Research for Ultra-Deepwater Production

Opening Seminar
Marintek do Brasil
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Petrobras Investment Plan

PN 2007-11
US$ 87,1 bilhões

- E&P: 56%
- Refining & Transport: 49,3%
- Gas & Energy: 23,0%
- Petrochemical: 7,5%
- Distribution: 3,3%
- Corporate: 26%

US$ 87,1 bilhões
Oil + LNG Production and Support Projects

- Albacora Leste P-50 180,000 bpd
- Rio de janeiro Espadarte Módulo II 100,000 bpd
- FPSO Capixaba Golfinho Módulo I 100,000 bpd
- ESS-130 Golfinho Mód. III (FPSO) 100,000 bpd
- Parque das Conchas 100,000 bpd
- Roncador P-52 180,000 bpd
- Frade 100,000 bpd
- Roncador P-54 180,000 bpd
- Marlim Sul Módulo II P-51 180,000 bpd
- Marlim Leste P-53 180,000 bpd
- Jubarte Fase 2 P-57 180,000 bpd
- Cidade de Vitória Golfinho Mod. II 100,000 bpd
- Piranema 20,000 bpd
- Jubarte Fase 1 P-34 60,000 bpd
R&D Investment

R$ Millions (Base 2005)

2001: 499
2002: 598
2003: 662
2004: 730
2005: 916
2006: 1,420
R&D Center – CENPES

- R&D Exploration
- R&D Production
- R&D Refining
- R&D Gas Energy & Sustainable Dev.
- Basic Engineering
- Technology Management

✓ 12 Technological Programs
✓ 1000 R&D Projects
✓ 50 Basic Engineering Projects
✓ 500 Production R&D Projects
✓ 4000 People

✓ Present area: 122,000 m²
  ✓ 137 labs
  ✓ 30 pilot units
✓ New Construction: 180,000 m²

Present area: 122,000 m²
137 labs
30 pilot units
New Construction: 180,000 m²
Technological Challenges

• **Ultra-Deep Water**
  – Risers and Pipelines
  – Mooring Systems
  – HPHT Wells and Equipment
  – Flow Assurance
  – Subsea Boosting and Processing
Production and Reserves vs. Water Depth

2005 Production
- 1.958.000 boed
  - Onshore: 60%
  - Offshore (0-300m): 19%
  - Offshore (300-1500m): 16%
  - Offshore (> 1500m): 5%

2005 Proven Reserves (SPE)
- 13,23 billion boe
  - Onshore: 25%
  - Offshore (0-300m): 10%
  - Offshore (300-1500m): 10%
  - Offshore (> 1500m): 55%

Exploratory Area
- 160,500 km²
  - Offshore (0-300m): 26%
  - Offshore (300-1500m): 24%
  - Offshore (> 1500m): 38%
  - Onshore: 12%
<table>
<thead>
<tr>
<th>Year Range</th>
<th>Description</th>
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<tbody>
<tr>
<td>1986 – 1991</td>
<td>Marlim and Albacora Production Technological Support</td>
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<tr>
<td>1,000m (3,300ft)</td>
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<tr>
<td>1992 - 1999</td>
<td>Roncador and Marlim Sul Production Technological Support</td>
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<tr>
<td>2,000m (6,600ft)</td>
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</tr>
<tr>
<td>3,000m (10,000ft)</td>
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</table>
PETROBRAS Activity

Completion Records

Installed Equipment

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Wet Trees</td>
<td>548</td>
<td>106</td>
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<tr>
<td>Subsea Manifolds</td>
<td>58</td>
<td>02</td>
</tr>
<tr>
<td>Subsea Flexible Lines (Km)</td>
<td>2.534</td>
<td>765</td>
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<tr>
<td>Umbilicals (Km)</td>
<td>2.229</td>
<td>622</td>
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<tr>
<td>Rigid Lines (Km)</td>
<td>1.964</td>
<td>305</td>
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</table>
PROCAP-3000 Main Areas

- Drilling and Completion
- Subsea Equipment
- Artificial Lift and Boosting
- Flow Assurance
- Riser and Flowline Systems
- Floating Units and Anchor Systems
- Environmental Database
**Drilling Equipment for Deepwater**
- Torpedo Wellhead
- Slender Wellhead
- Casing Drilling
- Surface Drilling BOP System

**Deep Horizon Drilling**
- HPHT Drilling and Completion
- Hard Formation Drilling Optimization
Deepwater
- Problem: narrow margin between pore and fracture pressures
- Theoretical Solution: Dual Gradient Drilling
- Many Practical Alternatives

Light Fluids
Gas-Lifted Riser

Hydrostatic Pressure (psi)

Equivalent Mud Weight (ppg)

Depth (m)

Mud SG 11 ppg

Mud DG 14 ppg
Torpedo Wellhead
PROCAP-3000
Artificial Lift and Boosting

Boosting Systems for Deepwater
► ESP for Subsea Well - BCSS
► Subsea Multiphase Pumping – SBMS
► Gas/Liquid Separation System – VASPS

Gas Lift for Deepwater Subsea Wells
Performance Tests
SBMS-500

► Benefit: production increase
► Performance and endurance tests concluded at Núcleo Experimental Eng. Baruzzi
► Modules under final assembly for installation at Marlim field (Oct 07)
Marimbá Pilot (P-8)
Production increase: from 4,700 to 6,300 bopd
Gas lift stopped
WD: 400 m
Phase 1: Jul/2001 to Dec/2001
Phase 2: May/2004 on
New R&D project to increase flow capacity, decrease CAPEX and installation costs
Wax and Hydrate Control
- Multisize Pig Development
- Wax Deposit Prediction
- Hydrate Blockage in na Emulsion System
- Wax Deposit in Condensate System
Subsea Equipment for 3,000m de WD

- Horizontal Tree for ESP Wells with ROV Tree Cap
- Equipment Installation by Cable
- Completion Riser for 3,000 m
- Test Xmas Tree with ESP in the Riser
- Deepstar phase VIII
BCSS Horizontal Tree for 2,500 m WD

- Benefit: short intervention time for pump changes
- Prototype installed at JUB-6 well on Dec 2005
Equipment Installation by Cable

Gas Lift Manifold for Roncador

- Installation Procedures
- System Modeling
- Hydrodynamic Analysis
- Installation Monitoring

- Cable Installation – pioneer
- WD 1.886m – world record (Manifold)
- 190 ton
Pendular Method

- No use of critical resources for equipment up to 270 ton

- Tests done in small scale (1:35) and with field scale model (1:1)

- Roncador Gas Lift Manifold installed (Dez 06)
Subsea Separation of Oil/Water SSAO

- Separation and reinjection of the separated water
- Aiming topside facilities debottlenecking
PROCAP-3000 Risers and Flowlines

- Rigid Riser System
  - SCR for FPSO and SS
  - SCR in “Lazy Wave”

- Flexible Riser System
  - Sour service lines
  - Integrated umbilical control-power

- Alternative Riser Systems
  - Tethered Riser Buoy
  - Self Standing Hybrid Riser RHAS
Tethered Riser Buoy
Benefit: Big diameter riser for deepwater and load reduction on the floating unit

FEED, Contract and Patent documents issued
SCRs for Roncador

Project P-52 - Roncador
Module 2, phase 1A

- Limits for the SS movements
- Optimized definition of the risers hanging points
- SCR viability
- Thermal Insulation thickness limits definition
- Maximum loads in support, pull-in and anchor systems

- Semi-Submersible 80,000 tons
- WD 1,800m
- 68 risers, being 47 SCRs and 21 control lines
Benefit: Low movement units allow deepwater risers
- FPSO-BR
- Mono-BR
► Hydrodynamic coupled movement analysis of the unit, risers and anchoring system
► Universities – USP, IPT, UFRJ, UFAL, PUC-RIO
Polyester Anchoring Systems

Applications of synthetic polyester

- 4 SS (P-19, P-26, P-27 e P-40)
- 6 FPSOs
  P-34, FPSO II, P-47, Avaré,
  P-38 e FPSO Brasil
- 2 Monobuoys
  IMO 1 and IMO 3
- Total Installed: 175km in 161 lines
Torpedo Anchors and Polyester Cables for Albacora Leste
Gathering and Treatment of Geological, Geotechnical and Oceanographic Data

- Benefit: support of production development projects (drilling, anchoring, flowlines, etc.)
Thank you