2024 GAS LIFT WORKSHOP

Application of Shear Gas Lift Valves in the Pre-Salt Buzios Field

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Goal

To give an overview of the procedure adopted by Petrobras to determine an adequate range of shear-out pressure for the annulus activated gas lift valves in Buzios.

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Agenda

- Motivation: history of failure in gas lift valves
- Gas lift scenario in Buzios
- Design concept of shear gas lift valves
- Technical criteria for determining the shear-out pressure
- Procedure for determining the shear-out pressure in Buzios
- Results
- Final remarks

Motivation

- Over 25 cases of **failure in gas lift valves**, since the beginning of pre-salt oil production
- **Symptom**: unwanted flow from tubing to annulus, in the early production stage, before gas lift injection had been initiated in the well
  - High GOR in pre-salt: wells only need artificial lift in specific situations, years after oil production starts
  - Detailed analysis of 6 valves: on average, **663 days** from installation to failure detection

Motivation

- Possible **causes**:
  - Transient effects, opening the check valve
  - Inefficient seal at low pressure differentials
  - Scale deposition (inefficiency of chemical injection system) in some, but not in all, cases
  - Debris

O-ring in undesired position, hindering dart from sealing

Check valve

Nozzle

Venturi

Scale deposition had completelly blocked the component

Motivation

- **Consequences**:
  - **Well integrity** problem: well barriers were compromised
  - At least 14 cases (67% of all cases) have required a rig intervention to replace the damaged valve: significant **cost** increase and production loss
  - Cost per intervention ≈ 60 gas lift valves

- **Possible solutions**:
  - Dummy valves: rig intervention if gas lift injection is needed (additional **cost**)
  - **Shear gas lift valves**

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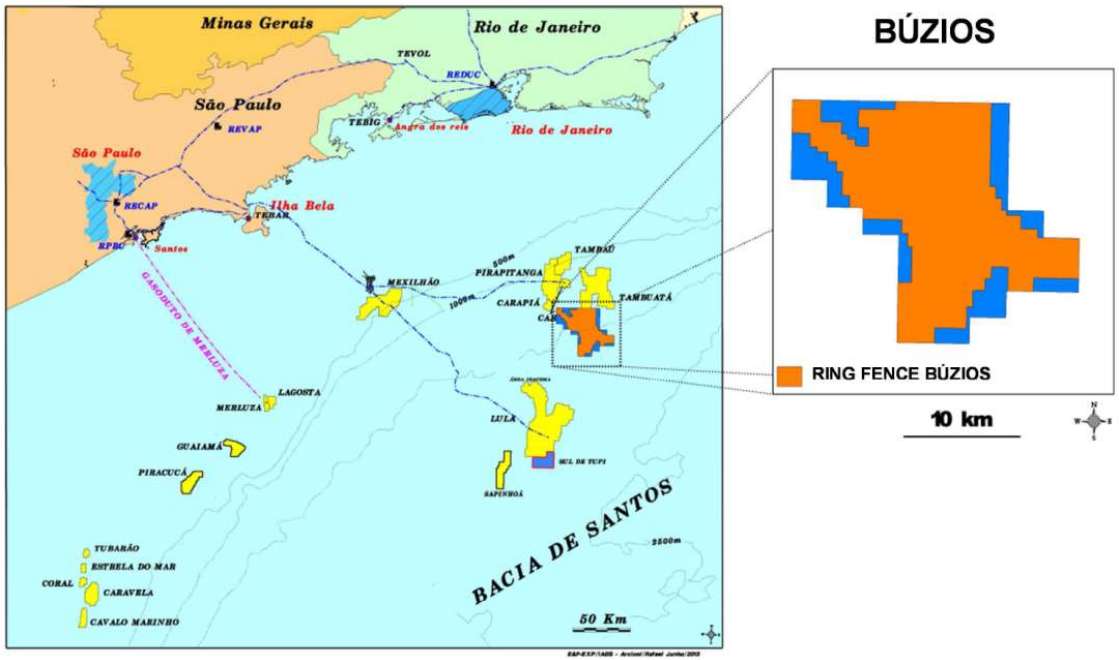
Gas lift scenario in Buzios



Santos Basin, 180 km from the coast of Rio de Janeiro

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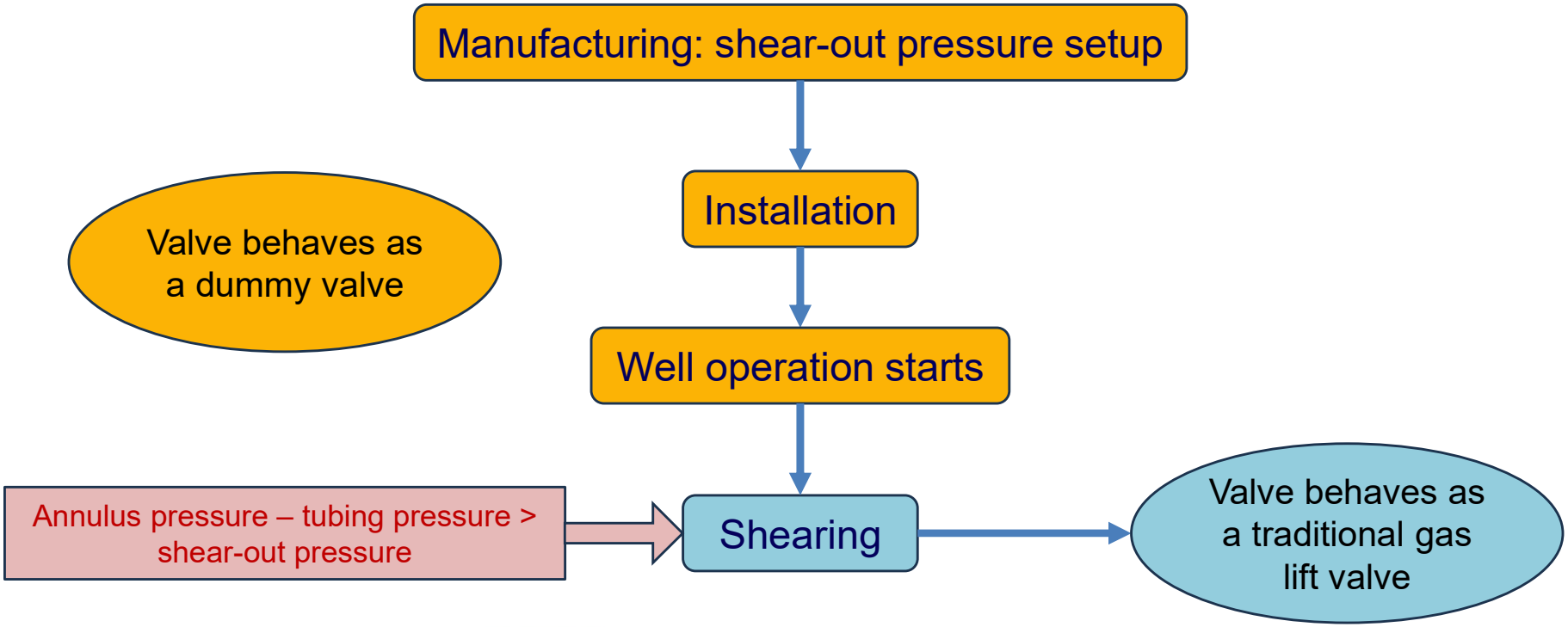
Gas lift scenario in Buzios

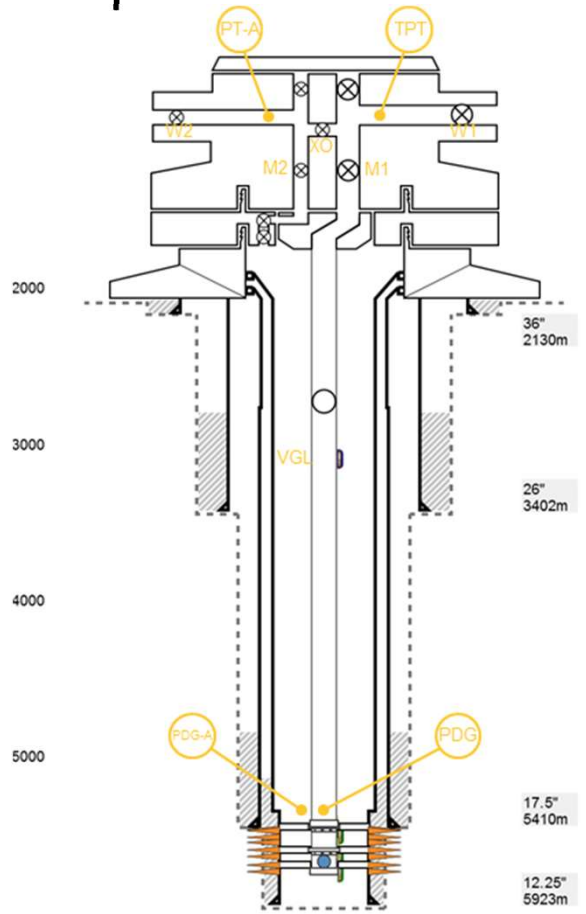
- High GOR and WAG injection: wells only **need** artificial lift in specific situations (high water cut combined with low GOR and depletion), which should only occur **5 to 10 years** after oil production starts
- Gas lift is typically **desired** to optimize production (water cut > 60%)
- Occasionally, gas lift is **needed** for stability reasons: intermittence due to geometry, difficulty to restart production after shut-downs
- One Venturi gas lift valve per well
- Intelligent completion in 3 zones, with one chemical injection point per zone

Design concept of shear gas lift valves



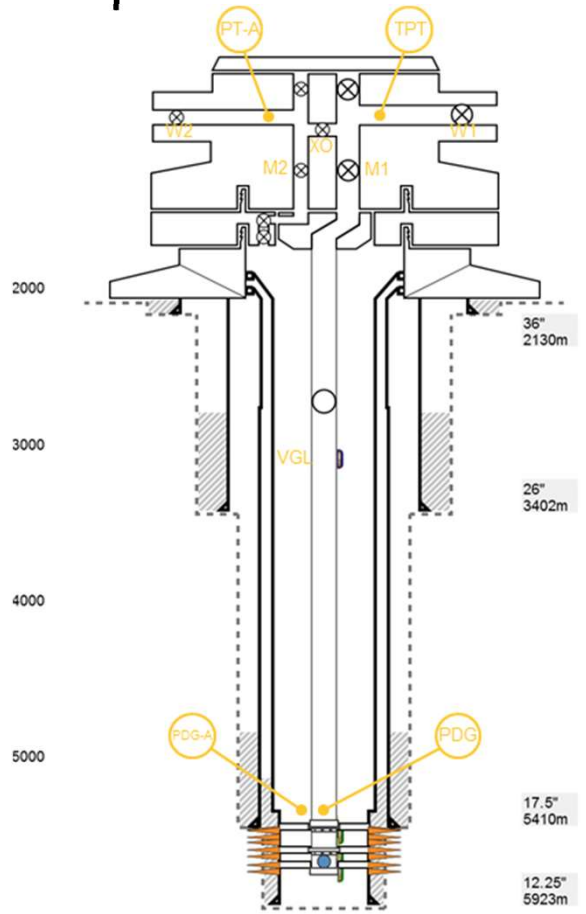
Technical criteria for determining the shear-out pressure

1) Avoid premature shearing
   - Low pressure inside the tubing
   - High pressure inside the annulus: heating of confined fluids (Annulus Pressure Buildup – APB), leaks in control lines



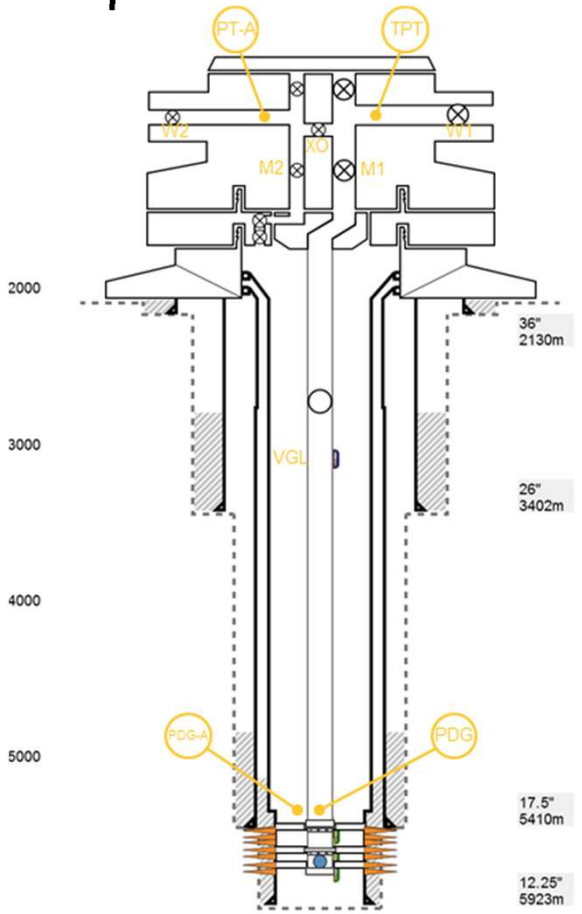
Technical criteria for determining the shear-out pressure

2) Ensure that shearing will occur when needed
   - Shearing during shut-in is desirable
   - Shearing during production must be feasible
   - Maximum available pressure to perform shearing
   - Fluid densities: gas lift/service line, chemical injection line, annulus (completion fluid)
   - Installation depth of the gas lift valve



Technical criteria for determining the shear-out pressure

3) Protect the well against structural failure
   - Shearing must occur passively with a smaller differential pressure between annulus and tubing than the failure of completion equipment, even when the expansion of confined fluids due to heating is significant
   - Fuse/circuit breaker: additional layer of protection
4) Standardization



Technical criteria for determining the shear-out pressure

- Safety margins:
  - ±10% admissible error in shear-out pressure set up
  - During well operation, keep ($P_{annulus} - P_{tubing}$) < 70% of shear-out pressure set up, to avoid premature shearing
  - Shearing must occur when ($P_{annulus} - P_{tubing}$) = 70% of the differential pressure that results in collapse of the tubing

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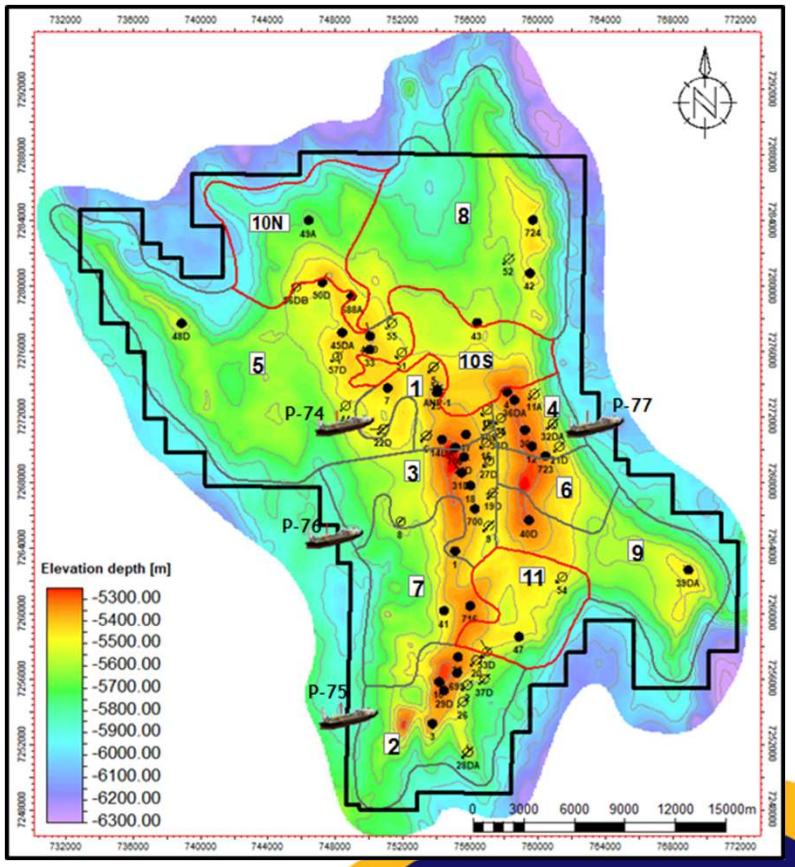
Procedure for determining the shear-out pressure in Buzios



Reservoir temperature increases

- Completion of new wells in modules 6-11
- Homogeneous reservoir: high connectivity, same fluid
- At least one representative well per module
- Special cases: data acquisition/exploratory wells
- 5 wells

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Procedure for determining the shear-out pressure in Buzios

- Production curve per well:
  - Maximum and minimum pressures inside the tubing
  - From the moment production starts until gas lift injection starts
  - Pressure and temperature profiles for each selected case (steady-state)

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Procedure for determining the shear-out pressure in Buzios

- Selected cases (for each well):
  - First oil
  - Maximum and minimum oil flow rate
  - Maximum and minimum water flow rate
  - Maximum and minimum liquid flow rate
  - Maximum restriction at topside
  - Maximum and minimum GLR
  - Maximum and minimum BHP
  - Injection of gas lift starts

Group A

- Selected cases (for the field):
  - Maximum oil flow rate
  - Maximum water flow rate
  - Maximum gas flow rate
  - Minimum BHP

Group B

Structural analysis

Results

- Designing for Group A or Group B gave us very similar results
- Designing for wells from different production modules of the Buzios field gave us very similar results
- The scenario with the highest temperature was the most critical for the structural analysis
- Depending on the well, the range of possible values for the shear-out pressure set up could be as wide as 2500 – 4500 psi
- Standard shear-out pressure set up: ($P_{annulus} – P_{tubing}$) = **3500 psi**

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Final remarks

- Safety requirements from the risk assessment analysis:
  - Alleviate pressure from annulus (to gas lift/service line or to production line) when production first starts, to prevent premature shearing
  - Constant monitoring of annulus pressure during well production
- First 3 valves already installed in 2024, with production starting in 2025
- Designing for a well from one of the first production modules of the Buzios field that would suffer a light workover intervention gave us a different result:
  - N_2 instead of completion fluid inside the annulus
  - Shear-out pressure set up: ($P_{annulus} – P_{tubing}$) = **3000 psi**

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Question Time

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