Vessel Dynamic Stability during Deep Water PLET Installation – a case study

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Agenda

- Introduction
- Lewek Centurion
- PLET Installation
- Vessel Stability Analysis
- Offshore Operation
EMAS-AMC has performed the installation of pipelines using Lewek Centurion, a deepwater S-lay vessel, at water depths ranging from 1100 to 1400m.

Due to long catenary line in deep water, crane hook load is significant during PLET installation.

Question was raised by operation team about safety margin for vessel dynamic stability in accidental case if the crane load is suddenly lost.
Deepwater S-Lay Vessel – Lewek Centurion

- **Lewek Centurion** (Emas AMC)
  - Length: 146.5m
  - Width: 30m

- **DP2 S-lay**
  - Pipe Storage Capacity: 6500mT
  - Adjustable Double Section Stinger (Radius 70m~300m)
  - 90deg Departure angle @stinger tip

- **Main Crane (Kenz):**
  - 300mT@15-16m, Hs=1-2m

- 1 Pipe transfer crane (36mT@30m)
- 1 Shipboard crane (20mT@20m)
- 300mT A-frame with retractable Hang-off platform
A-Frame & Hang-off Platform

- **A-Frame**
  - Max Boom Out Length: 6000mm
  - Max Load Capacity: 300mT

- **Retractable Hang-off Platform (PS)**
  - Carry the load from full catenary of pipeline in J-mode.
  - Max Load Capacity: 300mT
PLET Installation: Deployment
Crane Load Loss

- Crane Wire Tension (Max)
  250mT(dynamic)
  @Hs=1.5m; Tp=10s

- Safety Concern
  What if crane wire load is lost accidentally?
  Stability is sensitive as vessel CoG location is relatively high with pipe loads.
  Any excessive acceleration or unexpected large ship motion?

Oops…
For crane vessels, accidental load drop should be considered.

DNV, ABS, BV…
- $\theta_e < 15 \text{deg}$ from upright.
- $A_2/A_1 > 1.4$ (DNV, BV) or 1.3 (ABS)
- In favorable weather condition

IMO
- “Static intact stability standards based on the properties of the righting lever (GZ) curve have served the shipping industry well for decades, but it has been recognized that incidents do occur to ships meeting the standards and that there may be hydrodynamic related mechanisms that can lead to stability failure”
- 2nd generation stability criteria
- Excessive acceleration
Numerical Methodology

- MOSES
  - Displacement
  - COG & COF
  - Hydrostiffness
  - Load RAO
  - Added mass
  - Added damping

- Orcaflex
  - Link property
  - Batch run

Frequency domain

Time domain
## Weather Condition and MOSES Result

<table>
<thead>
<tr>
<th>Water Depth</th>
<th>1300m</th>
</tr>
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<tbody>
<tr>
<td>Hs</td>
<td>1.5m</td>
</tr>
<tr>
<td>T</td>
<td>10s</td>
</tr>
<tr>
<td>Wave Direction</td>
<td>Beam sea</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vessel draft</th>
<th>9.4m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>27,650mT</td>
</tr>
<tr>
<td>GMT</td>
<td>3.1m</td>
</tr>
<tr>
<td>GML</td>
<td>188.6m</td>
</tr>
</tbody>
</table>
• Phase 0: Wave ramp up.
• Phase 1: Vessel, with the crane connected to PLET, achieves stable stage.
• Phase 2: Crane load is released suddenly, vessel achieves stable stage gradually.
- ΔT refers to the time difference between the max wire tension and load loss.
- Static inclination angle after Load loss: 3.4deg to Starboard.
- Max angle acc. to IMO weather criterion:
  \[ 22.9^\circ + 9.1^\circ = 32^\circ < 48.7^\circ \] (Down flooding angle)
More to think

Higher crane load?  (1500mT@Hs=1.5m,T=10s).
  - Max dynamic roll angle 27deg.
  - Static inclination angle =14<15deg; Energy ratio also satisfied.
  - Considering IMO weather criteria, 50deg>48.7deg

Irregular wave?

Induced high acceleration?
  - Personnel safety
  - Crane structure
  - Equipment seafastening
Offshore Operation

<table>
<thead>
<tr>
<th>Vessel Heading</th>
<th>120°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swell1 Hs</td>
<td>0.4m</td>
</tr>
<tr>
<td>Swell1 Tp</td>
<td>10s</td>
</tr>
<tr>
<td>Swell1 Dir</td>
<td>E</td>
</tr>
<tr>
<td>Swell2 Hs</td>
<td>0.5m</td>
</tr>
<tr>
<td>Swell2 Tp</td>
<td>8s</td>
</tr>
<tr>
<td>Swell2 Dir</td>
<td>SSW</td>
</tr>
</tbody>
</table>

- 3hr most probable max value (roll)
  - Numerical value = 0.77deg
  - Offshore data = 0.52deg
Offshore Operation
Lewek Constellation - Ultra Deepwater Rigid & Flexible Lay / HL / DP3

Lewek Connector - Ultra Deepwater Multipurpose, Flex-lay DP3

Lewek Express – Reel Lay

Lewek Centurion - Deepwater S-Lay

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