Gas engine propulsion in ships

Safety considerations

Torill Grimstad Osberg, DNV
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Background

Summary of projects with gas engines in ships

Safety regulations
  - How are the installations made safe?
    - Engine room arrangement
    - Tank design and location
    - Gas piping systems
  - International rules on the way
Background
Background – before year 2000

- CNG driven ships in Russia, Netherlands, US, Canada, Australia
- Gas engines installations for maritime/offshore use (mainly FPSOs)
- LNG/LPG Carriers
  - gas propulsion, gas piping, gas tanks, materials, testing and so on
Gas fuelled ships - since 2000

- The LNG fuelled car and passenger ferry Glutra

- Gas engines located in 4 separate machinery spaces
- In full operation since January 2000- excellent performance

Photo: Harald Valdehaug
Gas fuelled ships - since 2000

- Platform supply vessels (PSVs) Viking Energy and Stril Pioneer: Worlds first LNG fuelled cargo ships delivered 2003 (dual fuel engines)
Gas fuelled ships - since 2000

- Small LNG tanker Pioneer Knutsen delivered in June 2004 (gas and diesel engines, DNV class)
- 3 LNG tankers built in France, delivered 2006/2007 (BV)
- Numerous LNG tankers on contract in Korea with dual fuel engines (33 vessels on order April 2008 (coltoncompany.com) -different class societies, including DNV
- Additional small coast trade LNG tanker to be delivered 2008 (RINA)
Gas fuelled ships - since 2000

- 5 LNG fuelled car and passenger ferries January/February 2007 (gas only engines)
- LNG fuelled platform supply vessel, Viking Queen and Viking Lady, first is delivered (dual fuel engines)
- More ferries contracted now (3 different types including HSLC for Brazil)
Gas fuelled ships - since 2000

- LNG fuelled coast guard vessels- first to be delivered March 2008 (gas and diesel engines) – 3 vessels contracted
Coast guard vessels engine room
RoRo/ RoPax

- BigLNG project
  - Research project (ColorLine, SeaTrans, Marintek, DNV, AkerYards, GasNor)

- Two designs developed, one for RoRo one for RoPax
Engine types used

- Lean burn prechamber spark ignited engine from Mitsubishi (low pressure Otto cycle)
  - Ferry Glutra
  - Knutsen Pioneer LNG tanker
  - Coast guard vessels
  - Some of the ferries on contract

- Lean burn prechamber spark ignited engine from Rolls Royce (low pressure Otto cycle)
  - Ferries delivered in 2007 (Bergensfjord, Stavangerfjord, Mastrafjord, Raunefjord, Fanafjord)
  - New RORO project Sea-Cargo

- Dual fuel (DF) engines (DF engine work as an ordinary diesel engine in diesel mode and as a pilot ignited Lean burn gas engine (low pressure Otto cycle) in the gas mode):
  - Gas supply vessels Viking Energy, Stril Pioneer, Viking Queen and Viking Lady (Wärtsilä DF)
  - LNG tankers France and Korea (Wärtsila DF, MAN Diesel DF)
  - FPSOs

- Gas Diesel:
  - FPSOs
Main challenges with natural gas as fuel

- Explosion risk
  - Range 5-15% mixture in air
  - Ignition source present
  - Where in the ship?
    - Engine room
    - Gas storage space
    - Bunkering station
    - Gas piping through the ship:
      - Between bunkering station and tank
      - Between tank and engine room

- Low temperature of liquid gas
  - LNG at -163°C
  - Special material, protection of normal ship steel

- Gas tank large energy content
Rules and Regulations - Gas as Fuel

- DNV Rules Pt.6 Ch.13 “Gas fuelled engine installations” issued January 2001
  - Applicable to all ship types
  - The part of these Rules addressing engine room installations are also relevant for LNG carriers

- Use of gas as fuel in ships other than LNG carriers need acceptance by flag state due to lack of international conventions

- International work in IMO: Interim guidelines/ code for gas fuelled ships in progress.
  - Based on the same principles as DNV rules
Engine room safety principle

- DNV Rules Pt.6 Ch.13 and IMO draft defines two concepts for safety against gas hazards in machinery spaces

  - Inherently gas safe machinery space. The two-barrier concept as known from the IGC Code

  - ESD protected machinery space. Single wall gas piping accepted.
Inherently gas safe machinery space

Double piping all the way into the engine (similar to IGC code)

"Inherently gas safe engine room"

All gas pipes in engine room are enclosed in a double pipe/duct that can withstand the pressure build up during pipe rupture

- Double pipe/duct to be pressurised and filled with inert gas or ventilated and with gas detection

- The concept is mandatory for high pressure piping (>10 bar), but can also be used with low pressure installations
ESD protected engine rooms

- Smaller low pressure gas engines have gas supply piping which is difficult to arrange with complete jacketing

⇒ Emergency ShutDown (ESD) protection

Lean burn pre-chamber spark ignited engine from Mitsubishi (low pressure Otto cycle)
ESD protected engine rooms

- The ESD protected machinery space is considered **Gas Safe** in the normal mode but changes status to **Gas Dangerous** on detection of gas.

- **Gas detection system with at least 3 detectors in ER- redundant system required**
  - Gas is detected at 20% of LEL (lower explosion limit) on one detector → Alarm (can switch to diesel for dual fuel engines)
  - Two detectors read 20% LEL
    → the fuel supply automatically to be shut down
    → all non explosion protected equipment is to be electrically disconnected.
Because of the shut-down requirement for an ESD Protected engine room, the power generation for propulsion and manoeuvring must be divided between two or more engine rooms independent of each other.
ESD protected machinery space

- Ventilation: 30 air changes / hour
- Gas detection
  - Automatic shut down of gas supply and disconnection of electrical equipment
- Excess flow shut down

Diagram:

- Gas engine room, ESD protected
- Gas engine room, ESD protected

Legend:
- Potential gas danger
- Gas dangerous zone
Arrangement on LNG supply vessels
Tank design

- LNG tanks to be of independent type, to be approved in accordance with requirements in IGC code
- Compressed gas tanks to be approved in accordance with recognized standards
Rules- Gas storage

- Tanks located above deck
  - CNG and LNG accepted
  - Location at least B/5 from ship side
  - Drip tray below LNG tank required if tank has connections below liquid level

- Tanks located below deck
  - Compressed gas normally not accepted, maximum pressure 10 bar
  - "Secondary barrier" around LNG tank called "tank room" in the rules
    - Stainless steel or equivalent low temperature resistant material
    - Designed to withstand maximum pressure build up, alt. pressure relief venting arranged
  - Thermal isolation towards ship steel required
Rules - Gas storage

Location below deck

Top view

Liquefied gas tank

Min. the lesser of B/5 and 11.5 m
Never less than 760 mm

Side view

Min. the lesser of B/15 and 2 m
Never less than 760 mm
Tank location
Tank arrangement on gas supply vessels

- Vacuum insulated tank
- Bunkering lines and tank
  ventilation pipes in ventilated duct with gas detection
- Gas detectors
- Insulated cold box
- Tank room
- Duct pipe - gas line
- All tank valves located in cold box
- Tank saddle
- Water vaporizer in/out
Rules - bunkering arrangement & piping

- Gas detectors
- Ventilation to open air
- Min. 760 mm
- To gas tank
Rules- hazardous and safe areas

- Rules define which spaces and areas are gas hazardous
- Requirements are set to the electrical equipment to be used in the different zones (zone 0, 1, 2)
- Gas hazardous zone 0: Inside gas tanks and gas pipes
- Zone 1: All confined spaces containing gas sources, like double ducts with gas pipes and the tank room/”cold box”. 3 meters from gas outlets in open air. 1.5 meters from ventilation outlets/openings from zone 1 spaces
- Zone 2: 1.5 meter around the open deck zone 1 above
International code


- Correspondence group delivered report to BLG’s (Bulk, Liquids and Gases IMO subcommittee) 10th meeting in April 2006

- Second correspondence group delivered report to BLG 11 meeting in April 2007

- Third correspondence group delivered report to BLG 12 meeting in February 2008

- 4th correspondence group formed in BLG 12. A correspondence group was also formed in FP (Fire Protection) committee to review the fire safety requirements.
International code

- This interim guidelines/code will be relevant for all ship types with natural gas engine installations.

- The current draft has similar technical content as the DNV rules, for instance contains the same two engine room concepts.

- The current draft in addition contains requirements for safety assessments for all new designs.


- Code to be developed after this, also to include other gases than methane/natural gas, and other machinery types.