Marine Gas Engines, solutions and possibilities

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Rolls Royce Marine, Engines - Bergen
A comprehensive range of products

- Focus on environmental friendly solutions based on the widest range of products in the marine industry

Ship design and integrated ship systems

Diesel and gas engines

Gas turbines

Automation and control (DP)

Propulsion systems

Steering systems

Electrical podded

Azimuth thrusters

Tunnel thrusters

Waterjets

Stabilising systems

Winch systems

Focus on environmental friendly solutions based on the widest range of products in the marine industry
Focus on Technology Intensive ship types

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Market Segments

Merchant

Energy

Offshore

Naval
Rolls-Royce Marine, Engines - Bergen

Designed for robustness, harsh operational environments, and the very best reliability
Rolls-Royce Marine Engines – Bergen

Marine Gas Engines.

Combustion Principles

and

Control
How to Burn Lean!

LEAN-BURN COMBUSTION SYSTEM

Spark Plug
Rich air/gas mixture
Lean air/gas mixture
Operating Principle
Rolls-Royce Bergen Lean Burn Gas Engines
Rolls-Royce Bergen Lean Burn Gas Engines

Variable Turbine Geometry:

A successful pioneering cooperation between ABB and Rolls-Royce Bergen
Exhaust emissions - Natural Gas versus Diesel Fuel

- Sulphur emission is eliminated
- Particulate matter is close to zero
- CO₂ is reduced by more than 20% due to unburned methane slip the net reduction of greenhouse gases is somewhat lower.
- NO₅ is reduced by 80-90%
Emissions from Diesel and Gas Engines.

NOx emission for Bergen engines

- B32:40 diesel with Clean Design notation
- C25:33 diesel with Clean Design notation
- B35:40 gas
- C25:33 gas

IMO Tier I (2000)
IMO Tier II (2011)
IMO Tier III (2016)
CO₂ Green House Gas Equivalent Emissions

Methane slip and Global Warming Potential (GWP)

GWP in percentage of IMO Tier2 diesel.
CH₄ in percentage of worst case engine.

E2 cycle (speed%/power%/weight): 100/100/0.2  100/75/0.5  100/50/0.15  100/25/0.15
E3 cycle (speed%/power%/weight): 100/100/0.2  91/75/0.5  80/50/0.15  63/25/0.15

- GWP 25% load
- GWP E2
- GWP E3
- CH₄ 25% load
- CH₄ 100% load
- CH₄ E2 cycle
- CH₄ E3 cycle

Old base load engine
Marine engine
Propeller curve engine (E3)
Rolls-Royce Gas Engines

Gas consumption & NOx for variable versus fixed RPM

- MJ/kWh propeller curve
- MJ/kWh 1000 rpm
- g/kWh NOx propeller curve
- NOx 1000 rpm

Engine Power %

MJ/kWh

g/kWh NOx

0 % 20 % 40 % 60 % 80 % 100 %
How to control emissions in Diesels?

- The options

- SCR NOx
- Scrubber SOx
- Filter PM
- Urea Equipment
- Water/MDO/HFO/fuel oil Treatment
- Spil Material

- Higher consumption => CO₂
- Urea => cost
- Complexity
- Maintenance
Smoke issues.....

Visible smoke 1910

Visible smoke 2008

Invisible smoke 2007 – due to natural gas engine

Natural Gas
- clean fuel for future vessels

- NO$_X$ $\div$ 92 %
- CO$_2$ $\div$ 23 %
- SO$_X$ $\div$ 100 %
- Particulate $\div$ 98 %

Rolls-Royce data-strictly private
Low emissions:

- How to achieve CO$_2$ reductions exceeding 40%?

- With modified/existing product range
  - To achieve this on a vessel to vessel comparable basis
  - Ingredients
    - Efficient hull design reducing loss in waves (2-5% CO$_2$)
    - Azipull and CPP/Promas (5-9% CO$_2$)
    - Gas engines (20% CO$_2$)
"Ny-frakt"
How to renew the aging coastal fleet?
Lean Burn Gas engines

- The logical choice for ships

- More than 500 sold, over 400 gas engines in operation
- More than 20 mill running hrs experiences
- Plants with more than 140,000 running hrs
- Plants operating 8,500 hrs/year
- The five car ferries (16 engines) have logged from 12,500 to 19,000 running hours
**Rolls-Royce marine engines**

- **The Bergen series**

  - Established in 1943
  - First HFO engine delivered in 1963
  - First lean-burn gas engine delivered in 1991
  - Part of Rolls-Royce 1999
  - First 16 gas engines for marine propulsion delivered 2006
  - Over 6000 engines sold world wide, more than 4000 are still in operation
  - Engine range 1400 kW to 8500 kW
  - Lloyd’s Quality Certificates: ISO 9001:2001 and 14001
The Bergen B-series gas engines

- Spark ignited lean-burn gas engine

- Types: B32:40L6-8-9 & B35:40V12, -16, -20
- Bore: 320 / 350 mm
- Stroke: 400 mm
- Power: 420 / 440 kW / cyl
- Speed: 500 - 750 rpm
- Power range: 2320 - 8500 kWmech
The Bergen C-series gas engines

- Spark ignited lean-burn gas engine

- Types: C26:33L6-8-9
- Bore: 260 mm
- Stroke: 330 mm
- Power: 270 kW / cyl
- Speed: 600 – 1000 rpm
- Power range:
  1460 – 2430 kW mech
Power range gas engines

B32/35:40 and C26:33 Gas Engines

- BV-20
- BV-16
- BV-12
- B32:40L-9
- B32:40L-8
- B32:40L-6
- C26:33L-9
- C26:33L-8
- C26:33L-6

Power (kW)
Powered by natural gas

- probably the cleanest cargo vessel since the age of sails

The 132.8 m LNG fuelled Sea-Cargo vessel will be able to carry 5,600 tonnes of cargo, with up to 94teu of containers on deck an 1,240 lane-metres of ro-ro capacity

• CO₂ emission reduced by 23%
• NOₓ by 90 %
• SOₓ eliminated
Typical vessels equipped with Bergen Gas Engines

LNG/LPG Carrier Coral Methane

RO-RO SEA-CARGO

MF “Bergensfjord” (coastal ferry)

LNG/LPG Tanker

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Gas safe machinery space

- All gas supply piping within closed spaces must be double wall piping or ducting.
- In case of leakage in a gas supply pipe making shutdown of the gas supply necessary, a secondary independent fuel supply must be available.
- For single fuel installations (gas only) the fuel storage shall be divided between two or more LNG tanks of approximately equal size.
- For “Gas Only“- engines, the two fuel gas supplies shall be independent all the way from the storage tanks to the engine.
“From bunker flange to propeller thrust”

Operational benefits with LNG, single fuel main engine:

• One stop bunkering, high efficiency with PTO, redundancy by PTI.
• No purification system for HFO, cleaner engine room, less waste oil, no “switch over” problems.
• Long-term compliance with local port regulations and potential benefits from taxation/green port dues.

May arrange hybrid LNG-direct (main) / Diesel-electric (Aux)
“From bunker flange to propeller thrust with single gas propulsion engine installation, - - can it be done - - ? ”

Requirements for single gas engine propulsion unit:

• Two independent fuel tanks.
• Two independent fuel supplies to the engine.
• Possibility to shut off one or a group of cylinders and still maintain steering speed?

• The answer to this is down to the final result of “IMO interim guidelines on safety for natural gas-fuelled engine installations in ships” an the national administration’s interpretation (Sjøfartsdirektoratets tolkning.) In addition comes any additional requirements from Class.
Hybrid Propulsion System

Diesel or Gas Mechanical at Full Speed

- The most economical power generating during transit
Hybrid Propulsion System

Diesel or Gas Electric at Slow Speed

• Fulfil emergency propulsion requirement
Hybrid Propulsion System

Diesel or Gas Mechanical Boost Mode

- For ice class fulfilment
- Meeting charter speed requirement
Heavy fuel oil
Natural gas
GasNor & Anthony Veder

Marine systems from Rolls-Royce

Rolls-Royce products installed
- 2 x Diesel engines, Bergen B32:40L8A
- 2 x Gas engines, Bergen KVGB12G4
- 2 x Azimuth thrusters, Azipull 120 FP
  with Helicon control system
- 1 x Tunnel thruster, TT 1650 CP ICE

Rolls-Royce data-strictly private
Crowley, Glosten & Rolls-Royce - Tug

Rolls-Royce selected due to Engine Load Response and Emissions
Example:
Product Tankers – on LNG

[Images of two different product tankers, one in black and white and one in color]
Legislation will drive future demand
LNG import and export terminals

"We can deliver LNG to any port in North America”  
Ref: groche@cleanenergyfuels.com
LNG terminals Nordic - Baltic
Limitations on LNG availability?

- Large scale LNG terminals does not allow any ship to enter terminal
- Large terminals does not have small ship piers and piping/flanges etc.
- Logistics and handling is a challenge

However: Nordic and Baltic will be earlier than a vessel can be built.
Huge price gap on Oil to Gas

NYMEX Natural Gas Futures Near-Month Contract Settlement
Price, West Texas Intermediate Crude Oil Spot Price, and
Henry Hub Natural Gas Spot Price

Note: The West Texas Intermediate (WTI) crude oil price, in dollars per barrel, is converted to $/MMBtu using a conversion factor of 5.80 MMBtu per barrel. The dates marked by vertical lines are the NYMEX near-month contract settlement dates.
Conclusion, gas engines for ships.

• Positive climate effect by green house gas emission reduction.
• NOx-emission challenge solved.
• LNG distribution infrastructure may need further stimulus.
• Await also possible benefits for EU ship operators e.g emission related Port Fees?

• The technology is ready for use -
Rolls-Royce Marine, Engines - Bergen
Engine no. 6000 B35:40V20-gas-engine

THANK YOU FOR YOUR ATTENTION