Bundle Pipeline Systems
& Shell FRAM Development
Iain Watson & Peter Walker

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**Agenda**

- Bundle Technologies
  - Advantages of Bundle Systems
  - Shell Fram FEED
What is a Bundle / Towed Pipeline Solution?

- A Pipeline Bundle is a carrier pipe within which any combination of individual pipelines and umbilical components is carried.
- The individual components terminate in “Towheads” within which manifolding may take place.
- A Towed Pipeline Solution provides a low stress installation method where-by a pipeline bundle is towed and installed using the Controlled Depth Tow Method.
Subsea 7 Installed Bundles

- 65 bundles in 33 years
- Up to 7.6km length
- Up to 28.7km in series
- Up to 320m water depth
- Shallowest 42m
- Longest tow 1000 km
- Up to 49.5” carrier
- Up to 545 te towhead
- Heaviest bundle 9154 te
- Up to 3 PiP flowlines
- U-value <0.7 W/m2K
- 3 Ongoing Projects
Bundle Components

- Flowlines
- Insulation
- Sleeve Pipe
- Control/Chemical Tubes
- Power, Signal, & Data Highway cables
- Main Spacer
- Centraliser – Pipe-in-Pipe Spacer
- Bulkheads
- Ballast Chains
- Anodes
What exactly is a “Pipeline Bundle?”
Typical Bundle Layout

BP Machar

BP Andrew

Kerr McGee Leadon
Materials

Flowline Materials
- Carbon steel - X52, X65, X70 with SS or Alloy Liners
- Corrosion Resistant Alloys - 13% 22% & 25% Cr Steels
- Plastic (HDPE) Liners for Water Injection Lines

Controls
- Hard Pipe Hydraulic and Chemical Systems - 316 SS, 25% Cr Duplex to Carbon Steel
- Electrical & Fibre Optic Control Systems
The Long Trek West

1978

1980
Wester Fabrication Facility
Hastigrow Fabrication Facility
Welding Firing Lines
Inner Bundle Fabrication
Insulation Type

Passive Insulation System

Pipe-in-Pipe System

Indirect Hot Water Heating

Electrical Active/Trace Heating
Production Line Insulation
Applying ITP Izoflex Insulation
Applying ITP Izoflex Insulation
Spot Welding Steel Sheet Over ITP Izoflex
Spot Welding Steel Sheet Over ITP Izoflex
Bundle System Applicability

- Pipe-in-Pipe
- Wet Insulation
- Flexibles
- Bundles - Towed Pipeline Systems

Water Depth (m)

U-Value (W/m²K)
Flow Assurance – Geometry of Pipelines

- The environment within the carrier pipe provides an ideal opportunity for innovative solutions in Flow Assurance.
- The pipelines can be arranged to facilitate heat transfer between product lines or from dedicated heating lines.
- Heat transfer analysis confirmed by experimental results.

Active Heating Systems
- Warm-up before Start-up
- Increase Temperatures for Low Production Rates
- Keep System Temperature High during Shutdowns
- Reduce Chemical Injection

Six Active Heating Systems installed in the North Sea
Hot Water Circulation over distances of 15 km
Electric Heat Transfer
Carrier Sheathing

- 27m lengths welded into 500-1000m trains
- All production operations on line
- Trains sheathed to final location
- Final field joint tie-ins
Towheads
Jura Manifold Beach Landing
Jura Manifold Beach Landing
Bulkheads
Bulkheads
Towhead Tie-In
Bundle Launch

- Structures greater than 500Te
- Tidal currents monitored & tug locations altered accordingly
- Tug bollard pull up to 400Te
- Capstan winch providing holdback tension up to 70Te
- A99 road bridge opens to allow large structures to pass through
Launch
Control Depth Tow Method

- Chains attached at regular intervals along the bundle.
- Ensures accurate weight control to approximately 0.5%.
- Weight of chain links on seabed is submerged weight of bundle.
- Chains can be easily cut by ROV to trim bundle for tow if required.
A data highway runs the length of the bundle and allows acoustic commands made at one end of the bundle to be implemented at the other, for example for valve actuation or acoustic spool metrology.

Towmaster’s real-time display of bundle shape and water depth.
What We Can Do

- Field Concept Development, FEED Studies
- Tender Engineering
- Detailed Design & Fabrication
- Launch, Tow & Installation Analysis
- Dynamic & Fatigue Analysis
- Failure Investigation Support
- Regional Support (Bundles), Norway & Asia Pacific
**Agenda**

- Bundle Technologies
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- Shell Fram Bundle FEED
Why Bundles? - Advantages

- Eliminate the requirement for heavy lift vessels by incorporating Subsea Structures within a Towed Production System (Maximum to date 545te).
- Testing and commissioning of complete system onshore therefore reducing offshore time: - Hydro testing, dewatering, drying, control fluid flushing, valve operations etc.
- Fast hook up and commissioning for early first oil dates.
- Installation under existing or temporary floating assets.
- Reduced number of subsea tie-ins and spool installations.
- Seabed stability using Gravity Based or Piled design.
- Protection incorporated in structure design.
- Improved Flow Assurance / thermal Management (Heated – Hot Water, Trace Heating).
- Leak mitigation in case of internal flowline failure (maintain leaked oil within Carrier Annulus) - Flowline safety class can be reduced when using DNV-OS-F101 Design Code.
- Use of CRA Lined pipe in place of Clad pipe or solid CRA pipe.
- High Temperature Flowline Design (up to 160°C currently).
- Turn out cost more predictable (reduced exposure to weather/soils risk).
Agenda

Bundle Technologies
Advantages of Bundle Systems
Shell Fram Bundle FEED
Fram Field Location
Fram Field Location
Fram Infield Layout
Fram FPSO Approaches (Xodus)
Fram Drill Centre East Towhead & Well Tie-ins (Xodus)
Fram Drill Centre West Towhead & Well Tie-ins (Xodus)
Fram Bundle FEED - Principal Design Assumptions

Principal Design Data / Assumptions for Fram FEED:

• 8 Slot towhead manifold at DCE (5 wells initially).
• 6 Slot towhead manifold at DCW (3 wells initially).
• 2 midline SSIV structures required at FPSO (out with swing circle).
• 14” NB Gas Export SSIV located in Midline Towhead (East).
• Shared services between drill centres (single test riser, gas lift riser & riser umbilical).
• Mixture of Oil & Gas Wells at both drill centres.
• 345 Barg Design Pressure / 110°C Design Temperature (Production/Test).
• Max CO2 content ~1.1 mol.% in produced fluids.
• Max. H2S ~6 ppmv in produced fluids.
• ~47,000 mg/l Chlorides in produced water.
• Water depth infield ~ 95 m (wrt LAT).
• 20 year system design life
Fram Bundle Cross Section Designs

DCE & DCW Bundle Cross Sections

<table>
<thead>
<tr>
<th>PRIMARY BUNDLE COMPONENTS</th>
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<th>BUNDLE SPACERS/CENTRALISERS</th>
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<td>BUNDLE MAIN SPACERS</td>
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<td>BUNDLE INTERMEDIATE SPACERS</td>
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<td>SLEEVE PIPE CENTRALISERS (PRODUCTION)</td>
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<td>SLEEVE PIPE CENTRALISERS (TEST)</td>
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Fram Bundle Cross Section Designs

Midline Bundle Cross Section (Shared Services)
Fram Bundle Cross Section Designs

Pipe-in-pipe Insulation System Performance (both options)

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<th>OPTION 1 – CONVENTIONAL PIP INSULATION (NANOGEL BLANKETS)</th>
<th>OPTION 2 – ITP PIP INSULATION (IZOFLEX INSULATION &amp; PARTIAL VACCUUM)</th>
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<tr>
<td><strong>FLOWLINE</strong></td>
<td><strong>FLOWLINE DIAMETER</strong></td>
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<td>Test</td>
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Fram Bundle Production & Test Line Linepipe Design

CRA Lined Pipe (Butting) – Mechanically Bonded (BuBi)

The Mechanically bonded Butting Bimetal Pipe (BuBi Linepipe)
Fram Bundle - DCW Towhead (General Assembly)
Fram Bundle - Midline Structure East (GA)
Fram Bundle - Midline Structure West (GA)
Bundle Launch at Subsea 7’s Wester Site
Bundle Tow Route
Bundle Tow Configuration

[Diagram of Bundle Tow Configuration with labels for TRAILING TUG, GUIDED VESSEL, LEADING TUGS, TOW FISH ACOUTIC LINK, BUNDLE, MIDLINE STRUCTURES, and ELEVATION.]
Bundle Tow Route
Control Depth Tow Method

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Questions?
seabed-to-surface

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