LNG Storage and Loading

TEP10 Gas Processing and LNG – Fall 2008

Jostein Pettersen

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LNG storage and loading schematic

1 = LNG Rundown from Process Plant to Storage at B.L.
2 = LNG Vapour from Storage to Process Plant at B.L.
3 = Vacuum Breaker Gas for LNG Tanks from Process Plant at B.L.
4 = LNG Loading from Storage to Ship at B.L.
5 = LNG Vapour Return from Ship to Storage at B.L.
6 = FlueGas (burned LNG Vapour) from LP Flare to atmosphere
20 = LNG Fuel from Storage to Process Plant at B.L.

LNG storage tank containment principles

Single containment
Double containment
Full containment

IN CASE OF RUPTURE OF INNER TANK

flare
Above-ground full-containment LNG tank design

- Pre-stressed concrete outer walls constructed by slipforming, sheathed internally with a gas-tight 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.

Tank safety systems

- **External leak**
  - The secondary barrier (pre-stressed concrete) is made to retain the liquid (full containment definition)
- **Internal leak**:
  - Leak protection system: Thermal Protection Barrier system, to prevent cold liquid to reduce resistance of the bottom tank,
  - Leak detection system in the annular space based on thermal sensors / level detectors and continuous monitoring
- **Over pressure**:
  - Vapor handling system,
  - Safety relief valves
- **Vacuum protection**:
  - Gas injection,
  - Safety valves
- **Fire and Impact**:
  - Pre-stressed concrete outer tank
- **LNG Rollover detection system**
  - Measuring temperature and liquid density at different levels. Remedy: Increased circulation
LNG/LPG/Condensate Storage - Hammerfest

- LNG: 125,000 m³
- Condensate: 75,000 m³
- LPG: 45,000 m³
Storage and loading system 3D
Hammerfest

LNG Tank - Hammerfest
Suspended LNG tank ceiling
Rollover

Rollover is a phenomenon that can occur when LNG at different density/temperature is filled into a storage tank

- LNG composition, density and temperature will change during boil-off of gas
- If not mixed, a high density liquid will settle below the lower density liquid
- During heat leakage and evaporation the density of the upper level of liquid can become higher than the lower level of liquid and a sudden rollover with mixing of the liquids may occur giving sudden evaporation and pressure build up, which again can lead to tank rupture
- In 1971 an rollover incident happened at the La Spezia LNG import terminal in Italy and damaged the tank roof. No ignition happened. No injuries/Fatalities
- Receiving terminals have now procedures to mix old and new LNG during filling. LNG tanks have rollover protection systems, which include distributed temperature sensors and pump-around mixing systems

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Rollover - principle

\[ T_2 > T_1 \]
\[ \rho_2 < \rho_1 \]

Light components evaporates
Density increases

\[ T = \text{Temperature (°C)} \]
\[ \rho = \text{Density (kg/m}^3\) \]
Tank wells

Bottom well without foot valve

Bottom well with foot valve

LNG pump extraction
LNG storage and loading system (Hammerfest)

Modes of operation

- **Modus 1**: LNG lagring og lasting 10%
- **Modus 2**: LNG lagring 85%
- **Modus 3**: LNG lagring, LNG lasting og fyrgasutsendelse
- **Modus 4**: LNG lagring med fyrgasutsendelse
- **Modus 5**: LNG lagring med LNG overførsel mellom tankene < 1%
- **Modus 6**: Fyrgasutsendelse uten LNG lagring < 1%
- **Modus 7**: LNG lagring med nedkjøling av skip < 1%
Emergency disconnect:
Break between two ball valves,
thus sealing against both loading system and ship
(connector stays on ship manifold)
PERC (Power Emergency Release Coupler)

StatoilHydro