LNG Systems
Low Emission Power Systems

Go LNG Visit to Rolls-Royce Ålesund

Ålesund, 2018-05-22
Oscar Kallerdahl
Vice President – LNG Systems

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LNG Power Systems

Plan

- 09.30 – Introduction
- 9.45 – Training Center
- 11.00 – ACON LNG System
- 12.00 - LUNCH
- 13.00 – LNG Systems
- 13.45 – Systems and Service
Low Emission Power Systems

Agenda

- Introduction
- Pure Gas Engines
- System Arrangements
- Whole Ship System Approach - Environship
- Summary
Our Business

Introduction

- Civil Aerospace
- Defence Aerospace
- Power Systems
- Marine
- Nuclear
Our Business

Introduction

• Civil Aerospace
• Defence Aerospace
  • Nuclear
• Power Systems

Marine
Rolls-Royce Marine

Introduction

**Ship design**

More than 900 UT and NVC vessels are in operation all over the world – under the toughest conditions known to man. Our UT design is the benchmark of the offshore oil & gas industry.

**System integration**

From the fingertip controls of our advanced bridge systems, to the engine room, propulsion systems and on-deck equipment, we have unparalleled systems integration capability.

**The widest range of products in the marine industry**

Our technology can be found in more than 25,000 vessels, spanning commercial and naval markets delivering mission critical marine power and propulsion systems and deck machinery.
Design and integrated systems

Introduction

Yacht
Explorer vessel

NVC-605-CT
Chemical Tanker

NVC-601 LNG
Bunker Tanker

NVC-253 LNG
Ro-Pax

NVC-485 LNG
Bulk Carrier

NVC-465 LNG
General Cargo

NVC-405 LNG
Ro-Ro

NVC-615 LNG
LNG Feeder

Rolls-Royce
A comprehensive range of products

Introduction

- Ship design and integrated ship systems
- Diesel and gas engines
- Electrical Systems
- Automation, Control & Positioning

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Rolls-Royce Gas Systems in Operation

Low Emission Power Systems

- 700 gas engines delivered – 77 for marine
- Over 31 million operating hours accumulated
- 39 vessels are in operation running on gas
The Lean Burn Gas Engine

Clean Exhaust

First marine gas engine delivered

2006

1908

2008

Rolls-Royce data-strictly private
The lean burn gas engine

Clean exhaust

Exhaust From the MDO Main Engine
40 hrs in operation

Exhaust From the Gas Main Engine
4000 hrs in operation
The Rolls-Royce Vision

To be the #1 pure LNG fuelled propulsion system provider in the Marine industry globally, through world leading design, equipment and service
Engine - C26:33L marine gas engines

- Types: C26:33L6,(L8), L9
- Bore: 260 mm
- Stroke: 330 mm
- Power: max. 244 / 270 kW / cyl
- Speed: 600 – 1000 rpm
- Power range: 1460 – 2430 kWmech

Fjord1 Gas fuelled ferry
3xC26:33L9AG + 1xC25:33L9ACD

Island Offshore – Platform Supply
2xC26:33L9AG + 2xC25:33L6ACD

NSK Shipping - Bulk carrier
1xC26:33L6PG
Engine - B35:40 marine gas engines

• Types: B35:40L (8)-9 & B35:40V12, -16
• Bore: 350 mm
• Stroke: 400 mm
• Power: 440 / 480 kW / cyl
• Speed: 500 - 750 rpm
• Power range: 3500 - 9600 kWmech

Fjord Line, Bergensfjord passenger vessel
4xB35:40V12PG

Torghatten Nord, Landegode Car and passenger ferry
1xB35:40V12PG

Nor Lines, Kvitbjørn Ro-Ro vessel
1xB35:40L9PG
LNG Propulsion Systems
Technology

- The Bergen Engine

- Pure Gas for simplicity and best performance
- Compact and powerful
- Exceptionally low emissions of NOx, CO2, SOx and particles
- High efficiency, above 50.3%
- Low fuel and lube oil consumption
- Service friendly
- Optimum response at all engine load points (Variable Turbo Geometry)
- Stable frequency
- No oil contamination
- Super silent resilient mounting
- Designed for single bearing alternators
- Direct mechanical governing of the gas
- Methane number 70 or higher without derating
LNG Propulsion Systems
Technology

- The Bergen Engine

[Diagram of the Bergen Engine with labeled components: spark plug, rich air/gas mixture, lean air/gas mixture, LEAN-BURN COMBUSTION SYSTEM, Engine control cabinet, Air, Exhaust, Turbo-charger, Gas, Fuel gas module, Air receiver, Knock sensing, Ignition control, Throttle valve control, VIG control, Main gas pressure control, Pre-chamber gas pressure control, Fuel gas control, P.C. gas supply, Input parameters.]
MTU Pure Gas Engine – 16V/8V 4000 marine

Introduction 2018

• Power:
  • 16 V 4000
    • 1500 - 2000 kW
  • 8 V 4000
    • 750 - 1000 kW

• Speed 1600 - 1800 rpm
LNG Fuel Systems for Marine Propulsion
Complete System Design

Complete propulsion system solutions
Technology – The LNG Fuel System

1 Tank 1 TCS

- Redundancy by:
  - A PTI/PTO through a gear box
  - 2 parallel systems with Gas Cross Over

Fjord Line

Norlines
Technology – The LNG Fuel System

1 Tank 2 TCS
• Redundancy by having 2 parallel power trains connected to 1 C-Type Tank

LNG/NG Feed System
• LNG Feeders and Bunker Vessels
• LNG Pumps and NG compressors
LNG Propulsion Systems
Whole Ship System Approach - Environship

- Norlines – 2 vessels
- Combined Cargo/Container
- 6000 dwt
LNG Fuel Systems for Marine Propulsion
Whole Ship System Approach - Environship

- Pure Gas Engine Mechanical Drive with Diesel Electric Back Up
- 1 Tank - 1 Tank Connection Space
- Redundancy by:
  - A PTI/PTO through a gear box
LNG Fuel Systems for Marine Propulsion

Whole Ship System Approach - Environship

- **Redundancy by:**
  - A PTI/PTO through a gear box

Rolls-Royce data strictly private
Vessels Operating purely on LNG
References and Applications

Kvibjørn and Kvitnos en Route
- 14 days roundtrip - 2900 nm
- Bunkering 290 m3 LNG
- MGO usage approx 2 m3
- 90 % load on main engine - Power Take Out mode
- Speed of 15 knots
Vessels Operating purely on LNG

References and Applications

If operating out of Singapore

- 400 m3 — 4300 nm range
- MGO add another 2200 nm
- Total Range 6480 nm
- 22 days of sailing
LNG Tug Design – Buksér and Berging

Rolls Royce delivery comprising:

• 2 x Bergen C26:33L6PG
• 2 x US 35 CP Azimuth Thrusters
• 80m3 LNG Tank
• LNG ACON – Alarm/Control System and Gas Safety System

Bollard Pull: 65 ton
Gas Propulsion Systems

• Mechnical Drive
• Pure Gas Berge Engine
  • 6 Cyl
  • 1705 kW
  • 65 ton BP

• Redundancy by:
  ▪ 2 parallel power trains connected with a Gas Cross Over
  ▪ 1 Tank - 2 Tank Connection Spaces
  ▪ Back Up give 100% power
  ▪ FILM
The LNG tank system - connections

- Sliding Support
- Fixed Support
The LNG tank system - Connections

- Ventilation Outlet
- VAP Water Inlet
- Expansion Tank VAP
- VAP Water Outlet
- Drain of TCS
- Trunk holding the gas pipe to the GRU
- Ventilation Inlet
LNG Tug Design – Robert Allan
The RANGLer 3600 – Robert Allan Natural Gas tug

- 2 x Bergen C26:33L9PG
- 2 x US 255 CP Azimuth Thrusters
- 80m3 LNG Tank
- LNG ACON – Alarm/Control System and Gas Safety System
- Heavy Duty Escort Towing Winch
- Diesel or Gas Gen Set

Bollard Pull: 80 ton
LNG Tug Design – Robert Allan

The RANGLer 3600 – Robert Allan Natural Gas tug

- Length: 36,5 m
- Beam: 15,4 m
- Draft: 5,8 m
- Installed Power: 2*2430 kW
- LNG Capacity: 80m³
- Speed: 14 kts

Bollard Pull: 80 ton
LNG Tug Design – Jensen Maritime

- 2 x Bergen C26:33L8PG
- 2 x US 255 CP Azimuth Thrusters
- 65m³ LNG Tank
- LNG ACON – Alarm/Control System and Gas Safety System
- Heavy Duty Escort Towing Winch
- Diesel or Gas Gen Set

Bollard Pull: 160,000 pounds - 72 ton

Rolls-Royce data - strictly private
Other Tugs operating on LNG

CNOOC LNG Tug

Rolls Royce Scope:
- 2 C6 Engines
- 2 US 255 Azimuth Thrusters

China Classification Society accept 1 C-type tank with 2 TCS (cold boxes)!
LNG Propulsion Systems
Optimize the Vessel Arrangement

- Main Propulsion
  - Gas Mechanic for lowest emissions
  - Operating Profile of the vessel
  - Main Engine Power to match the Operating Power Requirement
  - Ensure Redundancy Power
    - 2 Fuel Lines or
    - Electric Drive
- Other Requirements
  - Boost Power Mode
  - Transit Mode
  - Low Transit
  - Idle/Harbour Mode
LNG Fuel Systems for Marine Propulsion

Summary

- Understand the Vessel’s Operating Conditions
- Optimize the Engine and Propulsion Package
- Ensure Redundancy
- Size and place the LNG System
- Design and Analyse the LNG System
- Include the Classification Society early
Web and Social Media

www.Rolls-Royce.com/LNG

Linked In – join our group!
“Rolls Royce LNG “
End

Thank you for your attention
### Gas Engine/Systems Reference List

#### References and Applications

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<th>Prod. Year</th>
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- 39 Vessels
- 77 Engines
- 22 LNG Systems
Vessels Operating on Natural Gas

The UT 776 Clean Design Gas Concept

- 2 Pure Gase Engines
- 2 Pure Diesel Engines
- 100% Redundancy
- DP2
- All operation on Gas – Diesel is Back Up only
- 30 days operating cycle

FILM

- Island Offshore – 2 vessels
- The Naming Ceremony
Vessels Operating on LNG
Cruise and Passenger and Tug Vessels

Energy Efficiency Award 2013

RoPax - Fjord Line
4 Engines – 22 MW Power

Tug – Buksér & Berging - FILM
2 Engines – 3,5 MW Power

Tug - CNOOC
2 Engines – 3,5 MW Power
Vessels Operating on LNG

- Cargo vessel - NSK Hoeydal
- Bunker Vessel – Bergen Tankers Retrofit to run on LNG
- Cargo Vessel - Eidsvaag
LNG Propulsion Systems
Rolls-Royce LNG Propulsion Systems

- **FILM** – Rolls-Royce LNG Propulsion Systems
- **FILM** – Rolls-Royce 10 year Anniversary with LNG