FUEL GAS HANDLING SYSTEM AND BOG RELIQUEFACTION FOR LNG CARRIER

EIRIK MELAAEN
WÄRTSILÄ OIL & GAS SYSTEMS AS
Wärtsilä Oil & Gas Systems

Agenda:

- BOG Reliquefaction plant
- Low Pressure Gas to Engine (e.g. DFDE, 2-Stroke DFE) and BOG Reliquefaction System
- High Pressure Gas to Engine (Gas Diesel Engine) and BOG Reliquefaction System
- Future concepts

12 November 2013 Fuel Gas Handling System and BOG Reliquefaction for LNG Carrier, Eirik Melaaen
Our Expertise in the Gas Value Chain

Exploration & development
- Exploration & drilling
- Production & liquefaction
- Transport & storage
- Receiving terminals & regasification
- Distribution & transport to the users

- LNG fuel gas systems for OSVs
- Gensets
- On- & Offshore small scale liquefaction
- Antiflaring/VOC
- Oil separation
- Gas FPSO
- LNG fuel gas systems
- LPG, LEG & LNG cargo handling
- Jetty & Floating regasification
- Bunkering & barges
- Receiving terminals
- Gas/LNG distribution/logistics
- Feed gas to Power plants

Regasification (FSRU/JRU)
LNG receiving terminal
Small scale liquefaction plants LNG/LBG
Re-liquefaction of Boil Off Gas,
FPSO
LNG liquefaction & terminal
Power generation
LNG carrier
LNG bunkering & barges
Oil tanker with VOC
Distribution & transport
Gas/LNG distribution/logistics
Feed gas to Power plants
Fuel Gas Handling System and BOG Reliquefaction for LNG Carrier_Eirik Melaaen
12 November 2013
First free-standing small scale LNG plant in Northern Europe delivered March 2003.

Hamworthy EPCIC contract with GASNOR.

Technology feasibility and robustness thoroughly and successfully demonstrated.

### Kollsnes II LNG

- 2 x capacity of existing Linde plant (Kollsnes I).
- Hamworthy EPCIC contract with GASNOR.
- Full production August 2007.

---

Snurrevarden LNG Plant (22,000 tpy)

35 LNG BOG Reliquefaction systems

Al Gattara (Hyundai) BOG Reliquefaction System (58,000 tpy)

Kollsnes II (Gasnor) LNG Plant (84,000 tpy)
BOG RELIQUEFACTION PLANT
Different solutions available for LNG carrier propulsion:

1. Use BOG & LNG as fuel e.g. steam turbines, dual-fuel diesel electric, dual-fuel engines
2. BOG reliquefaction, *liquefy and sell excessive BOG or all LNG loaded onboard*

**Pattern for ship's using BOG & LNG as fuel for propulsion**

- **LNG level in tanks**
  - Maximum (Laden voyage)
  - Minimum (Ballast voyage)

- **Fuel used during roundtrip** (Natural BOG & forced)
- **Additional LNG delivered with full BOG Reliquefaction System**
Boil-off gas from cargo tanks vs. Fuel gas required by the engine

- Available BOG
- Excess BOG
- BOG consumed in the engine
- Available BOG
- Forced LNG

Balance between Vessel speed and BOG flow

Boil-off Gas (kg/hr)

Speed of the Vessel (knots)
BOG Reliquefaction System (LNGRS – Mark III)
No feeding of gas to engines (QFLEX vessels)
Typical dimensions: 30 x 22,5 x 7 m (L x W x H)
Equipment weights: 240 ton
ENGINES REQUIRING LOW PRESSURE GAS (DFDE, 2-STROKE DFE) AND BOG RELIQUEFACTION PLANT
Dual-fuel propulsion system
ENGINES REQUIRING HIGH PRESSURE GAS (Gas Diesel Engine) AND BOG RELIQUEFACTION SYSTEM
BOG Reliquefaction System (LNGRS)
High-Pressure Fuel Gas Supply System (HP FGSS)

HP-pump and Optimizer

LNG cargo tank

Pre-heater

BOG-Compressor with coolers

Cooler

Compressor Stage 1-3

Nitrogen loop

Expander

Cold box

Vent gas

LP gas

Auxiliary engines (LP gas – 6 bara)

GCU

High-Pressure Gas Diesel Engine
(HP gas > 300 bara)

HP-pump

Optimizer

LNG vaporizer

12 November 2013 Fuel Gas Handling System and BOG Reliquefaction for LNG Carrier Eirik Melaaen
PFD – Vaporization System

- **Steam/Hot Water Heater**
- **Brine Pump**
- **HP Pump**
- **LNG Vaporizer**
- **Condensate from BOG RS**
- **High Pressure Gas to Gas Engine**

Temperature: 45 ±10°C
Pressure: Max 300 bar

Temperature: -160°C
Pressure: 3-5 bar

Pressure: Max 300 bar
Temperature: 45 ±10°C
Updated Arrangement - Gas Supply System

Typical dimensions: $7 \times 3 \times 2$ m (L x W x H)

Equipment weights: Ca 25 ton
HP-compressor and HP-pump

LNGRS for excessive BOG?
Layout – Burckhardt compressors + BOG Reliq plant

Typical dimensions:
30 x 22.5 x 7 m (L x W x H)
FUTURE CONCEPTS

NEW MR

TWO REFERENCES:

NEW MR DEMONSTRATION PLANT – 2,5 TON/DAY
NEWMR EGE PLANT – 11 TON/DAY
Demonstration plant – 2,5 ton/hr
New MR Process Overview
Pictures EGE - Project
Flow Sheet of Liquefaction Plant

Pretreatment

- Raw gas inlet
- H₂O & CO₂ removal
- H₂O & CO₂

Liquefaction process

- Gas pre-cooling
- Pre Cooling system
- MR refrigeration unit
- Cold Box
- Expansion
- Export LNG pump

Storage system

- Gas from trucks
- LBG Truck Filling station

Fuel Gas Handling System and BOG Reliquefaction for LNG Carrier_Eirik Melaaen
BOG Reliquefaction System (LNGRS)

NewMR LP-Pressure Fuel Gas Supply System (LP FGSS)
Compressor and Forcing Vaporizer
LNGRS for excessive BOG

Main engine
(LP gas – 6 bara)

Auxiliary engines
(LP gas – 6 bara)

GCU

Vent gas

Multi refrigerant (MR) loop

MR compressor

After cooler

In-tank pump

LNG cargo tank

Boil-off gas

Forcing vaporizer

BoG-Compressor
with coolers

Heat exchanger

MR separator
Summary – Wärtsilä NewMR technology

**BOG reliquefaction system on LNG vessels in the future**  
→ **NewMR**

**Why?**
- Demonstration plant proven to be successful
  - Robust
  - Low OPEX
  - Load variations
- Robust main rotating machinery with high efficiency
- Designed for unmanned operation
- Shorter delivery time
- Simple energy supply, only electric power needed
- Easy and quick start up and shut down of all systems
- Standardisation of capacities: 1.5 ton/hr, 2.5 ton/hr etc.
- Supplied as modules
- Refrigerant process with phase changes which reduce the size of equipment and piping
- Simplified maintenance
- Reduced CAPEX compared to Nitrogen loop
- Two references
Thank you for your attention!

EIRIK MELAAEN
Business Development Manager
Tel: +47 66 10 95 66
Mobile: +47 959 67 377
Fax: +47 815 48 510
E-mail: emelaaen@hamworthy.com
Web: http://www.hamworthy.com