Deepwater Reverse-Circulation Primary Cementing

10121-4502-01
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CSI Technologies, LLC

Ultra-Deepwater Drilling, Completions and Interventions TAC Meeting
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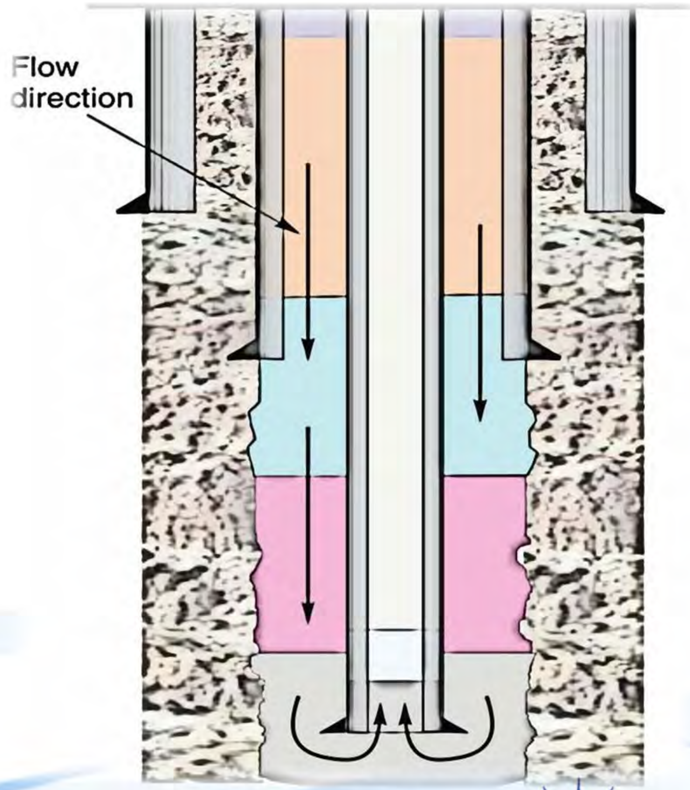
Project Background

Reverse-Circulation Primary Cementing (RCPC)

- o Used on land wells since 1960's
- o Few cases of RCPC offshore
  - None in US deepwater
- o Potential Benefits
  - Reduced ECDs
  - Reduced risk of lost circulation
- o 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

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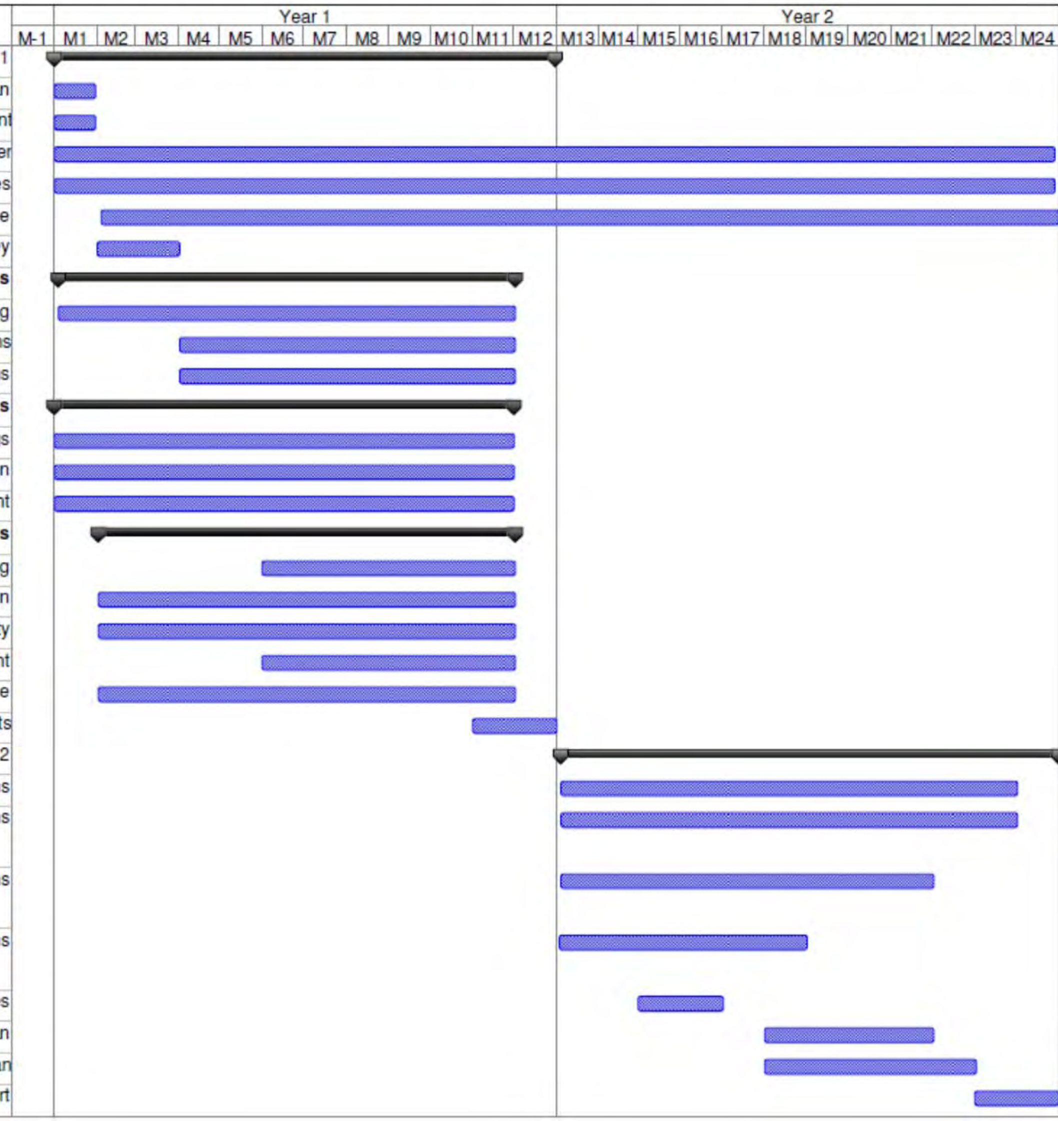
Gantt Chart

Project Start Date: June 22, 2012

ID	Notes	Name
1	Phase 1	Phase 1
2	Task 1	Project Management Plan
3	Task 2	Technology Status Assessment
4	Task 3	Technology Transfer
5	Task 4	Routine Reports and Other Activities
6	Task 5	Formation of Industry Steering Committee
7	Task 6	Industry Survey
8	**Task 7**	**RCPC Process Numerical Modeling and Simulations**
9	Subtask 7.1	Finite Element Modeling
10	Subtask 7.2	Temperature Simulations
11	Subtask 7.3	RCPC Job Placement Simulations
12	**Task 8**	**Mechanical Placement Controls**
13	Subtask 8.1	Plugs
14	Subtask 8.2	Crossover Design
15	Subtask 8.3	Float Equipment
16	**Task 9**	**Cementing Material Considerations**
17	Subtask 9.1	Fluid Intermixing
18	Subtask 9.2	Spacer Design
19	Subtask 9.3	Additive Sensitivity
20	Subtask 9.4	Compressive Strength Development
21	Task 10	RCPS Operational Performance
22	Task 11	Identify Technical Deficits
23	Phase 2	Phase 2
24	Task 12	Numerical Simulation under Real Well Conditions
25	Task 13	Mechanical Placement Controls under Real Well Conditions
26	Task 14	Cementing Materials Performance under Real Well Conditions
27	Task 15	RCPC Operational Performance under Real Well Conditions
28	Task 16	RCPC Performance Requirements and Capabilities
29	Task 17	RCPC Operational Plan
30	Task 18	Task 18 RCPC Operational Coningency Plan
31	Task 19	Final Report



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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	-
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

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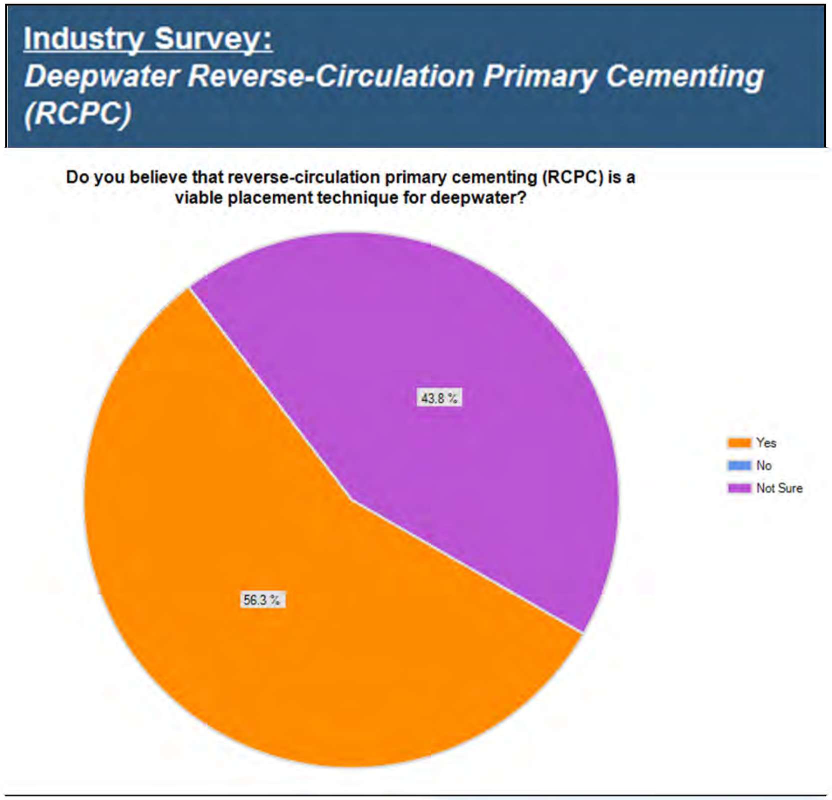
Work Status - Phase I Activities

- Task 6: Industry Survey
  - Industry-wide survey of deepwater experts
  - Gathers opinions, expertise and concerns about deepwater RCPC
  - Results used to determine future modeling parameters
  - Sent out to 75+ individuals at 20+ companies involved in deepwater operations



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Work Status - Phase I Activities

- Task 7: Numerical Modeling and Simulations
  - Subcontractor – University of Houston
  - Development of simulations and numerical models
  - Modeling parameters determined using Task 6 results

  - Analysis includes:
    - Review of available modeling software and simulators (in progress)
    - Finite Element Modeling
    - Temperature Simulations
    - Job Placement Simulations

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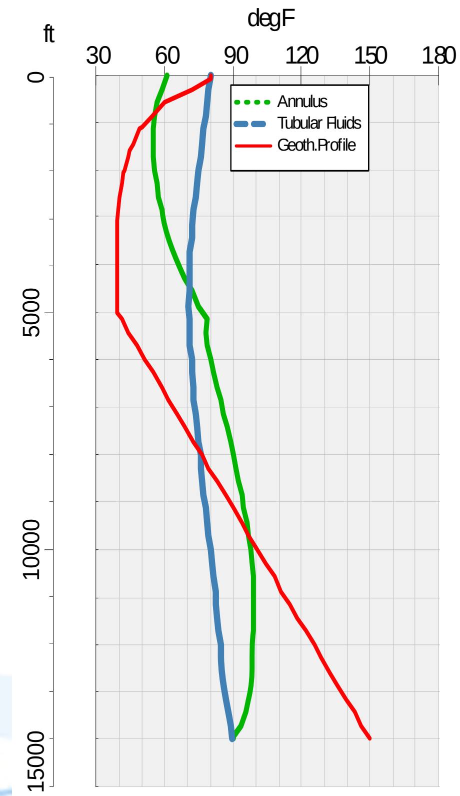
Work Status - Phase I Activities

- Commercial simulators have difficulty handling RCPC
  - Particularly for complex geometries
- - All-purpose simulator (COMSOL) to be used for:
  - Flexibility
  - Control of desirable features
- -First step (in progress): Vertical wells with radial symmetry
  - Develop Temperature, Pressure profiles
- - Next step: Deviated wells



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Work Status - Phase I Activities

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

- 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.
  - Separation of fluids in the annular area between the hole ID and casing OD has typically been done with spacer fluids on conventional jobs

Work Status - Phase I Activities

- Weatherford Dart Catcher Tool
  - Captures up to 3 darts
  - Gives a pressure indication when dart is pumped through restriction sleeve
  - Darts are captured within cage
  - Allows reverse circulation before and after darts are captured

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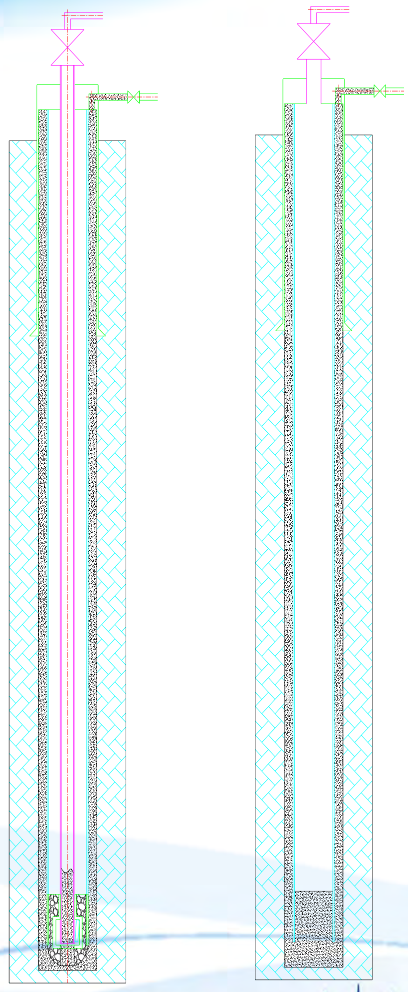
Work Status - Phase I Activities

- 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
  - Known methods used on land wells
  - A discussion on the location of the proposed reverse cement crossover tool

Work Status - Phase I Activities

Known Methods of Reverse Cementing on Land

- Casing is run to depth, one case has a drillable packer or sting in float shoe
- With the drillable packer or float shoe, an inner string is run from the surface and sealed off with a pack-off head at the surface
- Cement is then pumped down the backside of the casing until clean cement is returned through the inner string at the surface
- A second case the casing is run bare with no back pressure valve
- A predetermined amount Cement is then pumped down the back side while returns are taken through a casing head at the surface – Once the cement has been pumped the casing head and cement injecting port are closed in to allow the cement to set up



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Reverse Cementing Mechanical Placement Control – Task 8

Location and Operation for Reverse Cementing

- Ideally the reverse cementing method will allow cement to be pumped around the top of the casing without having a hole to pump through in the casing

- Returns will be taken through the casing ID and re-directed into the annular area above the reverse cementing crossover tool

- For liners the same inner string with the reverse cementing crossover will be used to set the liner hanger

- Ideally, the liner hanger will be set after the cement has been placed

- Ideally, as a contingency the system should be capable of a conventional cementing job with minor or no modifications

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Work Status - Phase I Activities

- Task 9: Cementing Materials Considerations
  - Prime Contractor - CSI Technologies
  - Laboratory simulations on cement performance under deepwater RCPC conditions
  - Laboratory analysis includes:
    - Effects of fluid intermixing
    - Spacer design and mud removal
    - Additive sensitivity
    - Compressive strength development

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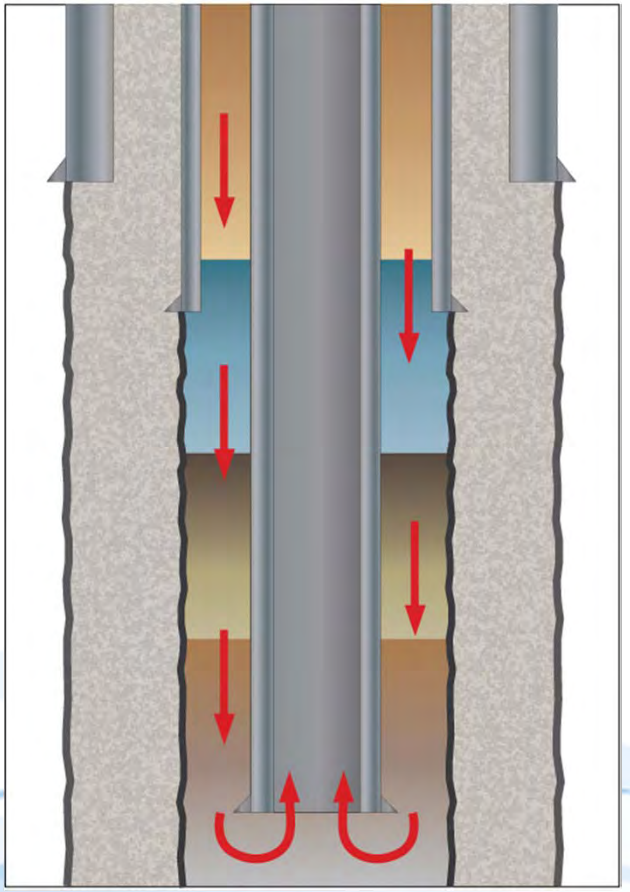
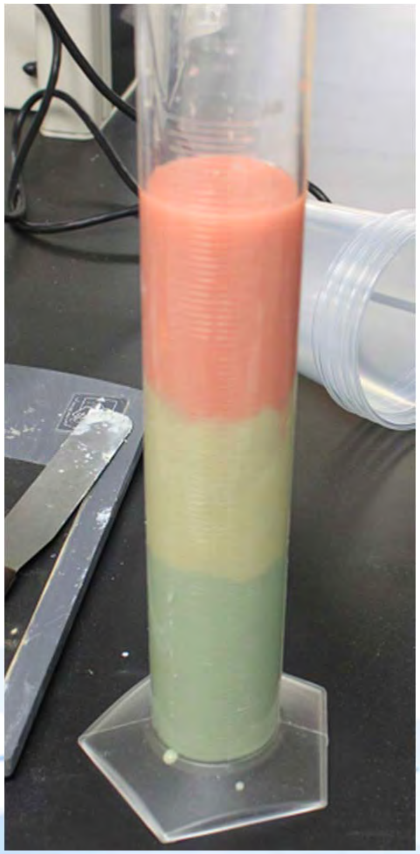
Work Status - Phase I Activities

- Conventional system, conventional placement
  - ρ and rheo hierarchy: mud < spacer < lead < tail
- Conventional system, reverse placement
  - Same system as (1) for comparison
    - ρ and rheo hierarchy: mud < spacer < lead < tail
  - Placement order – mud, spacer, **tail**, lead
  - Expected instability at spacer/tail interface
- Conventional system with modified rheology, reverse placement
  - ρ hierarchy: mud < spacer < lead < tail
  - rheo hierarchy: mud < spacer **< tail < lead**



Work Status - Phase I Activities

- <u>Other Slurry Design Considerations:</u>
  - Estimating degree of intermixing
  - Future work – Large scale modeling
  - Retarder concentrations
    - TT tests for staging retarder concentrations
  - Fluid Loss
    - More contact time with formation ('Tail')
  - WOC time
    - UCA for compressive strength development



Thank You

- Questions?

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