WATER INTAKE RISERS FOR PRELUDE FLNG

- Prelude FLNG Project Overview
- WIR Concept Selection
- WIR Concept Description
- WIR Installation on FLNG
- Response in Extreme Events
- Fatigue Design
- Flow Induced Vibrations

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PRELUDE FLOATING LNG

- Facilities for gas production, liquefaction, storage of LNG, LPG and condensate & direct offloading to market – all on FLNG
- Designed to be permanently connected and permanently manned
- Hull, Topside structures, moorings, risers all designed to survive 10,000 year environmental conditions, including tropical cyclones
- FLNG Facility is 488m long, 74m wide – largest vessel ever

- LNG Production: 3.6 mtpa
- LPG Production: 0.4 mtpa
- Condensate: 1.3 mtpa
FLNG CONSTRUCTION – Hull floated out of dry dock Dec 2013
Module 3P1 being lifted from Quayside (left photo) onto FLNG (right photo) using floating crane. Lift weight 2900mT.
LIQUEFICATION PROCESS

- Liquefaction process requires large volumes of cooling water
- Cold water boosts the process efficiency ~ more LNG production
- Dual Mixed Refrigerant successfully applied in Sakhalin and chosen for Shell FLNG
- Small footprint
WATER INTAKE RISERS – FUNCTIONAL REQUIREMENTS

Key Functional Requirements:
- Deliver 50,000 m³/h of cooling water
- Water intake depth: 150m below sea level
- Sparing philosophy: Allow for 1 spare riser
- Retractable for maintenance & inspection
- 25 years of service life

Avoid collision with moorings & risers

Typical water temperature profile in NW Australia

Temperature (°C)

6-10 °C
WIR – CONCEPT SELECTION

**Individual risers**

- Easy change-out
- Interferes with marine activity
- Requires protection balcony
- Large footprint on deck (piping)

**Riser Bundle**

- Protected from boat impact
- Small footprint
- Dedicated crane to retrieve riser

**Rubber**

- Flexible – can accommodate vessel motion
- Unknown failure modes
- Difficult life time prediction

**Steel**

- Extensive experience
- Weight just right
- Rubber only at hull interface
STEEL WATER INTAKE RISER BUNDLE

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Riser hang-off system
Dynamic Performance of the WIR

Performance Criteria

- Von-Mises Stress below yield in 10,000 yrs cyclone conditions
- No collision with flexible risers and mooring lines
- No compression in rubber hose in 10,000 yrs cyclone conditions
- Fatigue life of 25 years with a safety factor of 10

Unique challenges for a water intake riser bundle

1. Large internal flow in the pipe
2. Vortex-induced vibration of a riser bundle in a current
Effect of internal flow in the pipe

Before investigation

Theory  Unstable behaviour for $U_f > 0$ m/s

Experiments  Stable behaviour
Experiments at Delft Hydraulics
Experiments at Delft Hydraulics
EFFECT OF INTERNAL FLOW IN THE PIPE
Effect of internal flow in the pipe

Before investigation

**Theory** Unstable behaviour for $U_f > 0$ m/s

**Experiments** Stable behaviour

After investigation

**Theory** Unstable behaviour for $U_f > $ critical speed

**Experiments** Complex unstable behaviour for $U_f > $ critical speed
Vortex-induced vibrations of an individual riser

VIV characteristics

- Natural frequency = Shedding Frequency of Vortices
- Amplitude ~ 1 x diameter
Vortex-induced vibrations of a riser bundle

OPTION 1

OPTION 2
Vortex-induced vibrations of a riser bundle

- Scale 1:45 (Length of model is 3.3 m)
- Risers slide through spacers
Vortex-induced vibrations of a riser bundle

OPTION 3

SUPPRESSION OPTION
Vortex-induced vibrations of a riser bundle
Vortex-induced vibrations of a riser bundle
Installation of water intake riser bundle

- Structural riser is stored on deck of the FLNG vessel
- Hang first piece of structural riser in riser assembly tower
- Build riser piece by piece until completion
- Structural riser is assembled
Piece by piece built from Rat on flng vessel

- Connect structural riser to rigging
- Lower riser and disconnect pedestal crane using a ROV
- Reconnect and retrieve riser with pedestal crane, connect top part
- Water intake riser is installed from FLNG vessel
PRELUDE WI RISERS: Innovations Taking Shape

- As far as possible PRELUDE uses proven and tested systems and components brought together in innovative ways – However, some new concepts e.g. Offloading Arms, WIR

- **WI Risers:** Largest ever in terms of throughput; new concept, new components, new phenomena (in-flow induced vibrations, bundle riser VIV, Riser Hanger Assembly)

- Design development went through a **maturation process**, including small-scale tests, prototype experiments and CFD analyses

- De-risking of New Technology through FEED, Detailed Design & Construction to ensure full-size systems perform as intended – In a multi-billion $ project …get it right 1st time