People and Partnerships Delivering a World-Scale Field Development

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June 25, 2009
Agbami Field Overview

- 965+ MM bbl reserves
- 47° API (sweet crude)
- +/- 4,800-ft water depth
10 Years from Discovery to Production

- 1993
  OPL 216 license award

- 1998
  Agbami #1 discovery well

- 1999 – 2004
  Appraisal drilling
  Front-end engineering

- 2004 – December
  First Nigeria Deepwater Unit agreement
  FPSO contract award

- 2007 – October
  FPSO sailaway

- 2008 – July
  First oil production

- 2008 – October
  Gas injection

- 2009 +
  Development drilling continues

Concessionaires
- Nigerian National Petroleum Corporation
- Famfa Oil Limited

Agbami Unit Operator
- Star Deep Water Petroleum Limited
  (an affiliate of Chevron Corporation)

Other Funding Participants
- Statoil Nigeria Limited
- Petróleo Brasileiro Nigeria Limited
- Texaco Nigeria Outer Shelf Inc. (an affiliate of Chevron Corporation)
Field Development Plan

- Floating production storage and offloading vessel (FPSO)
- Flexible risers
- 38 subsea wells
- Crestal gas injection and peripheral water injection
- Offloading buoy with U-shaped pipeline
Agbami Field Size (If in Houston)
Agbami Contractor Locations

- Kongsberg
- Moss
- Paris
- Le Trait
- Newcastle
- Monaco
- Okpo
- UAE
- Nigeria
- Agbami Field
- Houston
- Brazil
- AGBAMI FIELD
- Newcastl
Critical Success Factors

• Establishing a worldwide Incident- and Injury-Free® culture
• Achieving schedule benchmarks
• Setting new standards in Nigerian content
• Maintaining high production reliability
• Managing a challenging cost environment
Creating an Incident- and Injury-Free Culture

• Agbami was delivered safely; however, every injury was clearly preventable: Five days away from work (DAFW) injuries in 18 million work-hours

• Commitment and belief in working injury- and incident-free across the global Agbami team

• Creative approaches to safety procedures and practices
Delivering a New Standard in Nigerian Content

- Strategic objective embraced by all project participants
- 10,000 tons fabricated in Nigeria
- 3 million work-hours with zero DAFW injuries
- 300,000 FPSO Nigerian engineering work-hours
- 100+ Nigerian engineers trained worldwide
Nigerian Content Successfully Delivered
Drilling Program: Decades of Commitment

Field level: 2 separation trains, complex network of 8 sub-sea manifolds & risers (prod/inj)
At the reservoir level, multiple lobes within the same reservoir
At the well level, 2 valves for zonal control plus a number of measurement devices- (6) P,T,Q

Drilling = ~ 50% of total project investment

• Stage 1
  – 22 wells to reach plateau production

• Stages 2 & 3
  – 16 wells to extend plateau and increase water and gas injection
Agbami Subsea System

Subsea Highlights

• One of the largest flexible subsea systems
• Design conditions pushing technology limits
• Interface design challenges led to construction success
• Marine vessel breakdowns required creative contingency planning
Agbami FPSO

AGBAMI Production Capacity
Total Liquids (B/D) 450,000
Oil Rate (BOPD) 250,000
Produced Gas (MMscf/D) 450
Injection Gas (MMscf/D) 415
Gas Lift (MMscf/D) 50
Produced Water (BWPD) 250,000
Water Injection (BWPD) 450,000

FPSO Particulars
New build construction
20-year life in field
2.15 MM bbl storage capacity
Offloading 45,000 bbl/hr
1.0 MM bbl approximately every four days
Dimensions 317 m × 58 m × 32 m
Displacement 404,811 t
Accommodations 153 POB
Offshore Hookup and Commissioning

Offshore Highlights

• Offshore work-hours greater than planned
• Interface management success
• No major technical problems
Startup Reliability
Higher Than Forecast

- Excellent teamwork between commissioning and operations
- Phased startup of nearly 100 systems:
  - January 2008 – FPSO Arrival
  - July 2008 – First Oil
  - October 2008 – Gas Injection
  - February 2009 – Water Injection
- Production ramp up continues through 2009
Subsea Design, Installation and Lessons Learned
Base Case Concept

Water Injection System (Blue)

Infield Umbilicals

Main Umbilical

Production System (Red)

Gas Injection System (Green)

Piggy-Back Production System (Red)

Piggy-Back Drill Center

Drill Center
Subsea Equipment – SEV Scope

- 5x2 – 10 ksi Horizontal Trees (17 Production, 9 Water Injection & 6 Gas Injection)
- 4 Slot Manifolds (Suction Pile Mounted)
- MUX Controls (Top Sides & Subsea)
- Flowline & Jumper Connectors
- Electrical & Hydraulic Flying Leads
- IWOCS & Tooling
Loading Trees onto Installation Vessel – Onne Port
Tree On Wellhead
5 Subsea Lessons Learned spanning a wide range of topics

1. Retrievable Flowmeter Issues
2. Flexible Flowline & Jumper Kits
3. Flow Assurance & Insulation
4. Cathodic Protection of Trees
5. Tree Installation
Lesson #1: Retrievable Flowmeter issues

**Flowmeter with ROV retrievable instrumentation**

– **Issue:** Unexpectedly complex, expensive, long-lead ROV tooling.
Lesson #1: Retrievable Flowmeter issues

*Flowmeter with ROV retrievable instrumentation*

– **Issue**: Unexpectedly complex, expensive, long-lead ROV tooling.

Ensure all parties understand scope of Company-required items prior to award.
Lesson #2: Interface Definition in FEED Direct Connect Flowlines

- **Cross-Contract Situation:**
  - *FMC to provide Flowline & Jumper end Kits*
  - *Installation contractor to provide Flexible flowlines / Jumpers and installation responsibility*

- **Issue:** Installation engineering details arriving late in fabrication program

- **Analysis:**
  - 2\textsuperscript{nd} End Flexible Flowline Connectors have integral padeyes resulting in one-piece elbow/padeye forging
  - Swivels required for all Jumpers and Flowlines 2\textsuperscript{nd} end connections.
Lesson #2:
Interface Definition in FEED
Direct Connect Flowlines

– Cross-Contract Situation:
  • FMC to provide Flowline & Jumper end Kits
  • SIC to provide Flexible flowlines / Jumpers and installation responsibility

– Issue: Installation engineering details arriving late in fabrication program

– Analysis:
  • 2nd End Flexible Flowline & Jumpers have integral padeyes resulting in one-piece elbow/padeye forging
  • Additional swivels required for all Jumpers and Flowlines

Early, continuing communication between contractors to identify and avoid costly and time consuming interface clashes.
Lesson #3: Flow assurance and Insulation

- *Ten Hour target cool-down period specified, 2” thick insulation calculated for trees.*
  - **Issue:** More conservative assumptions were introduced late.
  - **Result:** Insulation thickness increased to 3” and less aggressive cool-down period of 7 hrs agreed.
Lesson #3: Flow assurance and Insulation

- Ten Hour target cool-down period specified, normally require 2” thick insulation for trees.
  - Issue: More conservative assumptions were introduced late.
  - Result: Insulation thickness increased to 3” and less aggressive cool-down period of 7 hrs agreed.

Assumptions for thermal analysis should be agreed in early phase to avoid potential delays and costs.
Lesson #4: Cathodic Protection – Trees

- **Insufficient Cathodic protection on trees**
  - **Issue:** Calculations for cathodic protection of trees initially did not include for subsea well.
  - **Solution:**
    - Additional anodes added in-country to several trees already shipped, as well as all trees still in Houston.
    - FMC determined tree funnel could be removed in-country, anodes welded to funnel & re-attached.
Lesson #4:
Cathodic Protection – Trees

- *Cathodic risk to sensitive tree sensors*

- **Issue:** Initial calculations for cathodic protection of trees initially did not include for subsea well.

- **Solution:**
  - Additional anodes added in-country to several trees already shipped, as well as all trees still in Houston.
  - FMC determined tree funnel could be removed in-country, anodes welded to funnel & re-attached.

**Assumptions for cathodic protection analysis agreed in early project phase to avoid potential delays and costs.**
Lesson #5: Tree Installation

• **Planned Tree deployment from A-frame from edge of drilling rig.**
  
  – **Issue:** Concerns raised as to safety on rig and offshore transfer of trees to rig.
  
  – **Better solution:** Trees loaded out onto surface support vessel and installed from same vessel offshore from wire rope.
Lesson #5: Tree Installation

• **Planned Tree deployment from A-frame from edge of drilling rig.**
  – **Issue:** Concerns raised as to safety on rig and offshore transfer of trees to rig.
  – **Better solution:** Trees loaded out onto surface support vessel and installed from same vessel offshore from wire rope.

Careful consideration of safety issues in conjunction with alternatives can save costs as well as lowering risks!
Thank You!