GASEOUS FUELS - SAFETY ASPECTS

Bruno Dabouis
Bureau Veritas Marine Division, Paris/France

1 Environmental context

There are some environmental benefits in the use of gas fuels as alternative to liquid fuels in the particular context of the upcoming regulations of air emissions of ships.

The revision of Marpol Annex VI, which was adopted in October 2008 at the MEPC 58, and will enter into force on 1st July 2010, has introduced gradually increasing requirements on engine emissions. These requirements include in particular a cap on NO_x in engine exhaust gases and a cap on sulphur contents in fuels (see tables 1a, 1b and 2). Marpol convention identifies specific Emission Control Areas (ECA) where the most stringent requirements will apply. They include today the Baltic Sea (since 19 May 2006), the North Sea and the English Channel (since 22 November 2007 according to IMO or 11 August 2007 according to EU). In addition, after requests made to the IMO by the US and Canadian administrations, a North American ECA is on track for practical enforcement some time between July 2010 and summer 2012. On top of this, Europe has unilaterally introduced an even more stringent requirement that ships at berth in EU ports should use 0.1% sulphur fuels from 1st January 2010. Some states in North America have done the same. In any case, exhaust cleaning systems, currently referred to as “abatement technologies”, or onshore power supply, referred to as “cold ironing”, can be used as alternatives to comply with IMO, EU and others’ prescriptions.

Table 1a. Cap on NOx (Marpol Annex VI Reg. 13)

Engine fitted on ship built at date D (keel laying)	Outcome of MEPC58	
▪ 1/1/2000 ≤ D < 1/1/2011	Tier I	
▪ 1/1/2011 ≤ D < 1/1/2016	Tier II	
▪ 1/1/2016 ≤ D	Tier III in ECA	Tier II elsewhere
▪ “existing engines”: 1/1/1990 ≤ D < 1/1/2000 cylinders ≥ 90 l & power > 5,000kW	Tier I	

Table 1b. Cap on NOx (Marpol Annex VI Reg. 13)

Engine rpm	N < 130	130 ≤ N < 2000	N ≥ 2000
Tier I Current Reg 13(3)(a)	17 g / kWh	45 N-0.2 g / kWh	9.8 g / kWh
Tier II ~ 80% Tier I	14.4 g / kWh	44 N-0.23 g / kWh	7.7 g / kWh
Tier III ~ 20% Tier I	3.4 g / kWh	9 N-0.2 g / kWh	2 g / kWh

Table 2. Cap on sulphur contents of fuels (Marpol Annex VI Reg. 14)

<table>
<tr><td>Keel laying date D</td><td>Within ECA</td><td>Elsewhere</td></tr>
<tr><td>D< 1/7/2010</td><td>1.5%</td><td rowspan="2">4.5%</td></tr>
<tr><td>1/7/2010 ≤ D< 1/1/2012</td><td rowspan="2">1.0%</td></tr>
<tr><td>1/1/2012 ≤ D< 1/1/2015</td><td rowspan="2">3.5%</td></tr>
<tr><td>1/1/2015 ≤ D< 1/1/2020 *</td><td rowspan="2">0.1%</td></tr>
<tr><td>1/1/2020 * ≤ D</td><td>0.5%</td></tr>
</table>

Note: (*) Subject to review of fuel oil availability in 2018.

Although shipping is seen as the most carbon efficient means of transport with around 3% of the global CO_2 emissions, the conference of the parties to the climate change convention gave a mandate to the IMO, at COP 14 in December 2008, to find technical and operational solutions to reduce the emission of greenhouse gases from ships. The next convention COP15 will take place in December this year, where the IMO will support the idea that reducing greenhouse gases from shipping should stay under its responsibility rather more than be integrated within the Kyoto Protocol. The EU is also keeping an eye on the evolution of the IMO initiatives aiming at enhancing the energy efficiency of ships with a view to possibly place shipping into its emission trading scheme.

2 Use of natural gas as fuel on ships

In such a context, although it cannot be deployed to a great scale within a short period of time, the use of natural gas as fuel can offer an interesting solution to reduce exhaust gas emissions in air in terms of NO_x, SO_x and CO_2 as well as of particulate emissions compared to fuel oils. In particular it enables to meet the IMO tier III requirements (NO_x), it satisfies the highest requirements relating to SO_x as natural gas does not normally contain sulphur, and it achieves a reduction of 20% of CO_2 emissions.
Historically, until a recent past, LNG carriers have been the only ships currently equipped with gas burning propulsion systems using their cargo boil off as fuel. These ships used to be equipped with boilers and steam turbines until the break through in 2004 of the construction of the first dual fuel diesel electric propulsion on board the LNG carrier “Gaz de France EnergY”. This innovation was introduced at the initiative of Gaz de France, Wärtsilä, Saint-Nazaire shipyard, now STX Europe, and Bureau Veritas. It proved very successful as more than 50 additional LNG carriers have been ordered with dual fuel diesel electric propulsion since this first application. In addition, we have also seen the delivery in 2009 of one LNG carrier with single gas fuel engines also with a Bureau Veritas class.

Nowadays, gas burning engines are envisaged for a broader range of ships, in particular ferries (Ro-Ro / Ro-Pax), cargo and supply ships. Natural gas is also seriously considered for other vessel’s types such as container vessels and ships involved in “short sea shipping”. Spark ignition or pilot fuel injection are possible options depending of the required propulsive power.
It is also worth mentioning that some LPG carriers recently delivered have been fitted with diesel generators able to burn LPG vapours together with fuel in order to prevent the release of cargo vapours to the atmosphere during cargo transfers at terminal. This is the case of the series of LPG and ethylene carriers ordered by Lauritzen Kosan at Korea’s Sekwang Heavy Industries, the first of which, the “Isabella Kosan”, was delivered and has received the Lloyd’s list award of the “ship of the year” in 2008.

3 IMO regulation and class rules

The IMO has historically addressed the use of natural gas as fuel in the IGC code and in the earlier gas carrier codes, applicable to liquefied gas carriers, to cover the use of boil off gas as fuel.

After this first achievement, IMO has extended its involvement with the adoption of the “Interim guidelines on safety for natural gas fuelled engine installations in ships” that were adopted on 1st June 2009 by its resolution MSC.285(86) after the submissions made by flag administrations who developed their regulations in this field. IMO intends to continue its work towards the development of the “International Code of Safety for Gas Fuelled Ships” (IGF code).
The developments of the industry, however, have been quite fast. In this context, some class societies have been able to timely introduce classification rules for gas fuel engines in order to provide the industry with a recognized rule frame that it needed to be able to safely develop its technologies. This has been the case of Bureau Veritas with two specific rule notes

which are fully compatible respectively with the IMO IGC code and with the aforesaid IMO guidelines as relevant depending on the ship's type,

- NR481: "Design and installation of dual fuel engines using low pressure gas",
- NR529: "Safety rules for gas-fuelled engine installation on ships".

The main objectives of the rules are to set acceptable basic prescriptions and criteria so that the gas fuelled propelled ships achieve the same degree of safety and of reliability as the ships using liquid fuels. In other words:

- there should be a safe and reliable gas combustion in the engines,
- the gas plant storage, refuelling facilities and distribution systems should not create a substantial risk of gas leakage or spillage leading to brittle fracture, fire and / or explosion,
- the machinery space should be designed and arranged for gas burning engines, and
- the gas fuelled propulsion systems should have an adequate level of dependability.

Safe and reliable gas combustion genuinely require that the gas fuelled engines should be so controlled as to avoid detonation and misfiring and that it could operate in a efficient and reliable manner at various loads and possibly with variable proportions of gas fuel and liquid fuel.
Safe natural gas storage, fuelling and distribution depend on the design of the containment system and its equipment, on the location and segregation of spaces, on the design and arrangement of the gas fuel bunkering systems.
A safe arrangement of the engine room depends on an efficient combination between ventilation and gas detection, the right balance of which is difficult to find in ESD protected machinery spaces. This is why a double wall piping to conduct gas from storage to engines is recommended whenever feasible.
Beyond the reliability of the gas fuelled engine itself, the global dependability of the gas propulsion systems is assessed against its capability to maintain a sufficient propulsive power in all the operating situations, be they normal or abnormal, at least to a level that is equivalent to liquid fuel engines. This is currently substantiated with FMEA and HAZOP exercises.

And last but not least, engineers on board should be trained to operate gas fuelled engines in all the anticipated operating scenarios.

4 Conclusion

Natural gas appears to be a quite interesting fuel, in particular for short sea shipping, due to its reduced emissions in air, thus its ability to meet the most stringent environmental regulations gradually implemented by the IMO and by several national or international bodies like the EU.
The technical solutions to install gas fuel engines in various types of vessels are in place, demonstrating the feasibility of this alternative to liquid fuels, and opening the way to expand this mode of propulsion substantially more than what it is today.
Safety and dependability aspects of natural gas fuel have been studied by engine designers, design / engineering offices and shipbuilders, while IMO and class societies have developed rules and regulations to address natural gas propulsion of ships.

Logistical issues will have to be solved thanks to the development of a sufficient number of natural gas bunkering stations able to refuel the ships wherever they may be operated.
However, I would like to conclude this paper with a broader view on the steps that our world industries should make to really lower the global GHG footprint.
Although making ships more energy-efficient or using low carbon fuels will definitely help enhancing the environmental friendliness of shipping, it will only partly enable our global industry to meet its environmental obligations.
A significant impact may also be expected from a change in our transportation patterns such as making more intensive use of ships and ports and creating economic incentives to enable this. In addition, idle ships, unnecessary ballast voyages, port congestion, inefficient ship-shore interface, poor routing and transport mode selection certainly contribute a lot in terms of potential reductions in CO_2 emissions, possibly even more than those that could be obtained from improving the energy efficiency of individual ships. And this is definitely a very challenging subject ahead of us all.

Bruno Dabouis joined the Marine Technical Department of Bureau Veritas in 1985 after graduation of Ecole des Mines in France, and has been actively involved in the review of the cargo containment and handling systems of liquefied gas carriers. He was appointed Deputy Head of Ship Safety Department in 1990 and was then in charge of the review and approval related to the cargo and safety systems of liquefied gas carriers, oil and chemical tankers. He has been a member of the IACS working group Gas Tankers / Bulk Chemicals and represented Bureau Veritas in several international organizations dealing with transportation of bulk liquid cargoes on tankers. He is currently Vice President, Manager of the Marketing & Sales Department of the Marine Division of Bureau Veritas.