FPSO Vessels
Structure Design and Analysis

Viking Systems Experience and Capabilities

Annapolis | Houston | Singapore | Palm Beach | Tanzania
Viking FPSO/FSO Projects

• BP PSVM Angola FPSO
• Cendor MOPU Conversion (Malaysia)
• Chevron Frade FPSO (FEED / 3rd Party Verification / New Module Install)
• Chevron Frade FPSO Redevelopment
• CNR International FPSO Baobab Ivoirien MV10
• Cobalt Cameia FPSO (Angola)
• ConocoPhillips Belanak LPG FSO
• COTCO FSO Kome Kribi 1 (Esso Chad)
• ExxonMobil Yoho FSO
• HESS North Malay FSO
• Kuito FPSO (ABS)
• Petrobras UOTE (External Turret)
• Petrobras FPSO Vidade do Rio de Janeiro MV14
• Petrobras FSO Cidade de Macae MV15
• Petrobras FPSO Cidade de Niteroi MV18
• Petrobras FPSO Cidade de Santos MV20
• Petrobras FPSO Cidade de Angra dos Reis MV22
• Petrobras FPSO Cidade de Sao Paulo MV23
• Petrobras FPSO Cidade de Mangaratiba MV24
• Petrobras FPSO Cidade deltaguai MV26

• Petrobras Cidade de Caraguatatuba MV27
• Petrobras FPSO Cidade de Campos dos Goytacazes MV29
• Shell FPSO Fluminense
• TOTAL Kaombo
• TOTAL PazFlor (DSME)
• Tullow Ghana FPSO Kwame Hkrumah MV21 (Jubilee Field)
• Tullow T.E.N. FPSO Ghana
• 50+ FEED and Proposal Projects
Viking Clients

American Bureau of Shipping (ABS)
BP, Chevron, ConocoPhillips, Petrobras, Shell, Cobalt
Modec, Sofec, Mitsui
Mustang Engineering, Harvest
Sembawang Shipyards (Singapore)
Tanker Pacific Offshore Terminal (TPOT / OMNI)
Design Firms: Oceaneering, Gibbs & Cox, CSC, SAIC, NETSCO, OGI, VARD
General Dynamics NASSCO, Bollinger Shipyards, Bristol Harbor Group,
Gunderson, Bay Shipbuilding, AKER Philadelphia, Corn Island,
Alabama Shipyards (BAE), VT Systems
FPSO/FSO Typical Scope

FEED Structural Studies and Spec Development:
- T&S, motions, loads, topsides stool layout
- Review of CAP, surveys, gaugings
- Candidate tanker rule check using ABS, BV, DNV-GL Rule Programs

Detailed Structural Studies & 3rd Party Review
- Hull FEA: Load cases, hydro, strength and fatigue assessment
- Reinforcement plan: major steel, fatigue details improvement
- Riser and mooring interface for turret and spreadmoored vessels
- Stool and deck interface including effect of sliders
- Vibration assessment of hull and topsides
Initial Strength & Fatigue Assessment
Class Programs ABS ISE, BV MARS2000, DNV Nauticus Hull

ABS Software

DNV Software
Initial Strength & Fatigue Assessment
Guidance for Renewal and Survey at Conversion
Renewable/Allowable Thickness at Conversion Calculation

<table>
<thead>
<tr>
<th>Long Extents (Frame)</th>
<th>Strake</th>
<th>Material Type</th>
<th>Start of Strake Dist. OCL (m)</th>
<th>End of Strake Dist. OCL (m)</th>
<th>As-Built Thickness</th>
<th>FPSO Plate Thickness</th>
<th>Allowable Wastage Percent</th>
<th>FPSO Substantial Thickness</th>
<th>15 Year Anticipated Future Corrosion</th>
<th>15 Year FPSO Renewal Thickness at Conversion</th>
<th>Allowable Diminution at Conversion</th>
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<td>19.00</td>
<td>19.00</td>
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Guidance for Hull Steel Renewal & Inspection (Suspect Areas)
Corrosion Review and Application

Corrosion Survey Summaries

<table>
<thead>
<tr>
<th>Tank Types</th>
<th>Group</th>
<th>Member</th>
<th>Minimum Corrosion (mm)</th>
<th>Maximum Corrosion (mm)</th>
<th>Average Corrosion (mm)</th>
<th>Number of Survey Points</th>
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<td>LBMC Plate</td>
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<td>Inner Skin Plate</td>
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Corrosion Application (Direct Approach)
Hydrodynamic Load Generation

DNV HydroD Software
Hydro Pressure Loads Example

External View of Combined Sea and Tank Pressures on Shell – Still Water Loads Shown
Global FEA Stress Results

Femap & NX Nastran Software
DNV Sestra and STOFAT Software
Global FEA Strength Assessment

Viking’s program, SAGA, does buckling calculations and generates a summary plot for all load cases.
FPSO External Turret Support Structure
Bow cut type – Global Strength Assessment Model
Load cases include ship hydro loads and turret loads
FPSO Turret Support Structure
Local Strength & Fatigue Assessment Models

TSS top plate connection to existing vessel deck

TSS internal longitudinal girders
FPSO Turret Support Structure
Structural Drawing Development – Shipyard & Class

Centerline Profile

Structural Details
LPG FSO Turret Support Structure

Strut Type – Global Strength Assessment Model

Load cases include ship hydro loads and turret loads

Design made to handle ocean loads and turret loads

Global Model: Profile View

Global Model: Below View
LPG FSO Turret Support Structure
Local Strength & Fatigue Assessment Models

TSS Support strut connection to existing vessel bulbous bow

TSS/Turret interface connection details
LPG FSO Turret Support Structure
Structural Drawing Development & BV Class Approval

Centerline Profile

Structural Details
Riser Support Structure Analysis
Upper and Lower RSS Strength & Fatigue Assessments for Spread Moored FPSOs

Global RSS Model

Mesh Refinement
IWO RSS Structure

RSS Strength Assessment Plot
Mooring Support Structural Analysis
MSS Strength & Fatigue Assessment for Spread Moored FPSOs

Global MSS Model

Mesh Refinement IWO
Fairlead Structure

MSS Strength Assessment Plot
Topside Stool Structure Analysis
Stool Strength & Fatigue Assessments

SAGA iterates on entire deck sub-model until slider equilibrium and tracks reactions and deflections.
Contact Information

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