Advanced Structural Design & Engineering Solutions
For Ships and Offshore Structures

Viking Systems International, Inc
Naval Architecture and Marine Engineering

Annapolis | Houston | Singapore | Palm Beach | Tanzania
Oil & Gas (FPSO, FSO, etc)

- 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
• FPSO Hull Structure Conversion and Newbuild Tankers
• Topsides Deck Support
• Turret Support Structures
Military and Defense

- LCS (Austal Trimaran class of Ships)
- JHSV (Class of Ships)
- LCS (Lockheed Monohull)
- FRC (Class of Ships)
- OPC (Class of Ships)
- MLP (Class of Ships)
- LSD-42 (USS Germantown)
- LSD-43 (USS Ft McHenry)
- DDG-67 (USS Cole)
- DDG-60 (USS Paul Hamilton)
- LHD-6 (USS Bonhomme Richard)
- FFG-36 (USS Underwood)
- LPD-18 (USS New Orleans)
- LSD-47 (USS Rushmore)
- DDG-51 (USS Arleigh Burke)
- DDG-52 (USS Barry)

- DDG-53 (USS John Paul Jones)
- DDG-65 (USS Benfold)
- DDG-102 (USS Sampson)
- CG-66 (USS Hue City)
- CD-56 (USS San Jacinto)
- CG-57 (USS Lake Champlain)
- CG-53 (USS Mobile Bay)
- CG-54 (USS Antietam)
- CG-47 Life Extension
- CG-17 (USS Lake Erie)
- CG-71 (USS Cape St. George)
- Indian Navy Patrol Vessel
- Egyptian Navy Patrol Vessel
- US Navy Submarine Rescue Vessel
- Corrosion Modeling of 30+ CG, DDG, LHD, LSD vessels
• Naval and Coastal Patrol Vessels
• Hull and Foundation Structure Design and Optimization
• Monohull, Catamaran and Trimaran hulls
• Motions and Loads, SeaKeeping Analysis
Commercial

- Project America Cruise Vessel (STX)
- SeaAmeria Cruise and Conference Vessel (STX)
- Penn Maritime Barge (Alabama Shipyard)
- Penn Maritime Asphalt Barge (Alabama Shipyard)
- Matson CV2600 Containerships (Aker Philadelphia)
- SeaRiver Tanker (Herbert Engineering)
- NASSCO T-AKE Tankers (Herbert Engineering)
- OSG Maritrans Barges 244 / 252 / 254
- Corn Island Shipyard Asphalt Barge
- Ocean Residences Under Sea Resort Vessel
- Platform Supply Vessel
- Sargeant Marine Asphalt Commander Double Hull Conversion
- VT Halter Marine Barge Projects
- Gunderson Marine Projects

- VARD Projects
- Offshore Supply Vessels
- Work Boats
- Other projects
• Tanker, Container & Bulk
• Barges (Oil, Bulk, Asphalt)
• Cruise Ships and Luxury Yachts
Viking Clients

American Bureau of Shipping (ABS)
BP, Chevron, ConocoPhillips, Petrobras, Shell, Cobalt
Modec, Sofec, Mitsui
Mustang Engineering, Harvest
Sembawang Shipyard (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 Shipyard (BAE), VT Systems
SAGA – Viking System’s In-house Software

Proprietary software calculates all major class requirements within one program to generate output for vessel or structure based upon client and project needs.

Buckling Assessment Model
Global Modeling and Checking
Groups for Loads Application
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
Spectral Fatigue Assessment

Combined Fatigue Damage:
• Past Vessel Fatigue
• Future Wave Fatigue
• Future Loading Fatigue

Transverse Frame Bracket Model

Side Shell Stiffener Model
Initial Strength & Fatigue Assessment
Guidance for Renewal and Survey at Conversion
Renewable/Allowable Thickness at Conversion Calculation

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<th>Stroke</th>
<th>Material Type</th>
<th>Start of Stroke Dist. OCL (m)</th>
<th>End of Stroke 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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Guidance for Hull Steel Renewal & Inspection (Suspect Areas)
Global FEA Strength Assessment

Summary plot image created by Viking Systems’ SAGA program
Hydrodynamic Load Generation

DNV HydroD Software
Hydro Pressure Loads Example

External View of Combined Sea and Tank Pressures on Shell – Still Water Loads Shown
FPSO External Turret Support Structure
Bow cut type – Global Strength Assessment Model
Load cases include ship hydro loads and turret loads
Structural Drawing Development

Centerline Profile

Structural Details
FPSO External Turret Support Structure

FEA model to validate strength and fatigue
LPG FSO External Turret Support Structure

Strut Type – Global Strength Assessment Model – BV Approved

Load cases include ship hydro loads and turret loads

Design made to handle ocean loads and turret loads
Structural Drawing Development

Centerline Profile

Structural Details
LPG FSO Turret Support Structure
Local Strength & Fatigue Assessment Models

TSS support strut connection to existing vessel bulbous bow

TSS/Turret interface connection details
FSO Internal Turret Support Structure
Internal Turret Support Structure
FEA Based Corrosion Processing and Structural Optimization to Minimize Steel Renewal

SAGA – FEA Model Based Corrosion Input

SAGA – Corrosion Processing
Corrosion Assessment

Corrosion map

Areas requiring renewal
Steel Renewal Update

Before Scantling Optimization

- 11600 x 2850 x 21.5 AH
- 15450 x 2850 x 21.5
- 300 x 21.5 AH
- 2000 x 1550 x 21.5 AH

After Scantling Optimization

- 11000 x 3300 x 21.5
- 15450 x 3300 x 21.5 AH
- 15450 x 2800 x 21.5 AH
- 15450 x 3300 x 21.5 AH
- 1000 x 1000 x 21.5
Mooring Support Structures

Mesh Refinement IWO Fairlead Structure
Topside Stool Structure Analyses

Stool Strength & Fatigue Assessments

Global Deck Sub-Model

SAGA iterates on entire deck sub-model until slider equilibrium & tracks reactions and deflections

SAGA Stool Strength Assessment Plot
Riser Support Structure Analyses
Upper & Lower RSS Strength and Fatigue Assessments for Spread-Moored FPSOs

Global RSS Model

RSS Strength Assessment Plot

Mesh Refinement IWO RSS Structure
Mooring Load Verification

Turret and Mooring Layout within OrcaFlex
Chevron Frade FPSO (2012)
Helicopter Platform Evaluation & Analysis

Global Model Deck Structure

Overall Global Model Loading

Deformed Stress Plot – Critical Scenario
Model of A-Frame Foundation & Ship Structure
Pipelay Stinger Analysis

Stinger FEA Model

Transom/Hitch Local Model

Outboard Hitch Model

Inboard Hitch Model
Collision & Blast Studies
Stern A-Frame, Moon Pool, Crane Foundation

Light Condition - Roll RAO - 315 Degree Wave Heading

Period (s)
Ampitude (deg/m)

Analysis Run 1
Analysis Run 2
Structure Feasibility, Arrangement Considerations, Sea State Limitations, FEA Models to Check Deflections and Stress
Combined Thermal Hydro Load

Thermal Load

Wave Induced Vertical Bending

Wave Combined Local FEA Model

Suggest Modifications
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