Qualification of a DP Based FPSO Offloading Technology

DYNAMIC POSITIONING CONFERENCE
Houston - October 12-13, 2010

Early Draft Sept 30, 2010
Presentation Content

By Remora:

2. SYSTEM DESCRIPTION: How does it work? Main Systems
3. TANKER SIZES, MAIN DP PRINCIPLES: 70 000 - 320 000 dwt, same DP
4. OPERATION PRINCIPLES: a) Weathervaning  b) “Green Sector Offloading”
5. TANKER AND P&I CLUBS FEEDBACK: 20+ Tanker Companies, 10+ P&I Clubs
6. SEA TRIALS IN NORWAY: Program, objective, participants

By Kongsberg:

7. KONGSBERG PROJECT CONTRIBUTIONS: 10 years of close cooperation
8. DP PRINCIPLES: How to handle 1400 different tankers with same DP System?
9. BRIDGE LAYOUT: Alternatives considered, Main Systems Location
10. INTEGRATED CONTROL SYSTEM: User Interface, Ballast Sequence
11. DP TRAINING SIMULATOR FOR HiLoad DP: Overview, Integration with Marin
Year 1999 - Question asked: Could DP be utilized on the entire existing Tanker Fleet?

Utilize DP also on these tankers?
**Year 2003: DP Conference - Concept**

- The HiLoad DP **Concept** was presented at the DP Conference in Houston in 2003.

- Several major changes have been done to the concept since then:
  - Implementation of Own Power Generation – fully self-contained vessel
  - DP Operators onboard the HiLoad DP (not remotely operated from FPSO)
  - Implementation of Quick Connect/Disconnection System for FPSO Hose

*Illustrations from Presentation at DP Conference in 2003*
Year 2010: A Reality
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The HiLoad Concept
- Applying “intelligence” to Conventional Tankers

• Dynamic Positioning (DP Class 2)
• Bow and stern thrusters
• Dedicated mooring equipment
• Dedicated hose handling system
• High level of safety systems
• Fully trained operators
A Standard Tanker...
...is simply converted into a DP Tanker by use of HiLoad DP...
HiLoad Design Characteristics

- L-shaped floating docking unit – “fork lift”
- Connects to vessels using water ballast
- Sucks onto vessel’s bottom - becomes part of the vessel
- Slim towers for small wave induced loads
- COG below COB for stability
- No modifications needed for the vessels
- Accommodates any size tanker
- Only proven components
- 3 x 40 ton Azimuth Thrusters
- Class Notation: DNV ☰ 1A1 Floating Offshore Oil Loading Installation
Attachment System Description

- Friction Fenders
- "Gina" Seal

Tanker hull bottom
Hydrostatic pressure e.g. at 10 m depth = 1 bar
Friction fenders
Hydrostatic pressure e.g. at 10 m depth = 1 bar (10 ton/m²)

Compression seal

Water out
Air in

HiLoad®

Air W/1 atm no hydrostatic pressure
Hydrostatic pressure transferred to tanker hull through the friction fenders
Hydrostatic pressure e.g. at 10 m depth = 1 bar (10 ton/m²)

Video
Click to play
Presentation Content

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1 HiLoad – 1 DP - 1400 Tankers

Number of Tankers shown in BLUE
Weather-vaning Principle – "DP Turret"
DP2 Station Keeping of Tanker

- Station Keeping based on “Weather-vaning” of tanker
- 3 x 40 ton Azimuth Thrusters
- Capable of station keeping a VLCC in 1-year return conditions in WA
- DP2+ machinery arrangement
- 6 Model Tests carried out
- A number of DP Simulations carried out

DP Model Test at Marintek in Norway
Thruster Data and Redundancy
Station Keeping by DP2+, 3 separate engine rooms

Engine Room 1

Engine Room 2

Engine Room 3

Caterpillar 3516C

WARTSILA AZIMUTH THRUSTER
420 KN BOLLARD PULL

550 kW GENERATOR
MAIN ENGINE
CATERPILLAR 3516C

Engine Room Arrangement
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Typical Operation Sector

- Offloading - Safe Distance from FPSO – 600 m – Weather-vaning of tanker
- No tugs or assisting vessels required – DP2 station keeping of tanker
- Quick Emergency Disconnection of Hose
"Green Sector Offloading" – 200 m Distance

DP Grid Point Selected: 50°, 210 m (example)
“Green Sector Offloading” with HiLoad DP - 200 m Separation

- Spread Moored FPSO
- 200 m
- Constant Hawser Tension 10-20 ton
- DP Positioning of Tanker by HiLoad
- Stern Tug in Standby
“Green Sector Offloading” – DP Operation

Aframax, Suezmax or VLCC Tanker

HiLoad DP Ref. Point

Constant Hawser Tension 10-20 ton

200 m

Spread Moored FPSO

Docking to be removed from Animation (SBH)
DP Simulations and Training

• Kongsberg DP Simulator for HiLoad integrated with Marin`s Offloading Simulator in The Netherlands

• Two Successful Simulations of carried out for clients in 2010

• Site Specific Simulation and Training Session now offered to all clients for this simulator set-up
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Tankers Owners

TANKER OWNERS

- Remora is currently in dialog with the leading Tanker Owners regarding operation with HiLoad DP in Angola:

  *Frontline, Euronav, OSG, AET Inc, MOL, Teekay, BW Group, Maersk, StenaSonangol, SPT and others*
BACKGROUND
Remora has through in-house insurance broker ‘Henschien’ approached and entered into dialog with P&I Clubs and Insurance Companies for the HiLoad DP Site Trials.

COMPANIES IDENTIFIED AND APPROACHED

➢ Gard
➢ Skuld
➢ Britannia
➢ North of England
➢ The Swedish Club
➢ The UK Club
➢ West of England
➢ Norwegian Hull Club

Above listed companies represents the majority of P&I Clubs and Insurance companies involved in coverage of large size tankers and offshore operations world wide.
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Sea Trial – Location

• Location: Hardanger fjord – West Cost of Norway, about 35 nautical miles north of the construction Yard in Haugesund

• Short distance to exposed offshore location for open water testing
Sea Trial – Test Program

• Sea Trial for HiLoad DP No. 1 will be carried out in Norway in Q4 2010

• The Sea Trial program will comprise of following tests:
  ➢ Test 1 HiLoad DP Maneuvering and station keeping
  ➢ Test 2 Docking / undocking test. Docking on to Tanker
  ➢ Test 3 HiLoad DP station keeping of Tanker
  ➢ Test 4 HiLoad DP as a Tug - “Green Sector Offloading”
  ➢ Test 5 Crash stop test
  ➢ Test 6 Connection of export hose to tanker manifold

REMARK: Test 2 and 3 will be carried out in both sheltered waters and open waters

Planned participating oil companies:
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Kongsberg Project Contributions

- Design Studies
- Operational Procedures
- Simulator based Training and Verification
- Onboard Control and Monitoring Systems
  - Engineering
  - Station Keeping and Maneuvering
  - Marine Automation
  - Safety Systems
  - Control Room HMI
  - Commissioning & Trials
Kongsberg Systems
- DP
  - Sensors
  - Reference Systems
- Remote Thruster Control
- Automation
- Safety
Design Studies

- HiLoad DP / LNG
  - Own power or power via umbilical
  - Remote Control or own control room
  - Diesel Mechanic / Electric
  - Instrumentation
  - Operational Procedures
  - Operational Details
    - Manual / Automatic
Operational Procedures

- Modes
  - Attached to FPSO
  - Approach Tanker
  - Connect
  - Depart from Tanker

- Automation / Instrumentation
  - Sensor selection
  - Manual / Automatic
  - Sequence Control
  - Safety
- Station Keeping
- Ballast
- PMS
- F&G
- HMI
- Procedures
- Verification

### SAT Procedure

#### K-Pos DP-2 and cJoy

**HiLoad DP**

<table>
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<th>Project number:</th>
<th>31185; HiLoad DP</th>
</tr>
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<tr>
<td>Product</td>
<td>K-Pos DP-2 and cJoy</td>
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<td>Synopsis</td>
<td>Procedure describing the Sea-Trial program.</td>
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Tankers and Tanker Models

- Standalone HiLoad
- HiLoad & 150000 DWT
- HiLoad & 250000 DWT
Thrusters and Thruster Models
Control Principles

\[ F_x = K_x^P (x_0 - \hat{x}_{LF}) - K_x^V \dot{\hat{x}}_{LF} \]
\[ F_y = K_y^P (y_0 - \hat{y}_{LF}) - K_y^V \dot{\hat{y}}_{LF} \]

where

- \( F_x, F_y \) = longitudinal and transverse forces from thruster
- \( x_0, y_0 \) = wanted (target) position
- \( \hat{x}_{LF}, \hat{y}_{LF} \) = estimated slowly varying position of HiLoad
- \( \dot{\hat{x}}_{LF}, \dot{\hat{y}}_{LF} \) = estimated slowly varying velocity of HiLoad
- \( K_x^P, K_x^V \) = position feedback gains
- \( K_y^P, K_y^V \) = velocity feedback gains
Sector Warning and Alarm

Close Warning and Alarm

Approach Sectors.

Fare Warning and Alarm

Sector Warning and Alarm
Ballasting Operation

- Critical in attach & release phases
- Timing related to use of propulsion
- Timing related to connected / not connected
- Adjustments related to changing tanker draught
<table>
<thead>
<tr>
<th>Step ID</th>
<th>Action</th>
<th>Condition for next step</th>
<th>Timeout</th>
<th>Error Step</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>11</td>
<td>Check Start conditions: Main Ballast pumps running</td>
<td>801-DE-001A/OutRunning 801-DE-001B/OutRunning</td>
<td>60</td>
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<td>Pontoon Fenders extracted</td>
<td>831-GS-101/Meas1 831-GS-103/Meas1 831-GS-105/Meas1 831-GS-107/Meas1</td>
<td></td>
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<tr>
<td></td>
<td>Overboard valves opened</td>
<td>801-BU-022/OutOpened 801-BU-039/OutOpened</td>
<td></td>
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<td>Tower fenders extracted (Min 2 of 4 = OK. If Diagonal)</td>
<td>264-GS-101/Meas1 264-GS-102/Meas1 264-GS-103/Meas1 264-GS-104/Meas1</td>
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<td>Make Flexi and use CondA only.</td>
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<tr>
<td>5</td>
<td>Set Ballast tank 1 PS &amp; 1 SB Empty Level Set Point. Activate Set external Setpoint</td>
<td>801-LY-001/Empty 801-LY-002/Empty</td>
<td>60</td>
<td>23</td>
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<td>6</td>
<td>Close Sea Chest suction valves</td>
<td>801-BU-007/OutClosed 801-BU-030/OutClosed</td>
<td></td>
<td></td>
<td>Confirmed feedback.FRC’s in lower position</td>
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<td>7</td>
<td>Open Valves Fenders Retrieval</td>
<td>831-GS-101/Meas1</td>
<td>30</td>
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</tbody>
</table>
Simulator training and verification

- Kongsberg Polaris Simulator
  - Vessel model and visuals
- Kongsberg DP Control System
  - HMI
  - Tailored Solutions
  - Procedure verification
- Interfacing DP with Marin Simulator
  - Independent verification
  - Procedure Development
HiLoad DP Simulator