# Deepwater Reverse Circulation Primary Cementing

10121-4502-01
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RPSEA Ultra-Deepwater Drilling, Completions, and Interventions TAC Meeting
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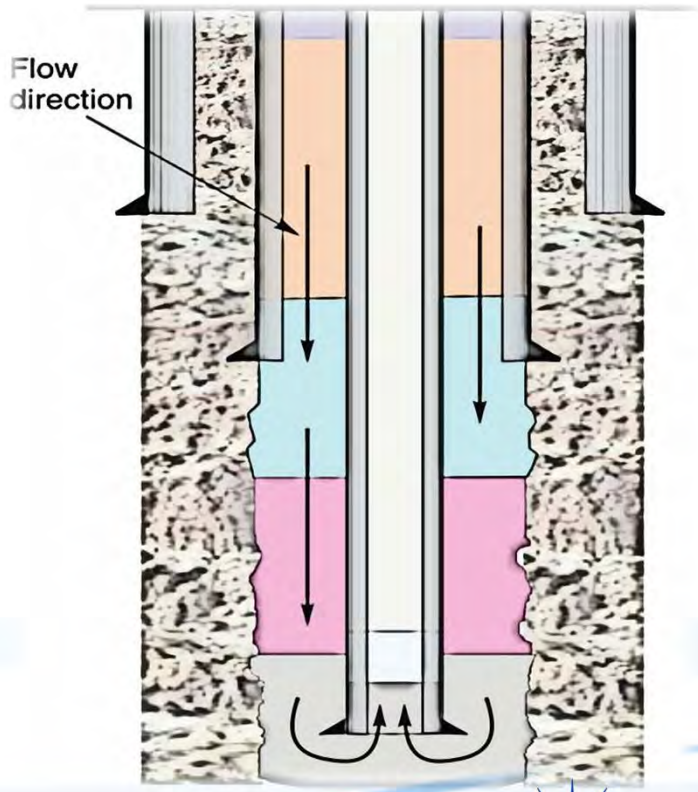
Houston, TX

# Project Background

## Reverse-Circulation Primary Cementing (RCPC)

- Used on land wells since 1960's
- Few cases of RCPC offshore
  - None in US deepwater
- Potential Benefits
  - Reduced ECDs
  - Reduced risk of lost circulation
- Expected Challenges
  - Placement simulators and modeling
  - Mechanical placement controls
  - Fluid design and mud removal

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# Project Objectives

- Provide step-by-step development path for deepwater RCPC
- Phase I Objectives:
  - Assess viability of performing RCPC on deepwater wells
  - Determine required technology to apply RCPC in deepwater wells
- Phase II Objectives
  - Present development strategy for required technologies
  - Develop operational procedures to perform deepwater RCPC
    - Including contingencies
- "Prototype Tested" Technology Readiness Level

# Project Milestones and Deliverables

| Milestone | Target Date | Delivered Date |
|---|---|---|
| Deliverable 1 – Project Management Plan Draft | 7/31/2012 | 7/17/2012 |
| Deliverable 2 – Project Management Plan | 8/14/2012 | 8/14/2012 |
| Deliverable 3 – Technology Status Report | 7/31/2012 | 7/27/2012 |
| Deliverable 4 – Technology Transfer Plan | 7/31/2012 | 7/27/2012 |
| Deliverable 5 – Phase I Interim Report Draft | 4/22/2013 | 4-22-13 |
| Deliverable 6 – Phase I Interim Report | 6/21/2013 | - |
| Deliverable 7 – Phase I Interim Progress Materials | 7/5/2013 | - |
| Deliverable 8 – Phase II Project Management Plan Draft | 7/21/2013 | - |
| Deliverable 9 – Phase II Project Management Plan | 15 days after receiving RPSEA comments | - |
| Deliverable 10 – Draft of Final Technical Report | 4/22/2014 | - |
| Deliverable 11 – Approved Final Technical Report | 6/21/2014 | - |
| Deliverable 12 – Final Technical Presentation | 6/21/2014 | - |



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# Financial Information

- Total Project Cost: $1,066,507
- Subcontractor Cost Share: $268,000
- RPSEA Maximum Share: $798,507
- RPSEA Maximum Share Minus 1% Tech Transfer: $787,842

# Current Work Status Update - Phase I Activities

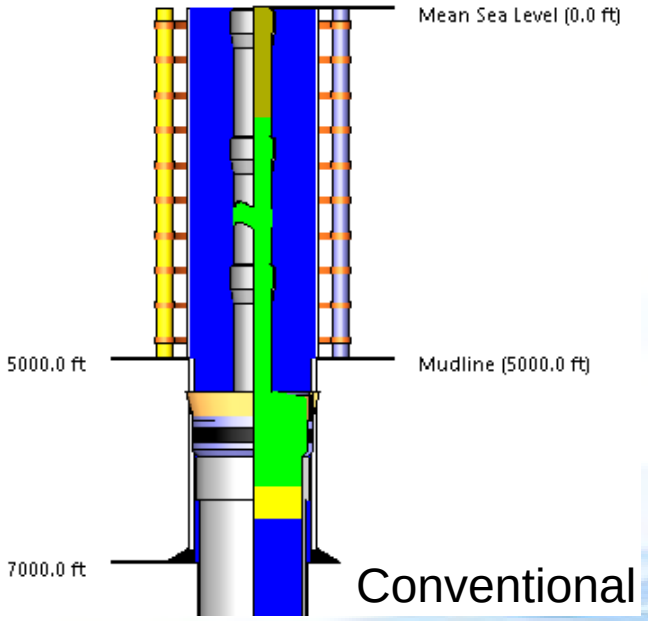
- Task 7: Numerical Modeling and Simulations
  - Subcontractor – University of Houston
  - Development of simulations and numerical models

- Task 8: Mechanical Placement Controls
  - Subcontractor- Weatherford
  - Evaluation of mechanical flow requirements and components

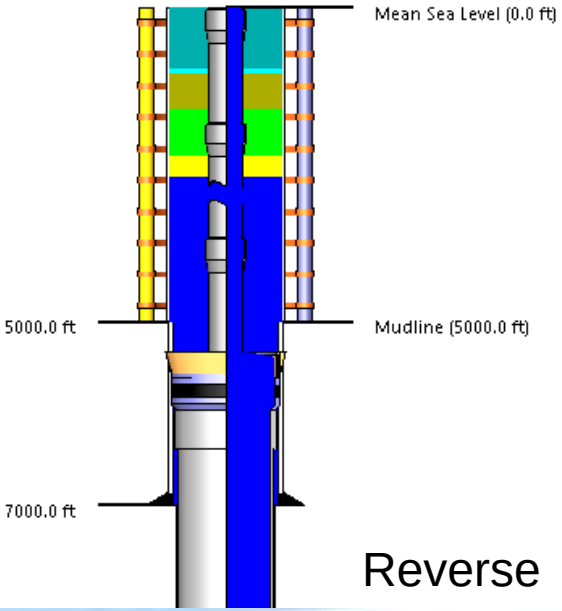
- Task 9: Cementing Materials Considerations
  - Prime Contractor - CSI Technologies
  - Laboratory simulations on cement performance under deepwater RCPC conditions

# Task 7: Numerical Methods and Simulation

- Temperature Simulations with WELLCAT
  - Version 5000.1.10 - It does not allow deepwater reverse circulation cementing configuration
  - Reverse temperature simulation was run in the software as a production operation




Conventional




Reverse

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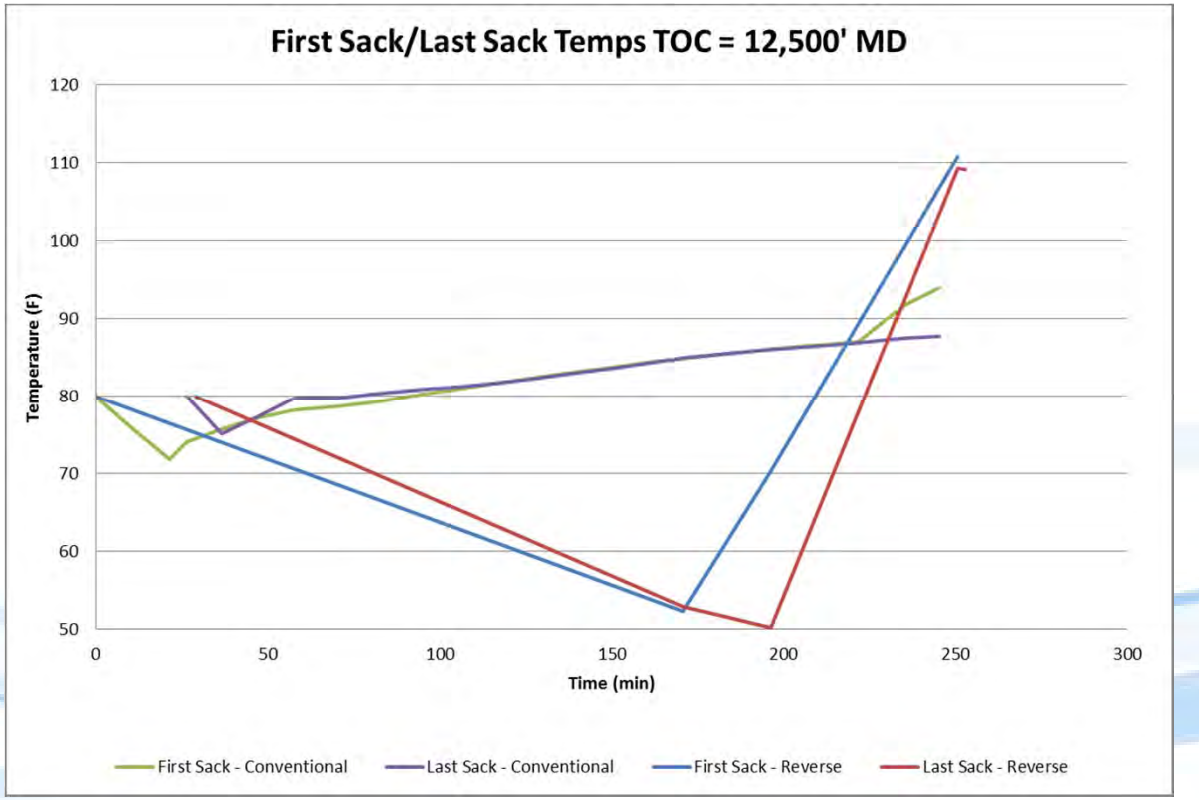
# Task 7: Numerical Methods and Simulation

- Temperature Simulations with WELLCAT
  - Reverse temperature simulation was run in the software as a production operation
    - Reverses down riser, inaccurate temperatures





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# Task 7: RCPC COMSOL Simulation

- COMSOL is a general-use finite element solver that can simultaneously solve the equations governing temperature and pressure.
- A model has been developed and successfully applied to a small-scale well, and is currently being modified so that it can be applied to full-size wells.
- Features of the model:
  - Full treatment of non-Newtonian rheology.
  - Incorporates effects of the crossover valve, unlike traditional software packages.
- Notable assumptions:
  - Perfectly vertical well.
  - The fluid-fluid interface is flat and no viscous fingering occurs





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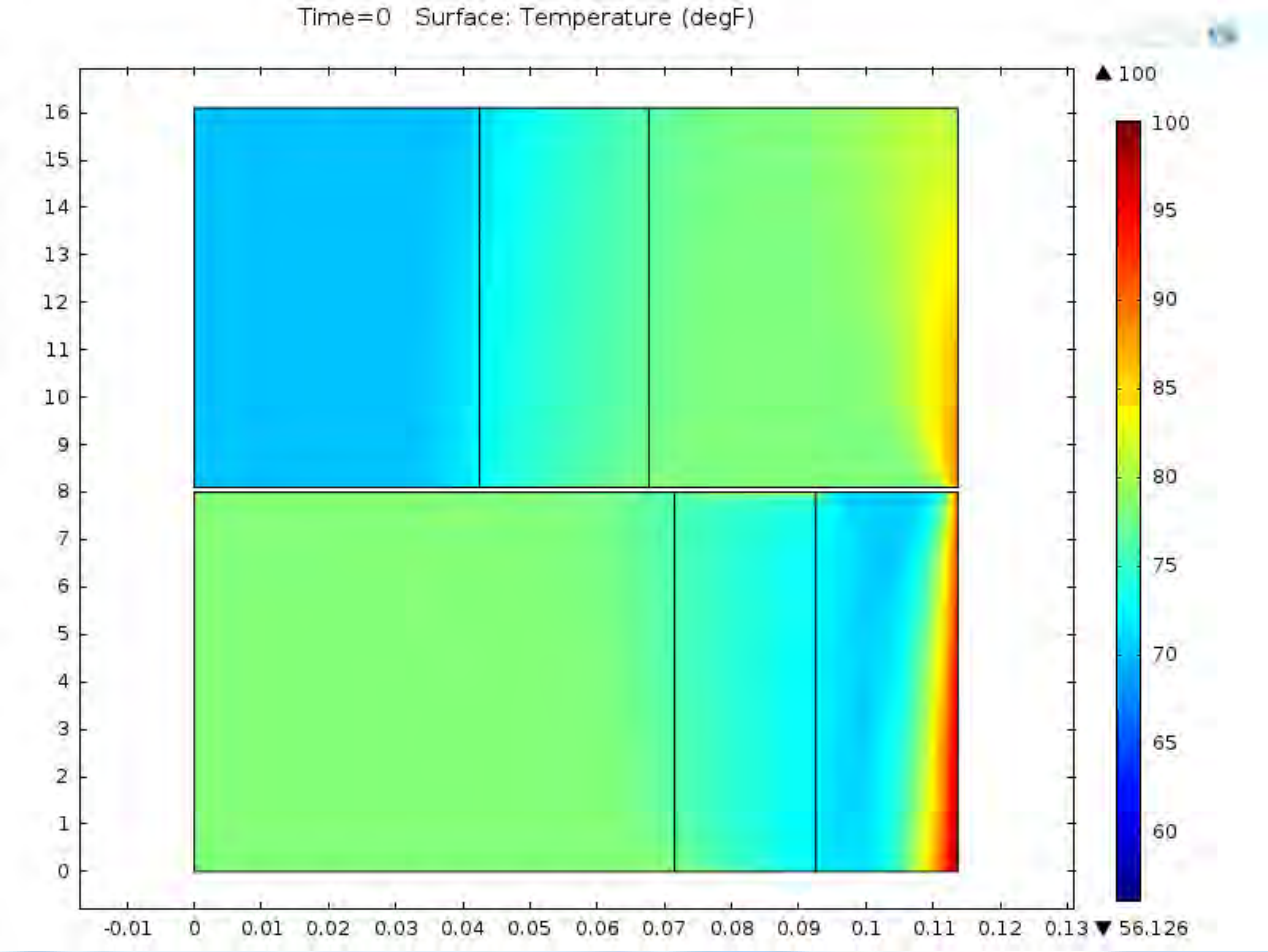
# Task 7: Temperature Profile in Scale Well

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# Task 8: Mechanical Placement Controls

- Subtask 8.1 Plugs: Objective is to evaluate a means of separating fluids and minimizing intermixing during placement
  - In pipe separation of fluids can be done mechanically. A dart or ball catcher run near the bottom of the inter string just above the crossover is commercially available. These systems can be run in vertical and high angle holes and can accept multiple darts and/or balls. Most give a pressure indication when the dart or ball reaches the catcher.

# Task 8: Mechanical Placement Controls

- Subtask 8.2 Crossover Design: Objective is to investigate various pumping techniques for placement of cement on the back side of the casing on long strings, liners, and tie back strings
  - Two types of crossover have been investigated. One, the decated crossover requires a port collar in the casing string to divert fluid to the annulus side. (Stage Cementers opened/closed with a work string) Two, the switchable crossover cablable of allowing fluid to be pumped the conventional circulation direction then switched to the reverse circulation direction. (Gravel Pack Systems) **As currently available neither appear to be adquate for reverse cementing a deep water casing string.**





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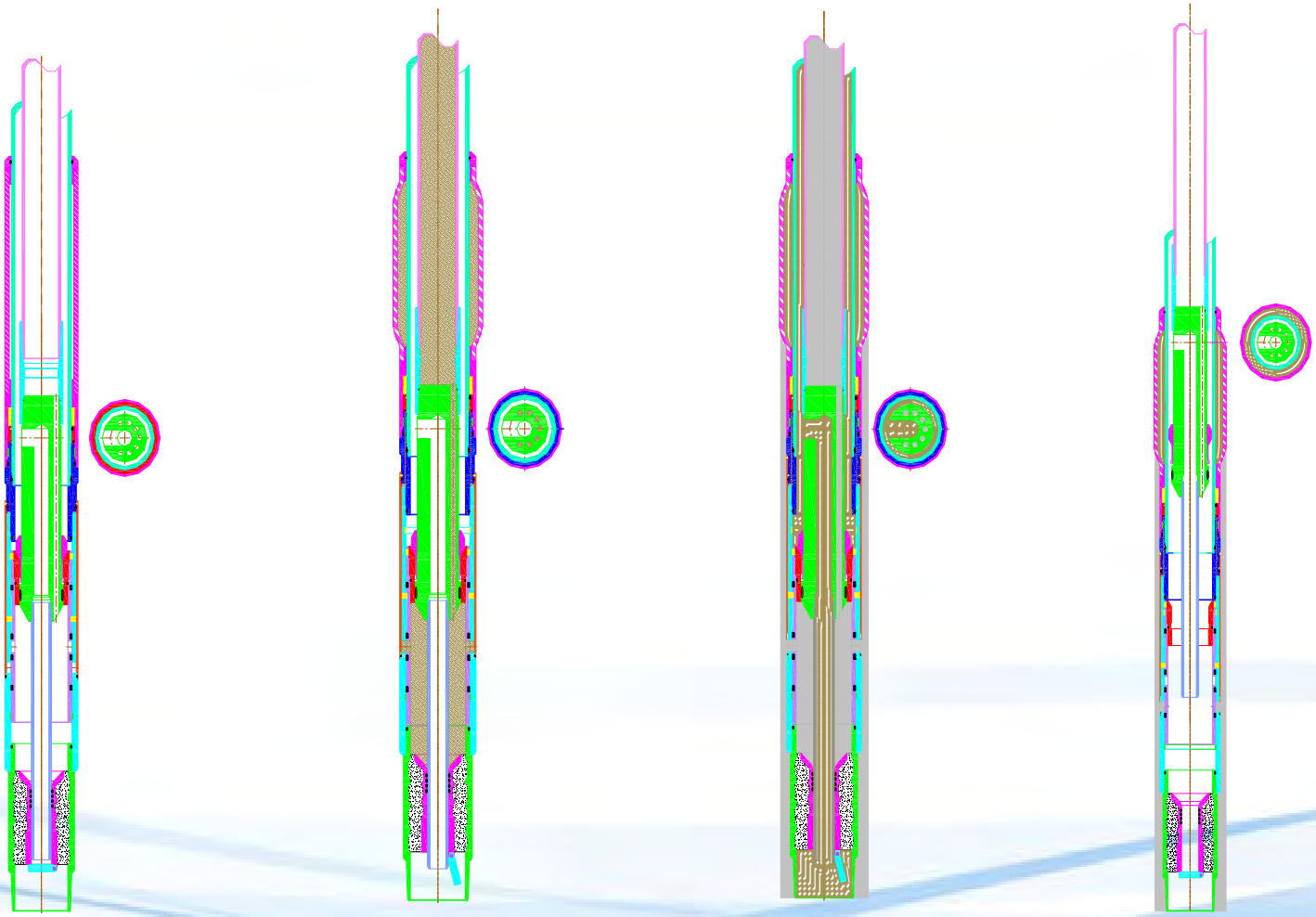
# Task 8: Mechanical Placement Controls

Dedicated Crossover System



Stung in

Inflate Packer

Pump Cement

POOH



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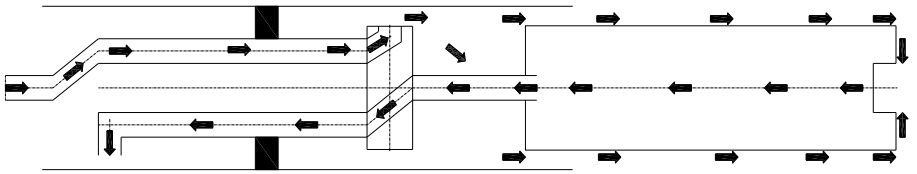
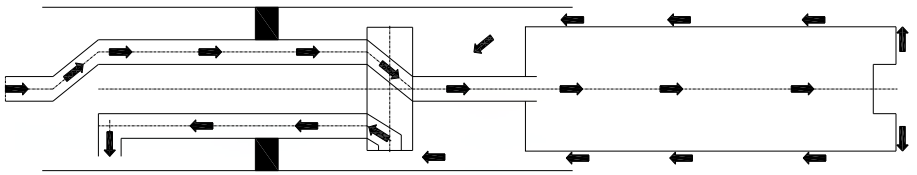
# Task 8: Mechanical Placement Controls

- Switchable crossover run at the top of the casing requires:
  - By-passable pack-off to allow fluids to go around the pack-off when circulating in the conventional direction –
  - A method of switching the flow directions to the reverse side, generally done with a ball/dart



REVERSE CIRCULATION PATH



CONVENTIONAL CIRCULATION PATH

Switchable Crossover System



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# Task 8: Mechanical Placement Controls

- Subtask 8.3 Floating Equipment: Objective is to study methods to control fluid-fill up and flow-back using existing equipment then if necessary determine modifications to existing float equipment and the optimum operation method for RCPC. Results will be summarized.
  - A good summary of various methods to retain the cement behind the pipe was presented in the RPSEA Task 2.0 Technology Status Assessment dated July 27, 2012 under Mechanical Placement Controls. It was noted that **"A challenge with RCPC is that conventional floating equipment cannot be used. RCPC jobs have used either specialized float equipment, or no float equipment at all."**
  - In reviewing the primary reason for doing RCPC jobs, which is to reduce ECD's, reducing flow restrictions at the shoe may be of prime importance. Therefore, the **type and need for float equipment will be on a case by case bases**.
  - Float equipment held open with an inner string appears to be the most practical, provided that the flow restriction is minimal, and the inner string can be reversed out or flushed out immediately after the cement is placed, the casing is hung off, and the stringer is removed from the float equipment.





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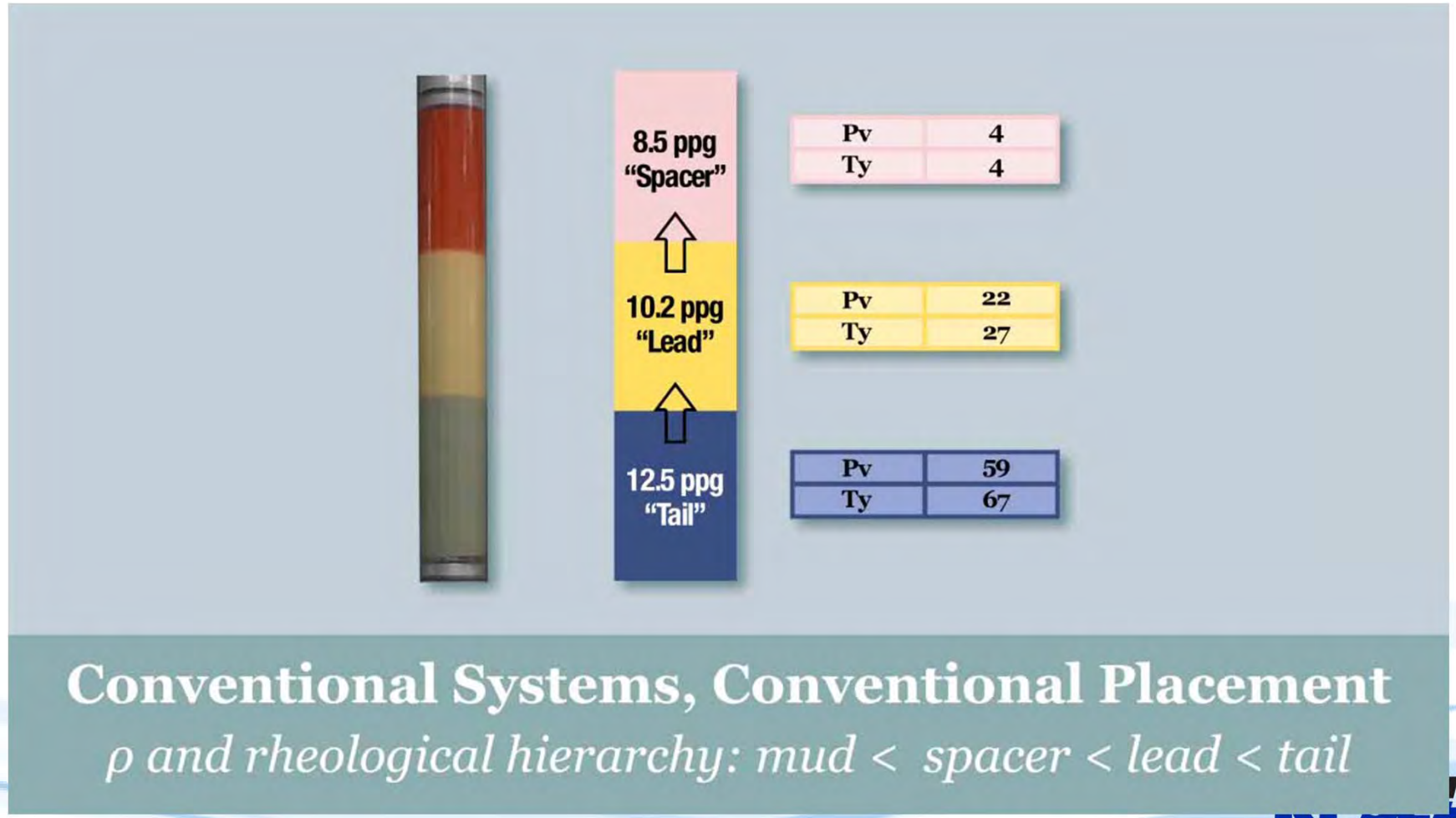
# Task 8: Mechanical Placement Controls

- In Summary RCPC for casing run on work strings:
  - Mechanical separation of fluids in a work string appears to be adequate for current needs
  - Current crossovers to divert flow to the back side of the casing dedicated and single time switchable from conventional to reverse circulation may not be adequate to do all the things an operator desires to do
  - Float equipment, if used, needs to be selected on a case by case basis

# Task 9: Cementing Material Considerations





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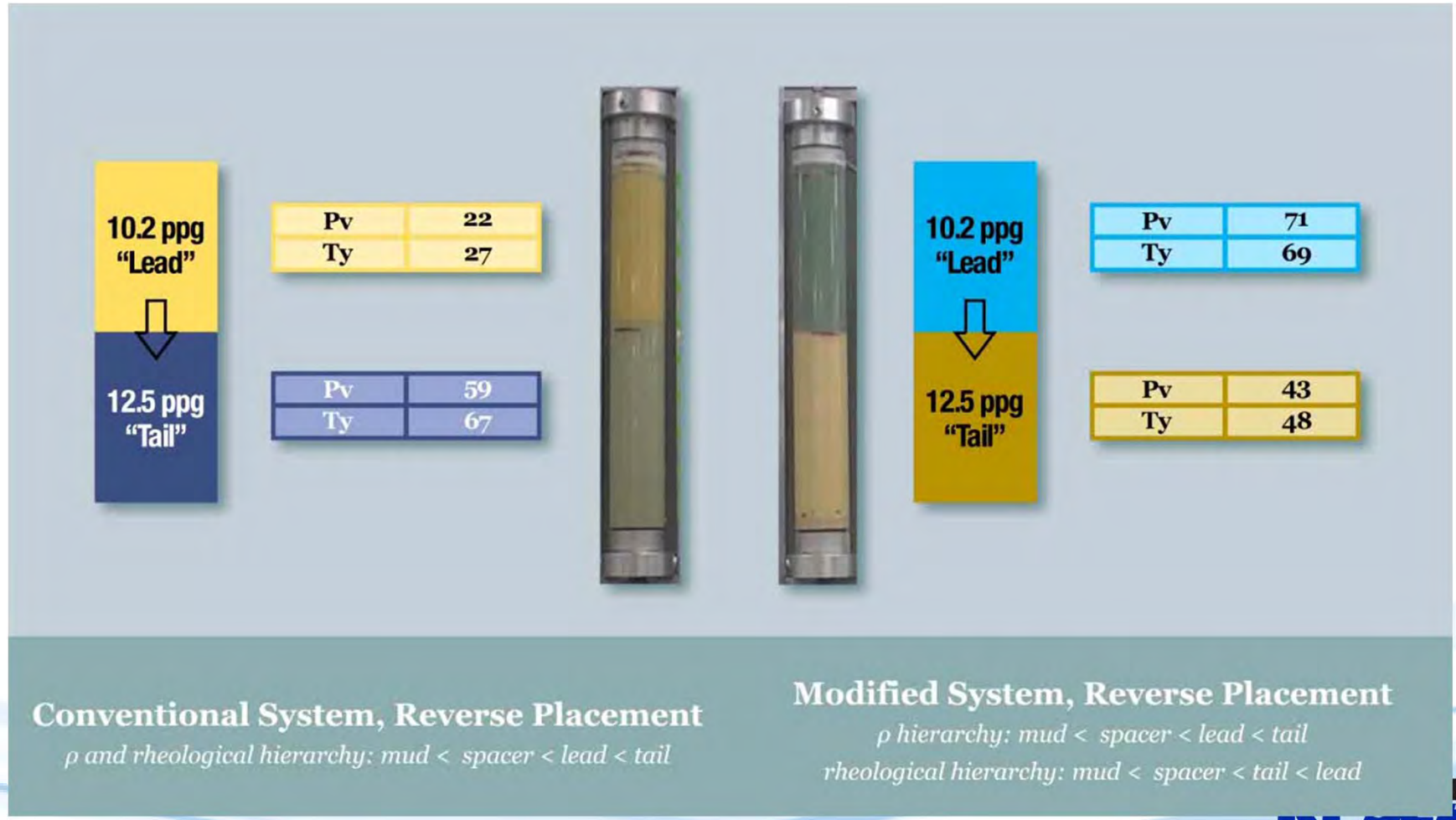
# Task 9: Cementing Material Considerations





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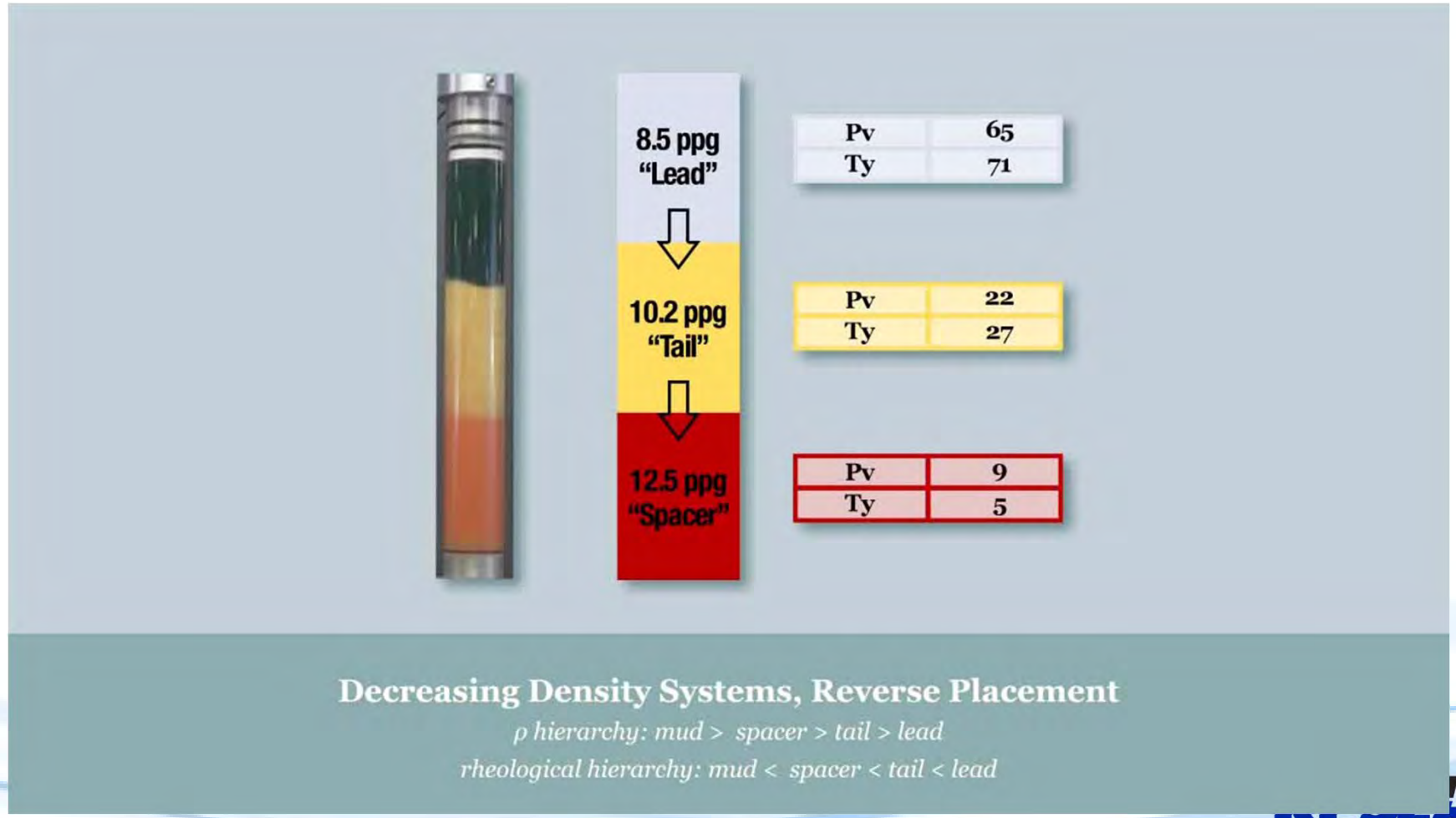
# Task 9: Cementing Material Considerations





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# Path Forward

- Continued investigation of:
  - Numerical Methods
    - COMSOL Model and “Tricking” WellCAT
  - Mechanical Placement Controls
  - Cementing Materials
    - Slurry and spacer design requirements
  - Operational Considerations

- Phase I Interim Report due June 22nd, 2013
  - Go/no-go point for project
  - Anticipated Phase 2 Objectives:
    - Present development strategy for required technologies
    - Develop operational procedures to perform deepwater RCPC





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