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Topside equipment Marinization for FLNG

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Agenda

- *Introduction*
- *Marinization Study Basis*
- *Marinization Study Results*
- *Conclusions*

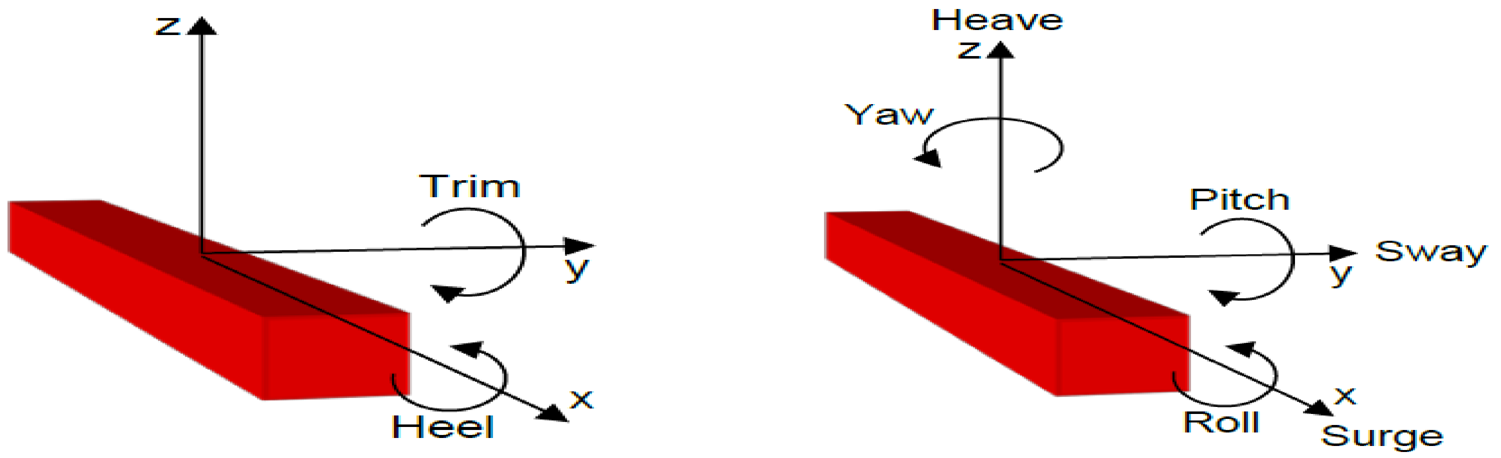
Introduction

- *Marinization is a modification of equipment that are normally used in onshore process plant to make them workable in offshore and mobile condition.*
- *Ship motion is a resultant of met-ocean conditions such as wave, current, wind and ship geometry. Motion data are generated from all these input parameters.*
- *Process performance get affected by the motion of the ship.*
- *Mechanical integrity of equipment is also affected by ship motion*

Introduction

Motion data are defined by static inclination and dynamic rotation:

- *The static tilt is defined by the corresponding inclination angle for each single rotation (trim, heel)*
- *A free- floating ship has six degrees of freedom of motion along X-Y-Z axis*
  - *Three rotational – Roll (X-axis), Pitch (Y-axis) and Yaw (Z-axis)*
  - *Three Translational – Surge (X-axis), Sway (Y-axis) and Heave (Z-axis)*



Introduction

Evaluation of motion data has two goals:

- *To analyse flow regime of gas/liquid flow and consequently the tendency of splashing/sloshing based on calculated acceleration*
- *To quantify the mal-distribution of fluid in the equipment through CFD studies and incorporate that factor in the mathematical model normally used for onshore.*

Modification of equipment dimensions

Addition of particular internals

Rearrangement of internals

Marinization Study Basis

Coral FLNG is designed based on three environmental return conditions:

- *Design Operating Conditions (DOC):*

  Maximum motion figures related to non-cyclonic 1-year return period sea states. At this condition the vessel shall be capable of continuously maintaining full capacity LNG production

- *Design Extreme Conditions (DEC):*

  Maximum motion figures related to cyclonic 100-year return period sea states. These motion conditions shall be used to perform the mechanical design.

- *Survival Conditions:*

  FLNG Facility as a whole should survive the event under fully manned condition for cyclonic 10,000-year return period.

Marinization study - Results

Three critical examples in the FLNG:

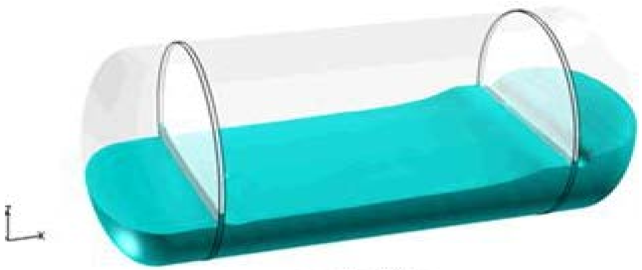
- *Separator (Horizontal) – High liquid inventory (sloshing)*
- *Column (AGRU unit) – G/L absorption (mal-distribution)*
- *MCHE (Liquefaction Unit) – Tall equipment (acceleration)*

Horizontal Separator (1/3)

A horizontal separator is a critical item due to its high liquid inventory. As a general rule, the following actions shall be normally applied, before starting a CFD study:

- *Horizontal separator should be oriented along the longitudinal axis to minimize the impact of motion as the pitch oscillation and longitudinal accelerations are less severe than roll oscillation and transversal accelerations.*
- *Motion induces sloshing in the vessel. As a general rule one perforated baffle should be provided every 2-3 m with a ½"holes size of and net free area of 25%, to minimize impact of sloshing.*

w/o baffle

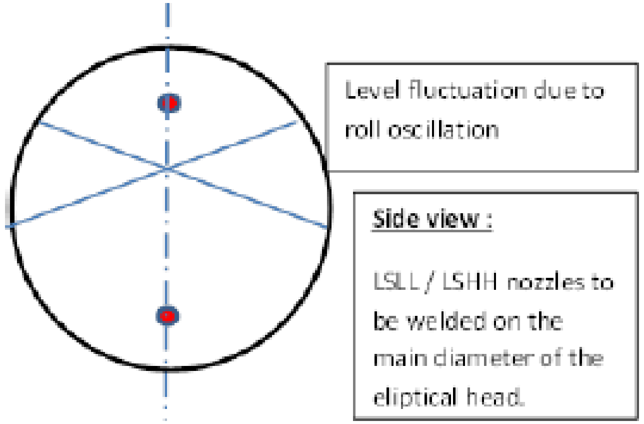


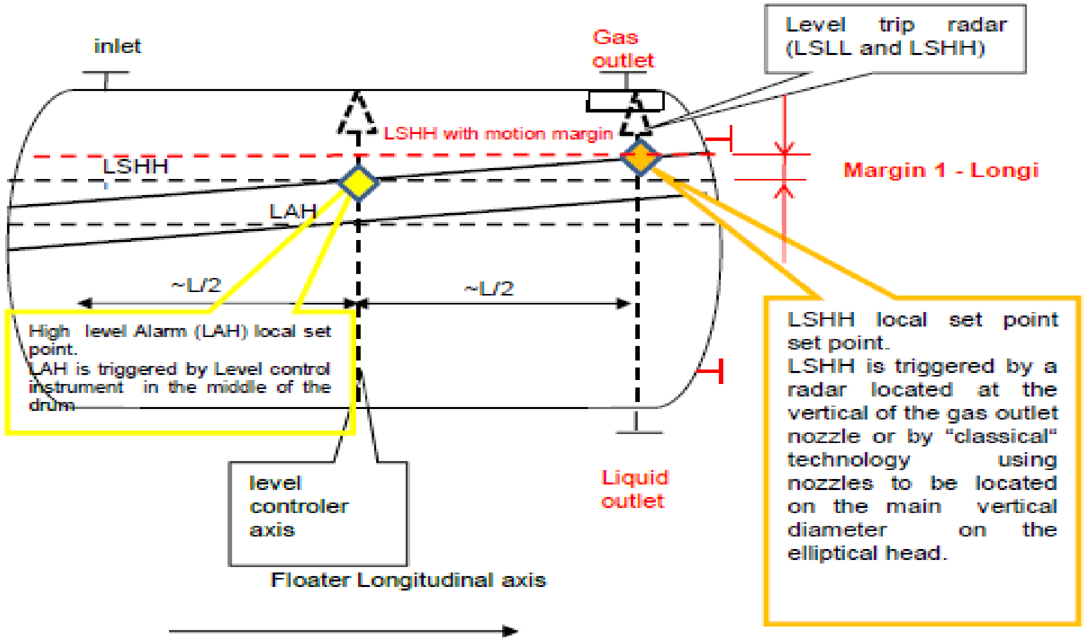
w baffle

Horizontal Separator (2/3)

Location of level instrument is also important because vessel end position changes with respect to liquid level and hence the level reading. A general rule foresees the following:

- *LT for control at the centre*
- *LT for LSHH at gas outlet*
- *LT for LSLL at liquid outlet*





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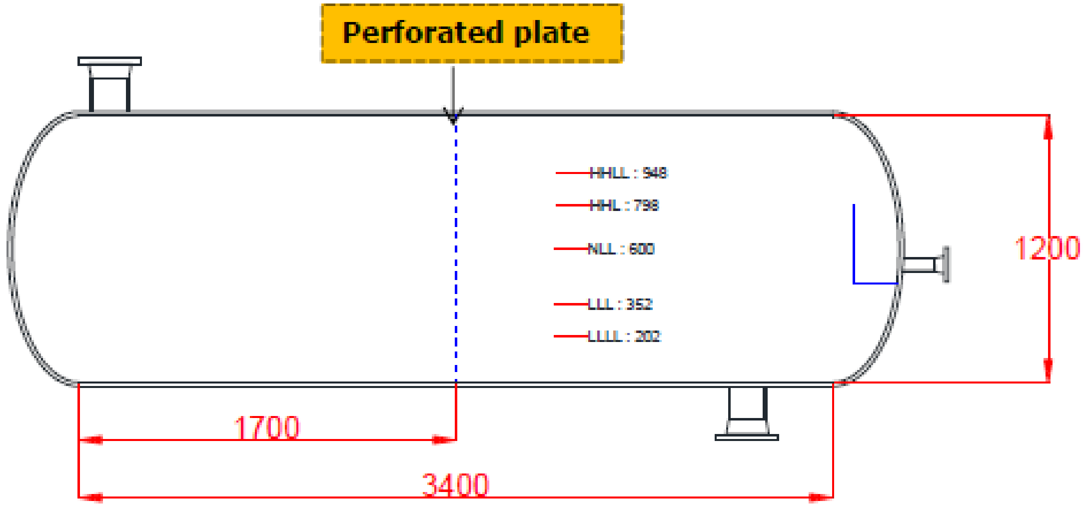
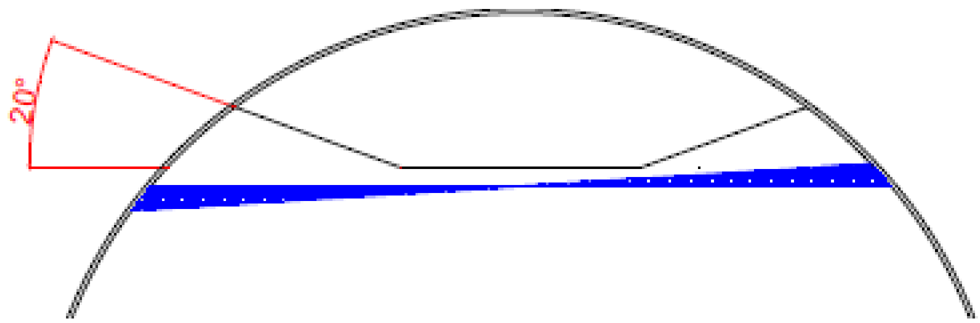
Horizontal Separator (3/3)

Example: MEG Regenerator Reflux Drum

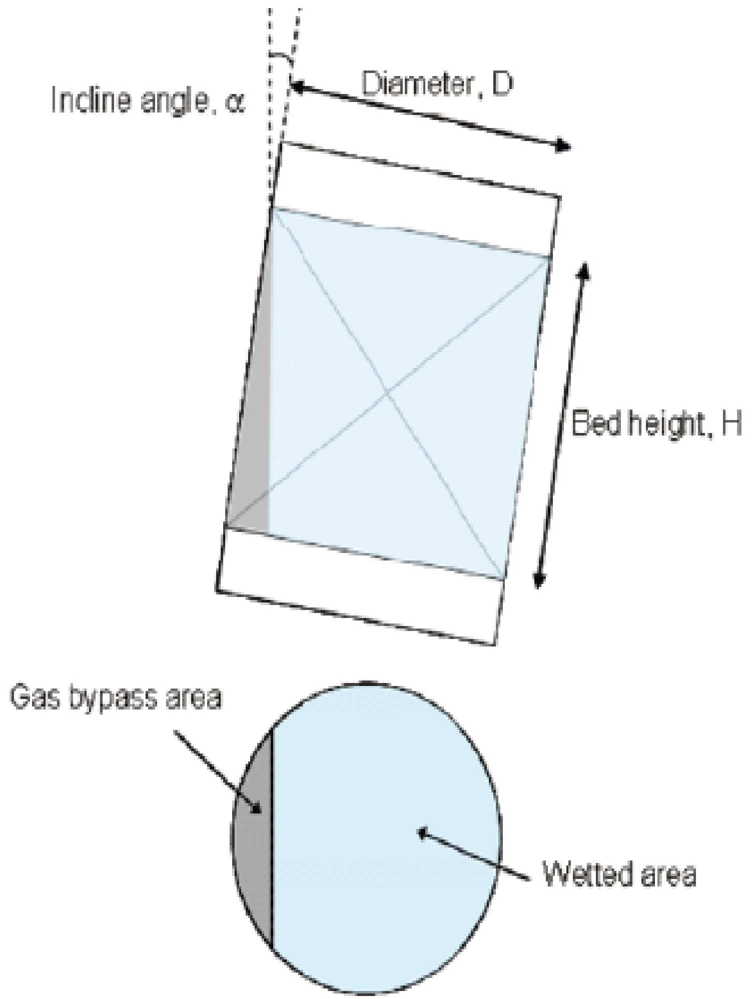
- *Without calming baffle, the wave interaction might cause high amplitude waves that can cause water spill into skimming bucket. Recommended to install wave dampening perforated plate.*
- *Recommended to install V-shaped rim on skimming bucket, with 20°, cover 1/3 of each side. This add safety margin towards water spill in to skimming bucket due to roll, or combined roll and pitch.*





Absorption Columns - AGRU (1/2)

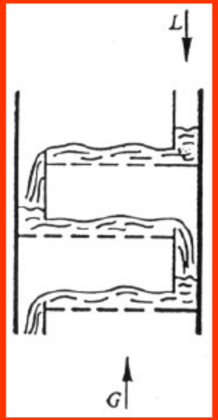
- *Absorber column and Stripper column are the most critical equipment of the FLNG*
- *Tilting of column affects the liquid flow and which results in insufficient contact between gas and liquid. Gas bypass area increases with inclined angle and bed height.*
- *AGRU licensors had developed a CFD model to describe the effect of tilt or motion on the liquid flow in column with packed bed.*
- *AGRU licensors had validated their model by conducting several experiments on a test rig.*



Absorption Columns - AGRU (2/2)

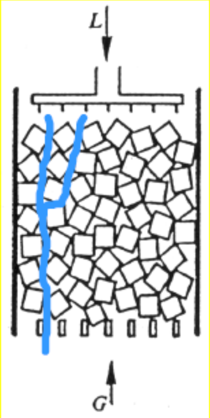
General approach to reduce the impact of liquid mal-distribution

- *Use of structured packing*
- *Use of more number of beds with lesser height*
- *Static tilt to be reduced to a minimum*
- *Use of special designed distributor*



TRAYS

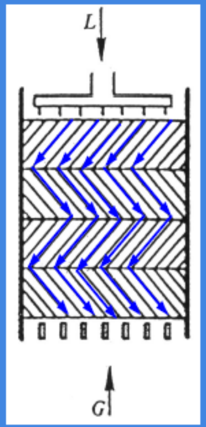
Free flowing liquid can slosh onto tray deck



Random Packing

Liquid is very sensitive to horizontal motion (liquid channelling!)

Little liquid spreading effect



Structured Packing

A liquid film on packing surface is less sensitive to motion

Main Cryogenic Heat Exchangers (1/2)

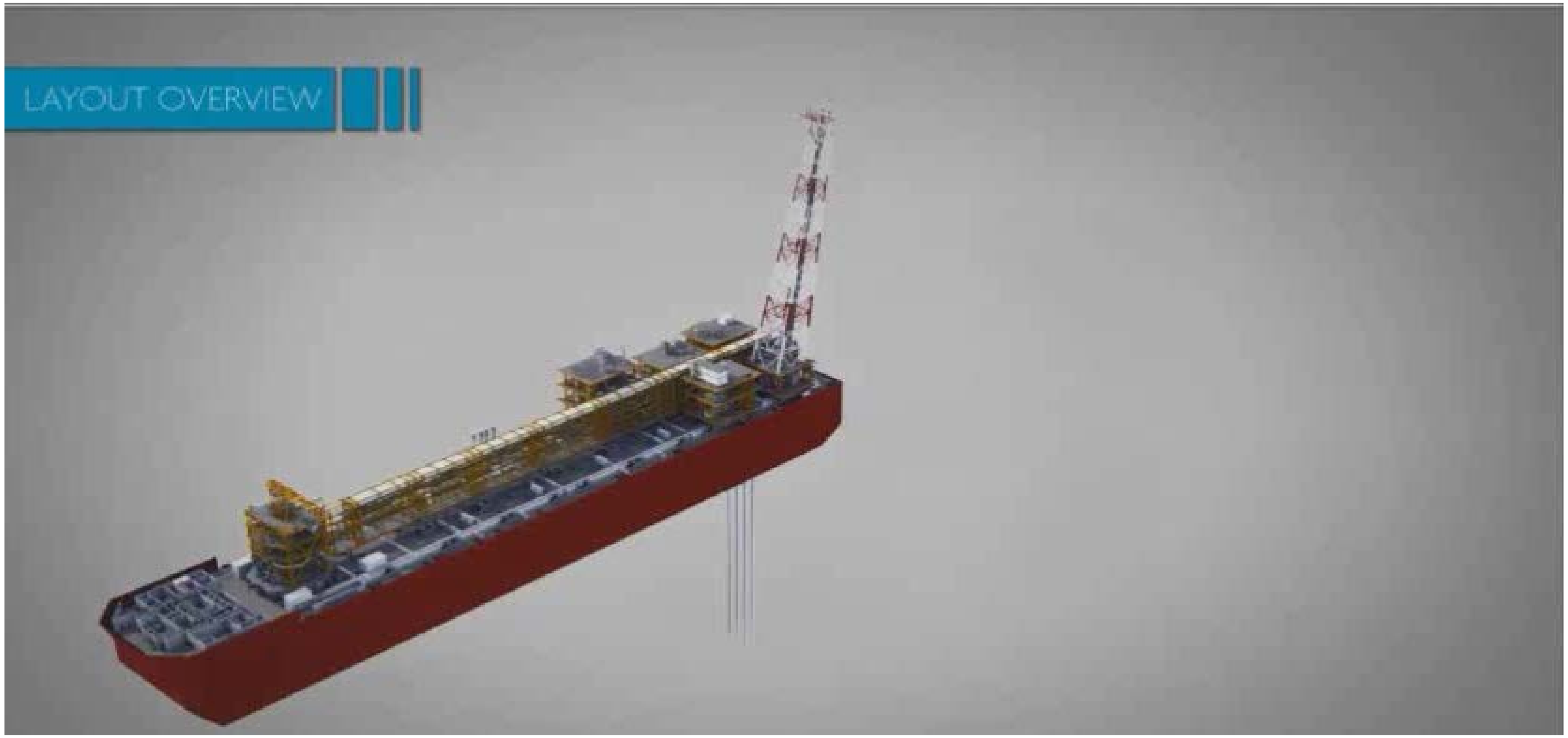
Parameters affecting exchanger performance:

- *Number of Transfer unit (NTU): Impact on mal-distribution is high with high NTU. Exchanger with high NTU (tall exchanger) can be divided into two or more exchangers with lower NTU each.*
- *Static tilt: Static tilt induces permanent mal–distribution. This must be reduced to a minimum.*
- *Period of oscillation: impact of high period of oscillation is similar to a static tilt effect*
- *Elevation: High elevation causes high acceleration and thus rapid change of shell side flow behaviour, thus splashing.*
- *Bundle geometry: Winding angle, tube diameter, tube spacing etc.*
- *Shell side flow: Both vapour and liquid side flow rate can affect sensitivity to mal-distribution.*

Main Cryogenic Heat Exchangers (2/2)

The height of the MCHE (~ 40 m) implies high acceleration, leading to massive strength and fatigue.

For structural integrity, SS instead of Aluminium is selected as MOC for shell.



Conclusion

- *Marinization is a very critical issue for a floating environment.*
- *Marinization may have an impact on the dimensions of the equipment. A late marinization assessment can have a side effect in the design of the whole module.*
- *It is therefore recommended to perform a preliminary assessment during the early stage of a project (FEED) to minimize possible future layout impacts.*

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Thank You

Q&A

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