LNG Plant Overview
Seminar with Supplier Association Murmanshelf
Murmansk, 15 May 2012
Jostein Pettersen
Table of Content

• Part 1 : LNG plant overview (Jostein)
• Part 2 : Main equipment units (Jostein)
• Part 3 : LNG plant construction principles (Jens Roar)
• Part 4 : Arctic LNG plant construction (Jens Roar)
Outline

• Introduction – Liquefied Natural Gas (LNG)
• Block diagram of LNG plant
• Main process stages
• Liquefaction process technologies
• Examples from Hammerfest LNG Plant
• Examples from other LNG plants
Why produce Liquefied Natural Gas (LNG)?

LNG is mainly produced for transportation purposes
- Gas market is far from the source of the natural gas: More economical to transport the gas as LNG instead of in a natural gas pipeline.
- LNG also offers greater flexibility than pipeline gas
What is LNG?

**LNG is a cryogenic liquid**
A cryogenic liquid liquefies at a temperature below −73 °C (-100 °F) at atmospheric pressure. Common cryogenic liquids are; Nitrogen, Oxygen, Helium, Hydrogen and LNG

- LNG is natural gas that has been cooled and condensed to a liquid
- At atmospheric pressure LNG has a temperature of about −162°C
- LNG contains about 85-95 % methane
- LNG is colorless, odorless, non-corrosive and non-toxic
- Evaporated LNG can displace oxygen and cause human suffocation
- Flammability range, 5-15 vol % concentration in air
- Autoignition temperature, 540°C
LNG Density

1 m$^3$ LNG corresponds to ca 600 Sm$^3$ natural gas

S = Standard state, 15°C, 1 atm

At temperatures above -110 °C LNG vapour is lighter than air

LNG is lighter than water
LNG Density: 450 kg/m$^3$
Water density: 1000 kg/m$^3$
Typical cost Distribution in the LNG value Chain – (numbers are confirmed by different sources)
LNG plant block diagram
Gas conditioning (pre-treatment)

• Acid Gas (CO₂ and H₂S) removal
  – Acid gas causes corrosion, reduces heating value, and may freeze and create solids in cryogenic process
  – Typical requirements for LNG: Max 50 ppmv CO₂, Max 4 ppmv H₂S (ppmv - parts per million by volume)

• Dehydration (water removal)
  – Water will freeze in cryogenic process
  – Typical requirement: Max 1 ppmw (weight) H₂O

• Mercury removal
  – Mercury can cause corrosion problems, especially in aluminium heat exchangers
  – Requirement: Max 0.01 μg/Nm³
MDEA (Amine) process for acid gas removal
Typical amine sour gas removal process

Source: DOW chemicals
Water removal by adsorption

Source: UOP
Cascade Liquefaction Process
(Licensor: ConocoPhillips)
Propane-precooled Mixed Refrigerant Process (C3MR)
(Licenser: Air Products and Chemicals Inc.)
Mixed Fluid Cascade Process (Linde)
(Hammerfest LNG plant)
LPG extraction
(Example based on C3MR process, Source: Air Products)

• Why LPG extraction?: i) LNG heating value adjustment, ii) remove components that may freeze out in liquefaction process, iii) generate valuable LPG product, iv) produce refrigerant make-up (C1, C2, C3)

• Upstream LPG extraction usually based on expander process. Can provide “deep” extraction of C3 and C2. Feedgas need to be recompressed before liquefaction. Liquefaction pressure can be high.

• Integrated process usually based on scrub column – i.e. feed gas pressure need to be sub critical. Scrub column reflux temperature determines degree of extraction. Pressure restricted by $p_{\text{crit}}$
Above-ground full-containment LNG tank design

- Pre-stressed concrete outer walls constructed by slipforming, sheathed internally with a gastight layer of nickel-alloyed steel.
- Inner tank in nickel-alloyed steel, separated from the outer walls by a layer of perlite - a variety of volcanic obsidian highly suitable for insulation
- Extra layer of steel and insulation at the transition between outer wall and tank bottom to protect it against strong local stresses should the inner tank begin to leak.
- Heating cables under the tanks will ensure that the ground remains above 0°C in order to prevent frost heaving.
Loading of LNG Carrier
Spherical tank cargo containment systems
(Moss Rosenberg)
Moss spherical LNG tank – key elements

The Moss® spherical system

- Tank dome
- Steel tank cover
- Tank plating = primary barrier
- Pipe tower
- Insulation (outside)
- Drip tray (partial 2nd barrier)

Cylindrical skirt
Steel foundation deck
LNGC – Membrane cargo containment system (GT No. 96, MK I and MK III, and CS1)
Mark III (Technigaz) Membrane system
Inside membrane tank
Hammerfest LNG Plant – Melkøya
Hammerfest LNG onshore plant
Darwin LNG (Australia)

Source: www.lngfacts.org
Yemen LNG

Sources:
www.yemenlng.com
www.yemenfox.net
www.nationalyemen.com
Sakhalin LNG
There's never been a better time for good ideas

LNG Plant Overview
Jostein Pettersen
Advisor LNG Technology
jospet@statoil.com
Tel: +4790952718

www.statoil.com