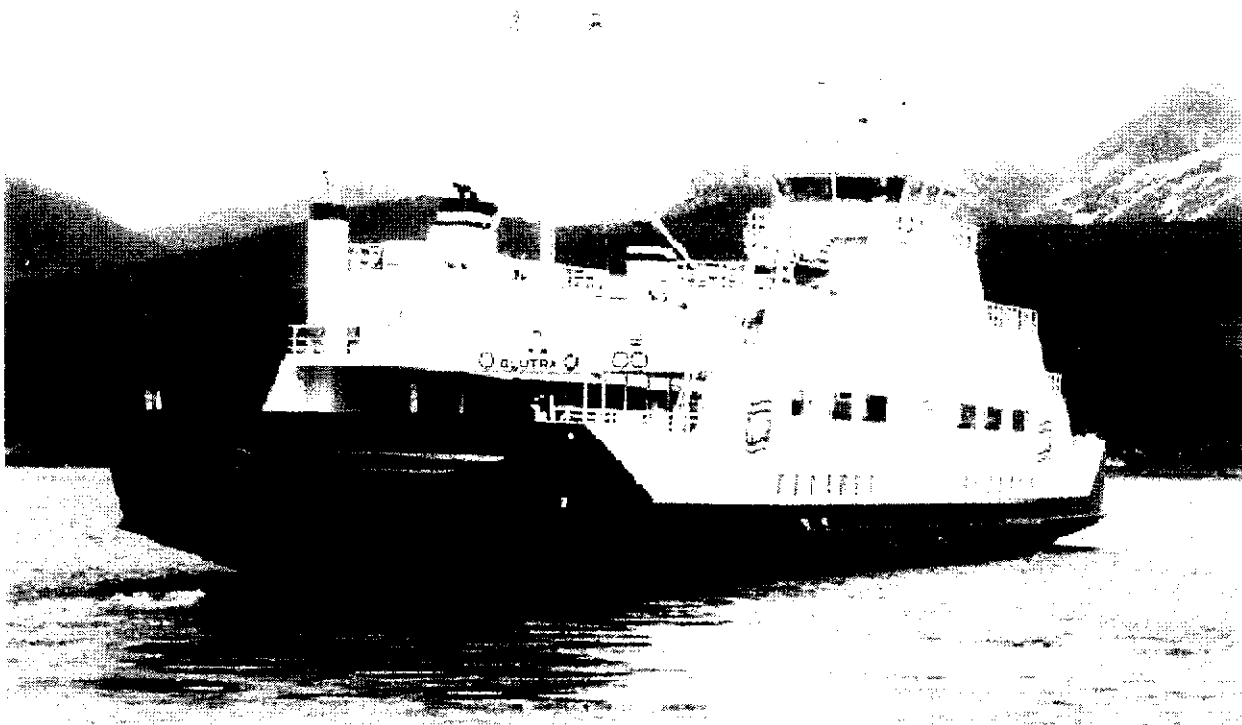


Figure 2. The LNG car/passenger ferry M/F Glutra

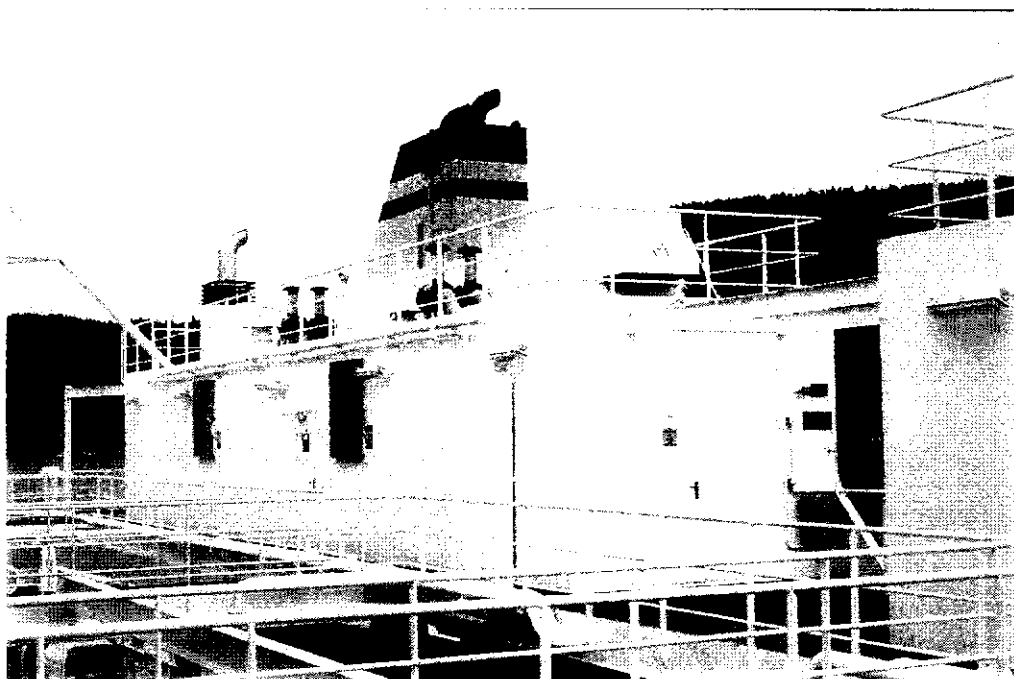


Figure 3. Two of the engine rooms separated by the main switchboard.



Figure 3. Refuelling LNG directly from the truck during docking at night.

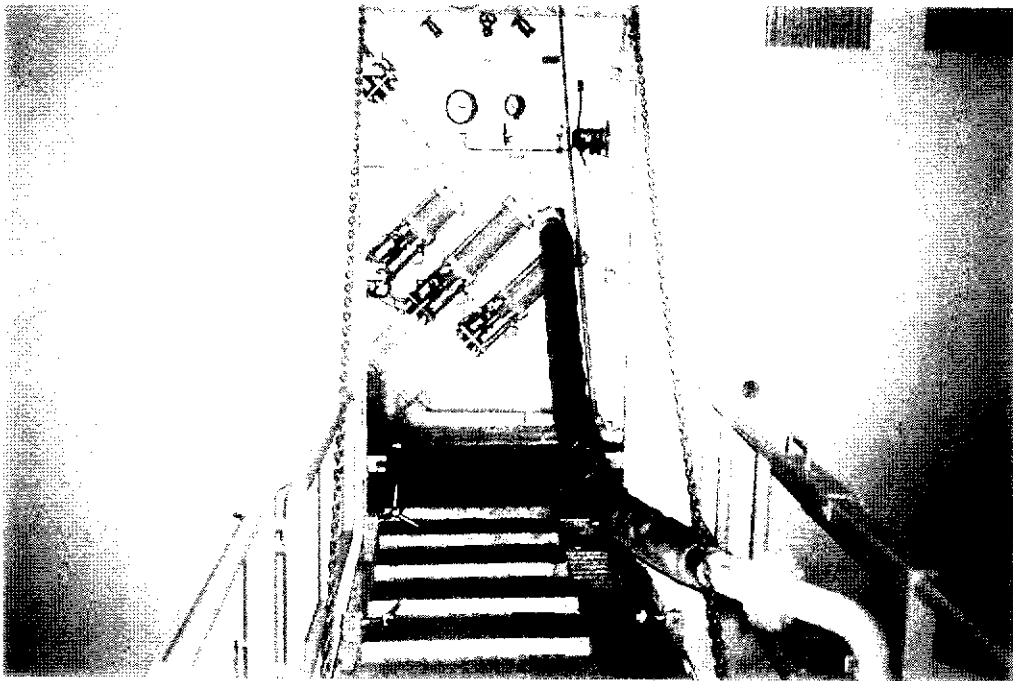


Figure 4. Close-up picture of the LNG filling station hatch at the shipside.

THE NORWEGIAN LNG PROJECT

Norway has great resources of natural gas and is one of the main suppliers of natural gas to the European market. Gas pipelines from the North Sea are landing at three different sites at the West Coast of Norway. At one of the landing sites close to Haugesund, there is a small local distribution pipeline for utilising natural gas in the industry and transportation sector. Norway has scattered population and has a topography with high mountains and deep fjords, making it very costly to distribute natural gas in pipelines to the main parts of the country.

Another possibility is to distribute natural gas in liquid form (LNG) by ships along the coast line and by road tankers in the same way as diesel oil gas gasoline are distributed today. This is probably the only way that natural gas will be utilised on large scale in Norway. The challenge is to produce and distribute LNG to a level of cost that could compete with the alternative, diesel oil.

At Tjeldbergodden, where one of the pipelines from the North Sea is landed, LNG could be produced at a low cost as in integrated part of the process plant producing methanol, air gases and bio-protein, mainly by using surplus cold energy. Since 1997 LNG has been produced on a small scale, about 10000 ton/year. Tjeldbergodden is located about 120 km from Trondheim.

In addition to the LNG ferry, there are city buses in Trondheim running on CNG made from LNG /6/. This program will be extended to include more busses and trucks. LNG is also used in industry to substitute diesel oil and heavy fuel. The combined distribution system for industry and the transportation sector makes it possible to keep down the cost of LNG. So even on a small scale distribution of LNG is viable.

A new LNG ferry is designed based on the same concept as Glutra and will be in the same size. This ferry will be contracted in the end of 2000 and is expected to go into operation at the end of 2001.

Further, the authorities have announced a new program for designing a series of larger ferries, 155 private car capacity. These ferries may differ from the existing one regarding the propulsion system.

ACKNOWLEDGEMENT

The authors would like to thank Mr. Knut Guttormsen, the Norwegian Road Administration, for his contribution. MRF the ferry operator and Langsten Yard for detailed information.

CONTACT

Per Magne Einang held the position as Research Manager (internal combustion engines), Division of Machinery and Technical Operations at MARINTEK, an independent research and development company in Trondheim, Norway. He has been involved in research and development of diesel and gas engines since 1981. The main part has been contract work for engine builders of both medium speed and high-speed heavy duty engines, mainly carried out in the Machinery Laboratory at MARINTEK. Further, Mr. Einang has a 20 years of experience in using natural gas as LNG and CNG in several programs like the LNG ferry.

E-mail: Permagne.Einang@marintek.sintef.no

Telephone: +47 73 59 5706

<http://www.marintek.sintef.no>

Fax: +47 73 59 5778

REFERENCES

- /1/ P.M.Einang, MARINTEK
Natural Gas as a Ferry Fuel Gastech 96 , Vienna Desember 1996
- /2/ Dr. Hermann Klein et al., MWB Motoren & Anlagen
Marine Propulsion with SI gas engines, 1st Dessau Gas Engine Conference, June 1999, Germany
- /3/ P.Bernardes-Silva, Iguana Seacraft Ltd, Southampton, UK
The designe of an estuarial LNG powered Ro-Ro ferry, ENSUS 2000, September 2000, Newcastle, UK
- /4/ Ian A. Smart, Ministry of Transportation of Highways, Canada
The use of Natural Gas in Marine Engines (1990)
- /5/ Det norske Veritas Clasification AS
Certification notes Noø.2.11
Certification of gas burning internal combustion engine installations (May 1994)
Rule proposal "Gas Fuelled Engine Intallation"
- /6/ P.M. Einang, D. Stenersen, MARINTEK
Natural Gas as fuel in city busses NGV-1996, Malaysia