TTR Mining Application
Review on Behalf of Origin Energy Resources Kupe NZ Ltd

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Director

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Review of TTR Marine Consent Supporting Documents for Origin Energy

> My specific expertise:
  • 30 years experience in the design of mooring systems for floating production facilities - 15 years with BHP Billiton Petroleum and 15 years with AMOG
  • Significant involvement in integrity management of mooring systems
  • Experience of operations in the South Taranki Bight since 2012

> Scope of Work - Desktop review identifying the potential threats or risks to the ongoing operation of the Kupe JV’s offshore unmanned facilities

> Specific areas of focus
  • General concept of operation
  • Risks to physical assets arising from TTR Mining assets *
  • Risks to assets arising from altered coastal processes
  • Risks to further exploration and development *
  • Intangible risks
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Potential threats to the ongoing operation of the Kupe facilities

> Loss of position event for the IMV
  - Thruster assisted mooring design
  - Mooring system design including 4-leg mooring wire configuration
  - Anchoring procedures
  - SIMOPS

> Risks to physical assets
  - TTR fleet and SIMOPS
  - Sediment transport
  - Jack-up rig mobilisation to the Kupe WHP

> Risks to exploration and future development
  - Geotechnical issues
  - Future infield pipelines tying back to the Kupe WHP
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Potential threats resulting in a “Loss of Position” event for the IMV

> Thruster assisted mooring design
  - Appropriateness of thruster-assisted mooring classification
    - Build
    - Redundancy
  - Adequacy of thruster system capacity
    - Environment (SE beam-on conditions)
    - Thruster interaction effects

> Mooring system design including 4-leg mooring wire configuration
  - Temporary vs Permanent design requirements
  - Mooring leg failure consequences

> Anchoring procedures
  - Verification of achieved capacity

> SIMOPS
  - Collision/mooring leg damage scenarios
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Potential Risks to Physical Assets

> TTR fleet and SIMOPS
  - Complex TTR marine operations with IMV, FSO and support vessels
  - FSO located upwind of IMV during ore transfer operations

> Sediment transport
  - Localised changes in wave climate due to pit/mound migration
  - Burial of pipeline
  - Impeding visual inspection activities along pipeline route
  - Potential changes in cathodic protection performance

> Jack-up rig mobilisation to the Kupe WHP
  - Interference with tow, approach, mooring and jack-down/removal of jack-up drilling rig
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Potential Risks to Exploration and Future Development

> Geotechnical issues for Jack-Up rigs
  • Addressed in detail by Mr Overy

> Future infield pipelines tying back to the Kupe WHP
  • Spanning issues
  • Stabilisation issues
  • Protection issues resulting from IMV mooring arrangement crossing pipelines or setting/dragging of anchors
"Why would you not expect the matters raised in your report to be part of the detailed design process when it is being undertaken by an experienced international naval architect and vessel construction company?"

- Unable to speculate on the experience, underlying understanding and the remit the TTR naval architects have been given
- We did not assume that their knowledge and experience was similar to ours
- Our remit was to review the information provided by TTR to assess the threats/potential risks to the ongoing operations or future operations in the Kupe Permit Area
- Many of the issues raised in our reviews were not addressed in the information provided
- Subsequent acceptance of our recommendations by TTR indicates our advice was not unreasonable
Review of TTR Marine Consent Supporting Documents – Questions on Notice

“Why would you not expect the matters raised in your report …” Cont.

> Naval architects and vessel construction companies not necessarily ones that would have experience in the design of station-keeping systems, particularly for long-term mooring in harsh environments

> AMOG has been working at the forefront of improving mooring integrity management in the offshore oil and gas industry

> Failure rates on permanently moored floating production systems have been more than an order of magnitude greater than the underlying design assumptions embodied in Class guidance

> Reliance on Class does not necessarily provide a robust and reliable system. Class rules based on experience and come primarily out of the shipping sector.
Drivers for Improved MIM Practice:
Recent Failure Rates for Permanent Moorings

> Industry codes based on annual probability of expected single line failure due to overload at $10^{-3}$

> Notional annual probability of expected two line failure due to overload should be $< 10^{-4}$

> Operational performance is not reflecting design expectations

<table>
<thead>
<tr>
<th>Event Type</th>
<th># of Events</th>
<th># of Mooring Lines Affected</th>
<th>Annual Probability per Asset</th>
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</thead>
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<td>System Failures (Riser and Subsea Damage)</td>
<td>4</td>
<td>20</td>
<td>$2.0 \times 10^{-3}$</td>
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<tr>
<td>System Failures (No Riser and Subsea Damage)</td>
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<td>19</td>
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<td>Pre-Emptive Replacements</td>
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<td>148</td>
<td>$1.6 \times 10^{-2}$</td>
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</tbody>
</table>

Typical Observed Failure Modes

Drivers for Improved MIM Practice: Actual Failure Likelihood over Lifetime

Mooring Component Age at Failure / Replacement

Installation Failures
Infant Mortality
Age-Based Failures?

Source: OTC-25273-MS Industry Survey of Past Failures, Pre-emptive Replacements and Reported Degradations for Mooring Systems of Floating Production Units
Lifecycle Approach to Threat Management

Feasibility
Concept Selection
FEED
Detail Design
Construc-tion
Installat-ion
Technology
Design Basis
Design Rigour
Commercial
Contractual
Manufacturing
Installation
Operate
Age-Based
Event-Based
Inspection
Procedural
Emergency Response
Review of TTR Marine Consent Supporting Documents – Questions on Notice

"Why would you not expect the matters raised in your report …”

Cont.

> Loss of position events of TTR vessels place OERKL assets directly at risk
  > Direct collision with the Kupe platform
  > Direct collision with any jack-up drilling rig at the Kupe platform
  > Anchor drag across the Kupe pipeline and umbilical or abandoned well heads

> Origin requires verifiable assurance that the threats from a TTR vessel loss of position event have been identified by TTR and properly mitigated through preventative controls to eliminate/minimise the threat and through mitigative controls to reduce the likelihood of damage should a loss of position event occur

> Industry experience shows that the identification and mitigation of threats to station keeping performance requires improvement