PETROBRAS Deepwater Gas Lift Project
(an overview)

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Objective

- Search for products that will optimize gas lift process in high pressure and high flow rate deepwater subsea wells

- The Deepwater Gas Lift Project is part of a major PETROBRAS Technological Program
  - PROCAP 3000 -

Deepwater Gas Lift Project Schedule:

Phase I: Feb, 1999 to Feb, 2005
Phase II: Mar, 2005 to Jul, 2006
PHASE I: AREAS OF INTEREST

1 – Scenario Studies
2 – Gas Lift Equipment Development
3 – Gas Lift Software Development
4 – Gas Lift Automation
Production Methods – Campos Basin

Number of Wells

- 104 wells, 22% flowing
- 70 wells, 15% continuous GL
- 295 wells, 63% ESP

Legend:
- FLOWING
- CONTINUOUS GL
- ESP
Production Methods – Campos Basin

Flow Rate

- Flowing: 59%
- Continuous GL: 36%
- ESP: 5%

Legend:
- FLOWING
- CONTINUOUS GL
- ESP
Focus in Campos Basin Fields:

1 – Roncador

2 – South Marlim
SCENARIO STUDIES

Main Oilfield Data:

**Datum:** -2500 to -3200 m

**Water Depth:** 1000 to 3000 m

**Well to Platform distance:** 1.5 to 12 km (1 to 7.5 mi)

**Oil Specific Gravity:** 12 to 30 °API

**Bottom Hole Pressure:** 250 to 290 bar (3600 to 4200 psi)

**Productivity Index:** 10 to 100 m³/d/bar (4.5 to 45 bpd/psi)

**Formation GOR:** 50 to 75 m³/m³ (280 to 420 scf/bbl)
Points to inject lift gas

1 - downhole
2 - at the Subsea Well Head
3 - at riser base
Where is the best GL injection point?

Depends on BHP, Flow Line Length, PI, ....

-EXAMPLE-

Water Depth / Datum

Liquid Flowrate (m³/d)

WD = 1500 m  WD = 2000 m
Reservoir Datum = 2500 m
What is the best type of operating valve?

Venturi  X  Orifice Gas Lift Valves

![Graph showing oil flowrate increase (%)](image-url)

Wells

Oil Flowrate Increase (%)
What is the best type of IPO GL valve?

High Pressure X Conventional IPO Valves

Oil Flowrate Increase (%)

Poços
Advantages of Subsea Injection Gas Points

Operational flexibility:

- Reduce the number of GL valves
- Prevent instabilities and severe slug
- Easy way to start up the well

Single point injection in ultradeep wells
EQUIPMENT DEVELOPMENT

- New GL valves
  - Venturi
  - High pressure IPO
  - Normally Open Valve
  - Electric GL valve

PETROBRAS Gas Lift Valve Test Site (Aracaju-SE)

Dynamic Performance and Endurance Tests
Development of New Gas Lift Valves

- Venturi type valves

- Intensively bench and field tested by Petrobras
- Standard valve in Petrobras deepwater wells
- Petrobras patented valve is being manufactured in Brasil
Venturi Valves Performance

Gas Flowrate (m³/d) vs. Downstream Pressure (psig)

- Petrobras Valve
- Manufacturer Valve

Venturi Gas Lift Valve 1 1/2"
Development of New Gas Lift Valves

- 3000 psi Gas Lift Valve
  - Developed under a Cooperation Agreement
  - Allows deeper operation injection point
  - Bench tested
  - Field test: one valve is operating in Albacora field since July, 2003
High Pressure Bellows Valve Performance

C-R20H-16Tg-SSG12030-2000

VAZÃO (Nm³/d) vs. PT-M2 (psig)

Nível 1
Nível 2
Nível 3
Nível 4
Nível 5
Development of New Gas Lift Valves

- **Electric Gas Lift Valve**
  - Petrobras was a member of a JIP with other operators and one manufacturer
  - Field tested in the USA (Simpson Field, Indiana) in 2001
  - High cost => not attractive for standard applications
- Normally Open Gas Lift Valve
  - opens with low injection casing pressure
  - closes with high injection casing pressure
  - failed in field test in Campos Basin in 2001 (Cherne field)
  - endurance tests in Atalaia Test Site in 2004 showed a need for further improvement
  - Application scenario:
    • as an operating valve (dual compression sites)
    • as a kickoff valve
Development of New Gas Lift Valves

Normally Open Gas Lift Valve

Problems detected
PETROBRAS GAS LIFT TEST SITE

PERFORMANCE TESTS
PETROBRAS GAS LIFT TEST SITE

ENDURANCE TESTS
Software Development
Steady State Software

MARLIM

(Multiphase and Artificial Lift Modelling)

- In-house and continuous development
- Accurate Pressure and Temperature profiles prediction in multiphase flow
- Used to design and troubleshooting analysis
- Includes dynamic performance of GL valves
Temperature Profiles Comparison

Test 03/01/1999
Marlim
Simulator A
Simulator B

Temperature (C) vs Depth (m)

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Transient Softwares

- Calculate transient temperature and pressure profiles (production and annular systems) in multiphase flow
- Useful for kickoff and design analysis with natural gas or nitrogen injection and including coiltubing if necessary
- Dynamic Performance of GL valves and chokes are included

Two softwares are being developed by Petrobras:
- FLOWLIFT – with external consultant
- TRACELIFT – specific presentation will be made at GL workshop
Transient Software

- System geometry

- Fluids:
  - oil + formation water
  - Formation gas
  - Natural gas as *lift gas*
  - Nitrogen as *lift gas*
  - Completion fluid during kickoff
Flowlift - Example

Diagram showing the flow rate of gas for Valve 1 and Valve 2 over time, with peaks indicating changes in flow.
Automation and Phase II of the Project
Goals:

- Optimization and automation of gas allocation per well
- Automatic instabilities control

- Specific presentation on the subject in this Workshop
A low cost alternative for automation without depending on well intervention

The optimum injection point may be inferred from the surface temperature

Temperature is proportional to the flow rate (simulation results)

Keep GL optimized all the time

- Surface temperature
- X-tree temperature
- Liquid flow rate
GL Automation by Temperature

Delay analysis chart

Flow rate [m³/h]

Temperature [°C]

Time

voleo

toleo
SUPERVISORY INFORMATION
PHASE II: AREAS OF INTEREST

- Gas Lift Riser Base Injection
- Erosional Velocity – Bench Tests in Atalaia
- New Venturi Developments