LNG Storage and Loading

TEP10 Gas Processing and LNG – Fall 2008

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- LNG tanks
- Rollover
- Storage and loading system
- Jetty and loading arms

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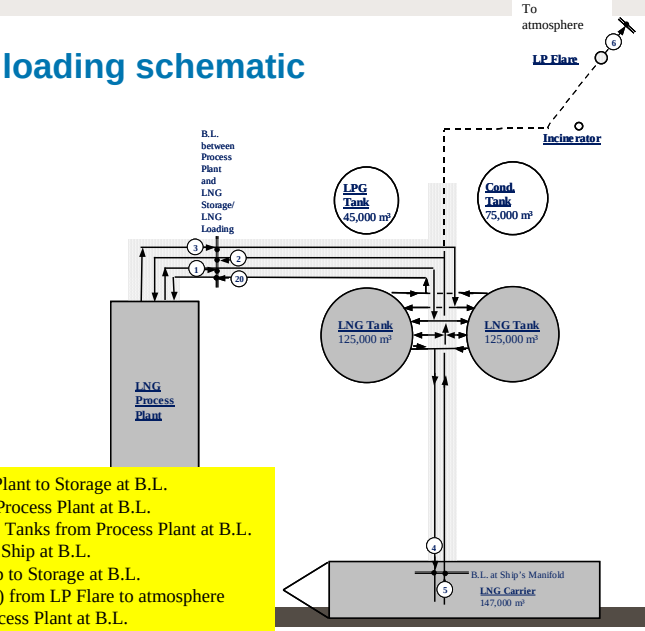
LNG storage and loading schematic



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.

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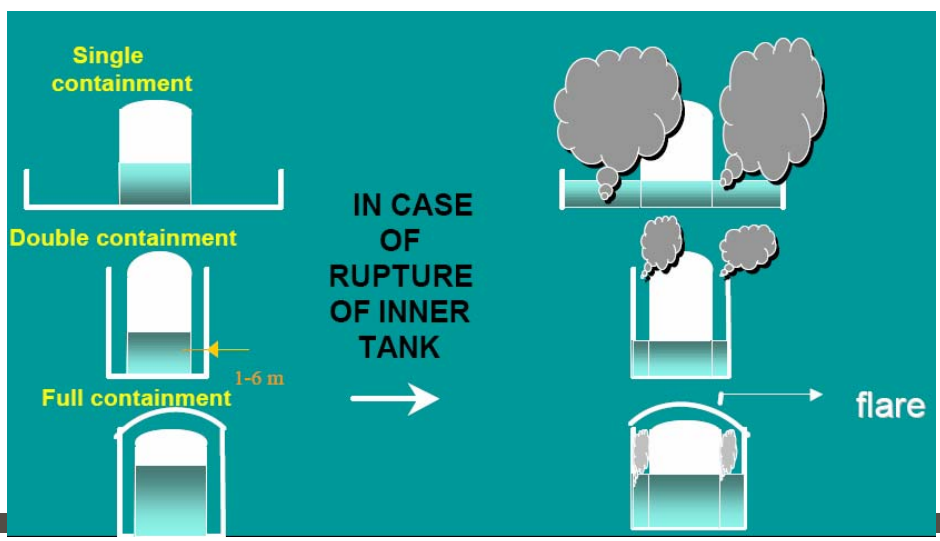
LNG storage tank containment principles



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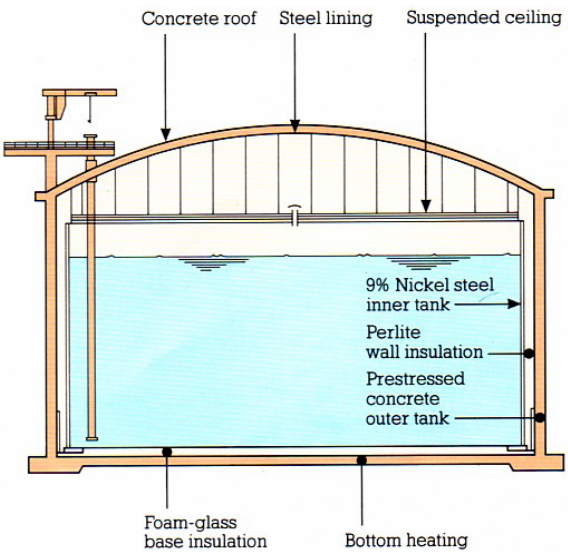
Above-ground full-containment LNG tank design



- 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.

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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**

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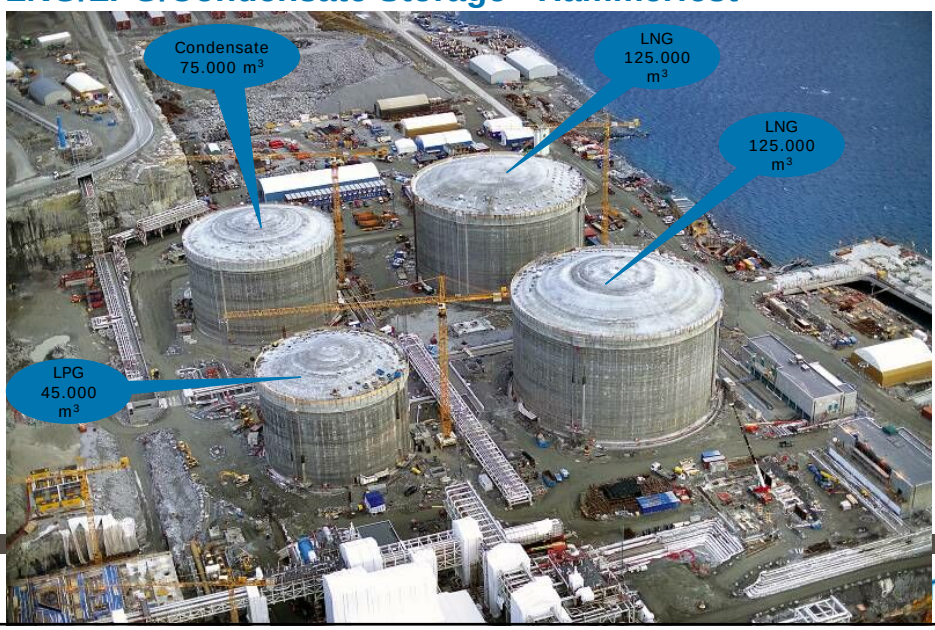
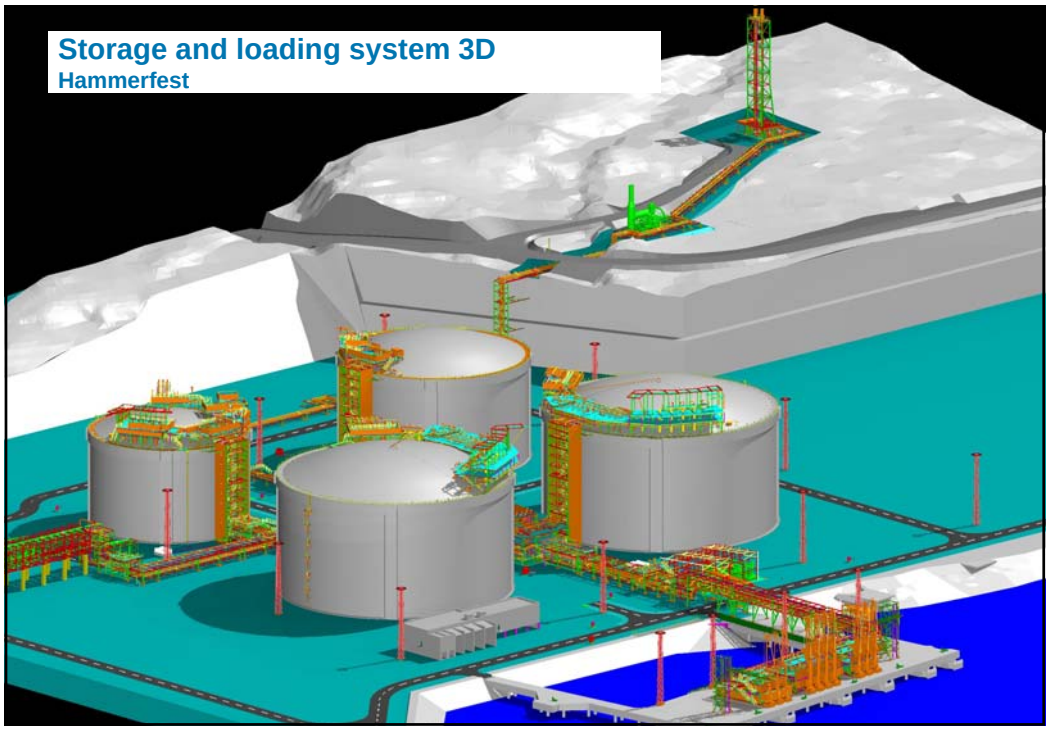
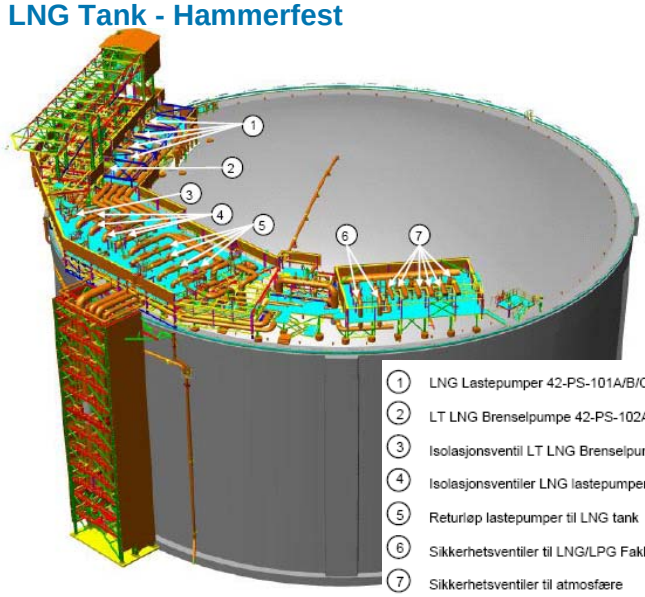
LNG/LPG/Condensate Storage - Hammerfest



Storage and loading system 3D
Hammerfest



LNG Tank - Hammerfest



1. LNG Lastepumper 42-PS-101A/B/C/D (42-TR-101) eller 42-PS-101E/F/G/H (42-TR-102)
2. LT LNG Brenselpumpe 42-PS-102A (42-TR-101) eller 42-PS-102B (42-TR-102)
3. Isolasjonsventil LT LNG Brenselpumpe
4. Isolasjonsventiler LNG lastepumper
5. Returløp lastepumper til LNG tank
6. Sikkerhetsventiler til LNG/LPG Fakkel 54-FC-103
7. Sikkerhetsventiler til atmosfære

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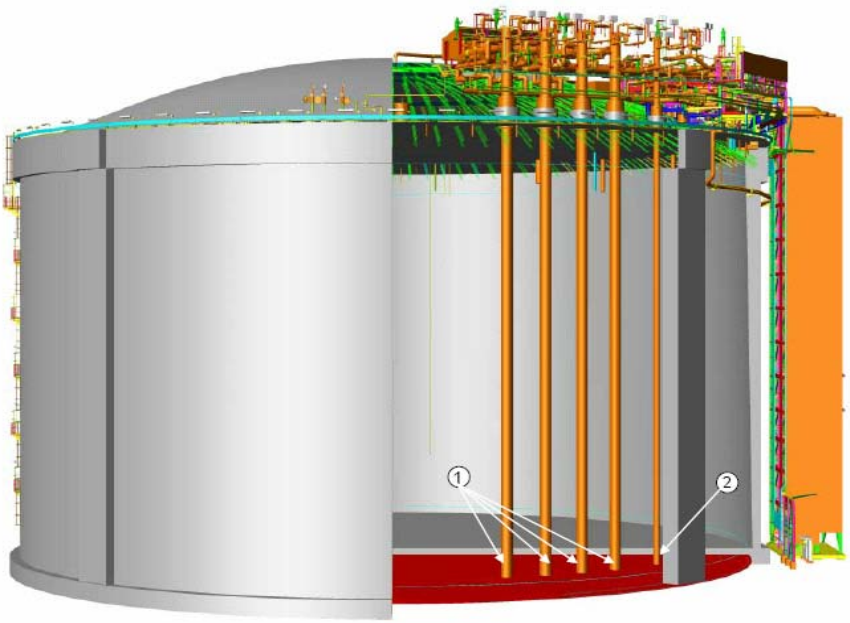
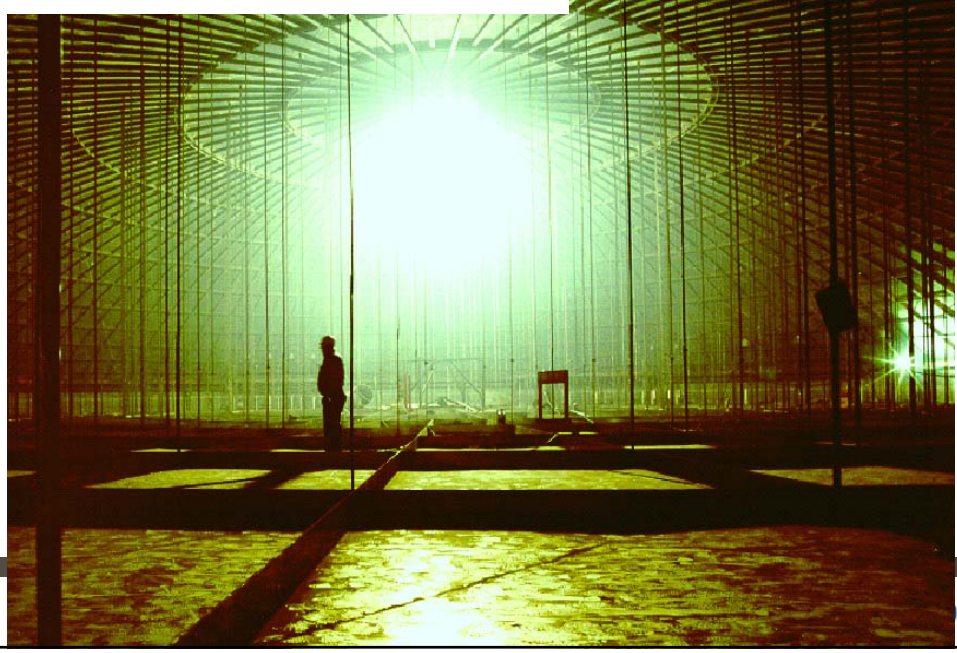
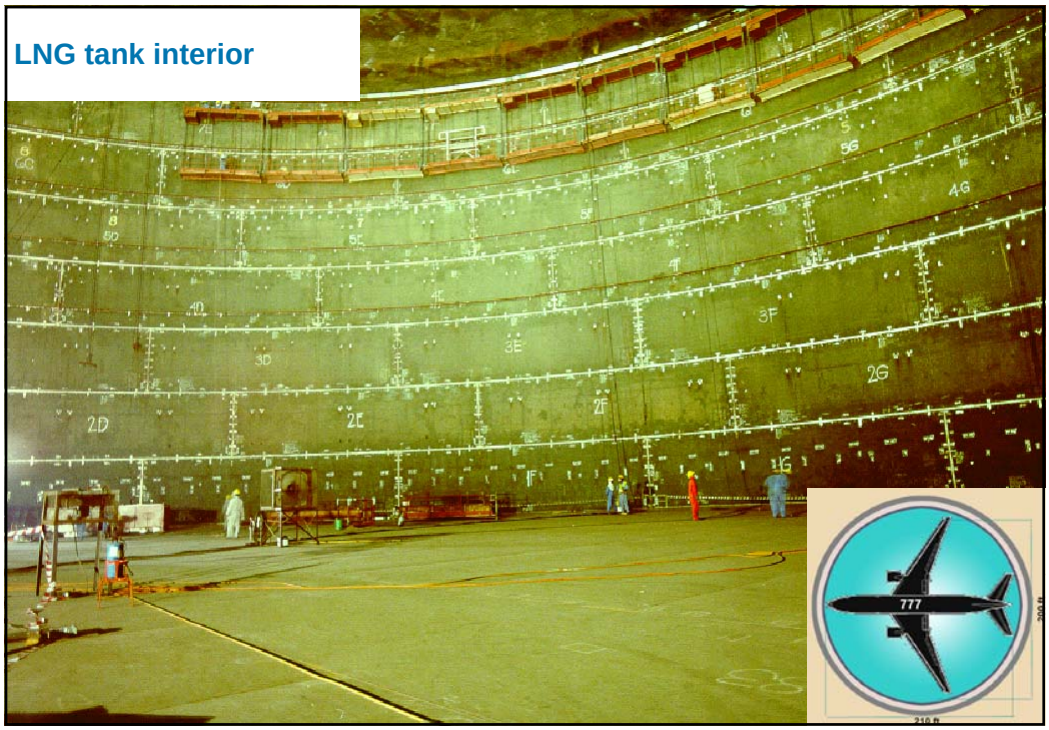


① LNG Lastepumper 42-PS-101A/B/C/D (42-TR-101) eller 42-PS-101E/F/G/H (42-TR-102)
② LT LNG Brenselpumpe 42-PS-102A (42-TR-101) eller 42-PS-102B (42-TR-102)

Suspended LNG tank ceiling



LNG tank interior



Bermed, full containment tanks

Karratha -Australia

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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 happend. No injuries/Fatalities
- Receving 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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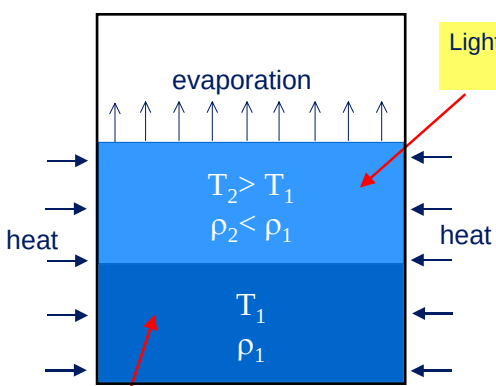
Rollover - principle



Light components evaporates
Density increases

ρ_2 becomes larger than ρ_1
A sudden change, rollover, of the liquid phases may happen
A sudden pressure increase because of large evaporation may happen

T = Temperature (°C)
ρ = Density (kg/m^3)

Temperature increases
Density decreases

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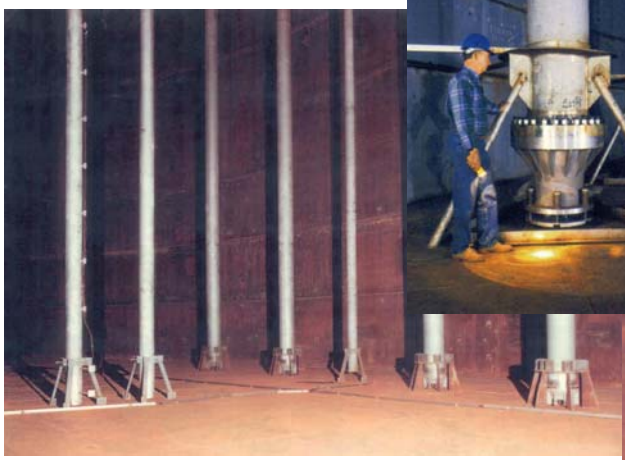
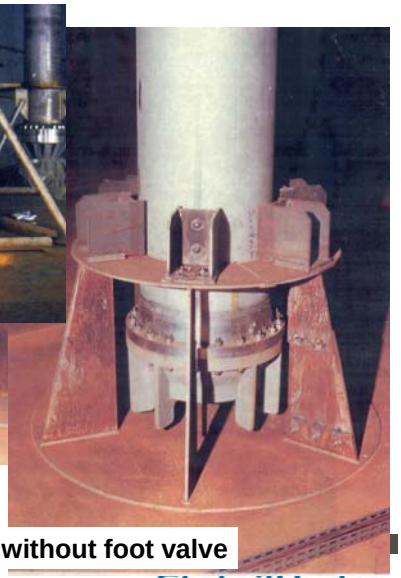
Tank wells



Bottom well with foot valve



Bottom well without foot valve

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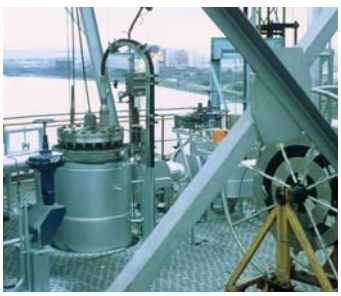
LNG pump extraction



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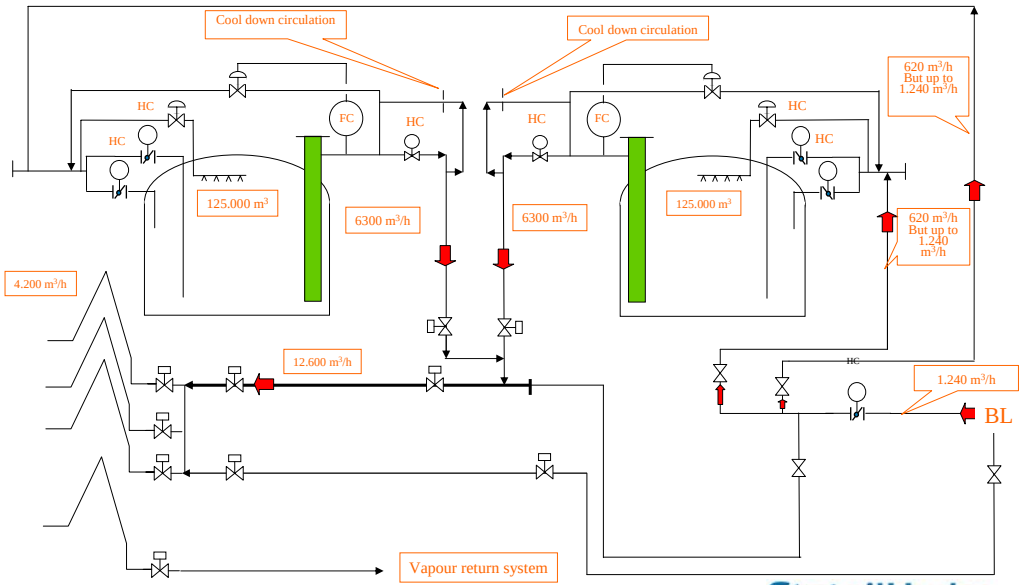
LNG storage and loading system (Hammerfest)



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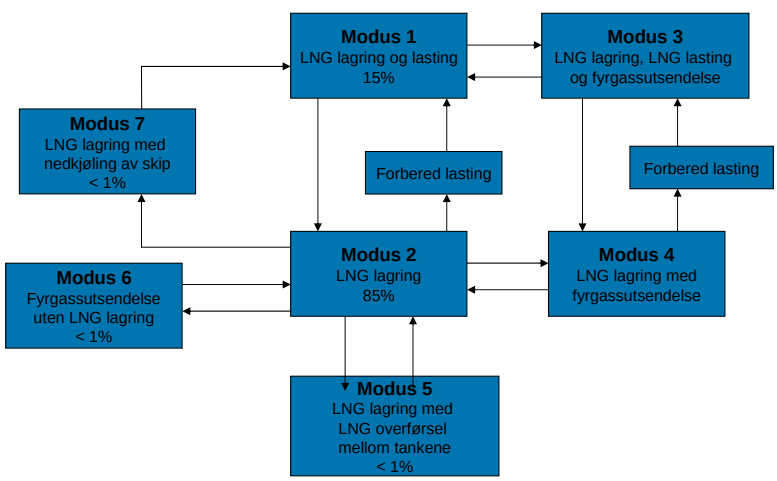
Modes of operation



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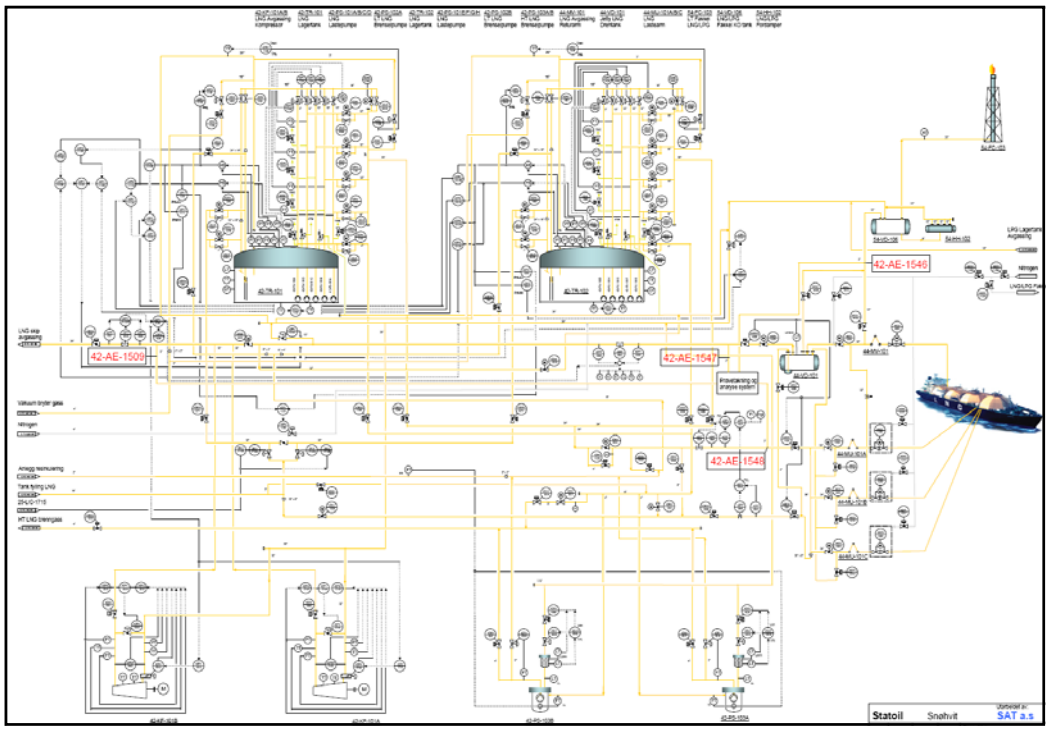
42-AE-1509
42-AE-1546
42-AE-1547
42-AE-1548
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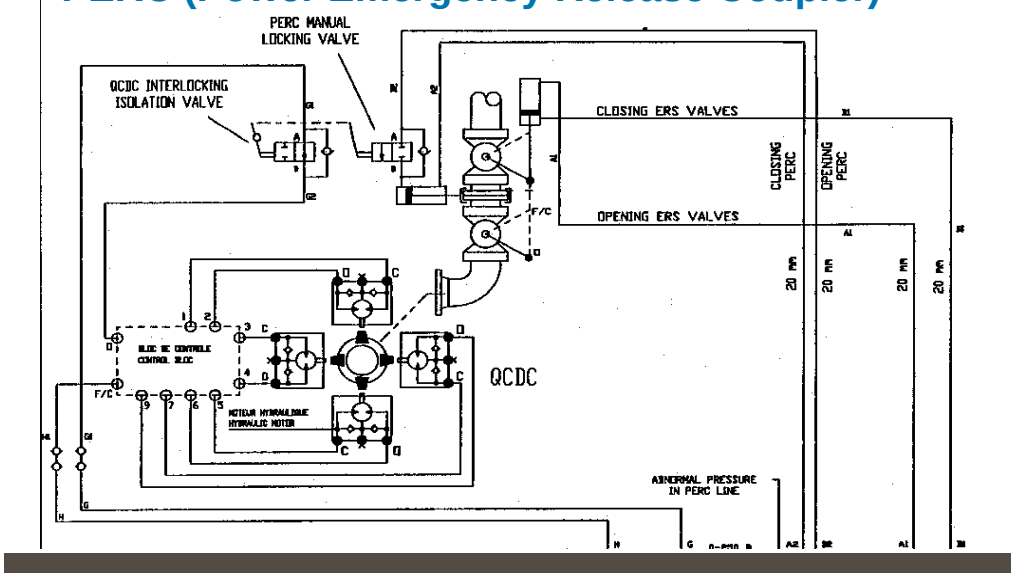
Emergency disconnect:
Break between two ball valves,
thus sealing against both loading system and ship (connector stays on ship manifold)

PERC (Power Emergency Release Coupler)



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Loading Jetty (Example)