GEOTHERMAL 2023
REALISING THE AMBITION

MULTIPHASE DRILLING FLUID
UTILIZING CCS ON
GEOTHERMAL OPERATIONS

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Geothermal Drilling with Constant Circulating System (CCS) in Conjunction with Multiphase Fluids

Enables the reduction of NPT in Geothermal Drilling:

- Combined systems have been used in Volcanic Ash/Tuff drilling sections
- Mitigate Total losses in fractured formations
- Mitigates Stuck Pipe/Lost BHA’s from hole collapse
- Reducing Connection Times with Multiphase flow
- Good ECD control
- Allows for improved BHA Temperature Control
# MULTIPHASE DRILLING FLUID FOR GEOTHERMAL OPERATIONS

<table>
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<th>Drilling Fluid</th>
<th>Description</th>
<th>Application</th>
<th>Remarks</th>
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| Air            | • Air is the continuous phase | • Extremely low formation pressure  
• Non water-bearing formations | • May require large air equipment spread  
• Higher annular velocities can be expected |
| Foam/Stiff Foam | • A mixture of water or polymer slurry with foaming agents is added to compressed air stream | • Large annular spaces (washouts, vugular formations)  
• Macro fractured formations  
• Water-bearing formations | • Less volumes of water required than single phase fluids  
• Mist pump required to achieve stiff foam  
• Improved well bore stability  
• Improved cuttings carrying capacity |
| Aerated Mud    | • Liquid based Drilling fluid is the continuous phase  
• Air is added to reduce the hydrostatic pressure | • Weak Formations  
• Unstable formations with subnormal pressure (6 to 8 ppg (0.72-0.96 sg) EMW | • Maintain Higher density Fluids  
• No Mist pump required |
The CCS system is a DNV certified process that allows the pressure isolation of the rigs top drive via diverting flow through a manifold to a drill pipe sub that has an internal ball valve and side entry port. Thus, enabling the continued circulation of drill pipe whilst making a drill pipe connection.

Subs are made up to the top of each drill pipe stand that is required to drill a predetermined well section.

Subs can be manufactured to fit desired drill pipe tool joint from 4” to 6 5/8”. 

MULTI PHASE FLUID WITH CONTINUOUS CIRCULATION

CCS - Flow Schematic & System Overview

- Mud Pumps
- Standpipe Manifold
- Top Drive
- Air, N2, or Foam Supply
- CCS Manifold
- Conventional
- CCS Operation
- Upper Drill String Isolation Valve
- Sub Side Entry Port
- Rig Floor
- Drill Pipe
Two Phase Drill Fluid

Outflow to fluid cuttings process

Loss zone charged up with two phase fluid and cuttings

ECD Maintained to Drilling Parameters

Normal Drilling Operation

Pumps off air flow diverted

Outflow to fluid cutting process

Charged formation releasing fluids cutting back to well bore possible phase break out

ECD lowered as no flow to drill string

Normal Connection

Two Phase Drill Fluid to CCS sub by pass top drive

Outflow to fluid cuttings process

Pressure stable no surge back to well bore

ECD maintained to Drilling Parameters

CCS Connection
• Left diagram drilling volcanics 3m/hr 8.5” reservoir section with water utilizing normal drilling connection procedures

• Right diagram drilling volcanic 3m/hr 8.5” reservoir section with water utilizing CCS on connections

• Results show that by using CCS a 35 to 40 deg C decrease in near well bore temperature. The reduced temp allows for longer use of mud motors and MWD tools limiting high temp degradation to down hole tools
Assessed Hydrothermal Influx $350\text{degC}$ at 60mbsf

Pumping

8-1/2" Hole:
- Influx Flow-in: $350\text{degC} \times 200\text{gpm}$ at 60mbsf
- $38-114\text{degC} @ 600\text{gpm}$
- $21-95\text{degC} @ 800\text{gpm}$
- Annular BP: 40psi @800gpm x 100mbsf

12-1/4" Hole:
- Influx Flow-in: $350\text{degC} \times 200\text{gpm}$ at 60mbsf
- $26-74\text{degC} @ 1200\text{gpm}$
- Annular BP: 20psi @1200gpmx100mbsf

Pumps Off

8-1/2" Hole:
- Influx Flow-in: $350\text{degC} \times 400\text{gpm}$ at 60mbsf
- Max $182\text{degC} @ 2\text{min}$
- Max $212\text{degC} @ 3\text{min}$

12-1/4" Hole:
- Influx Flow-in: $350\text{degC} \times 400\text{gpm}$ at 60mbsf
- Max $128\text{degC} @ 2\text{min}$
- Max $168\text{degC} @ 3\text{min}$
- Max $196\text{degC} @ 4\text{min}$

• LWD Specification for 8 ½” hole size BHA temperature rating = $175\text{degC}$

• Worst conditions encountered during “no pumping” events while the hydrothermal fluid influx occurred upwards of 400degC
Star Energy / Schlumberger IPM first well NSD MBC-1 in Indonesia, 2017

- Drilled 3 sections, 17-1/2”, 12-1/4” and 8-1/2” section.
- WBM used for the 17-1/2” section with 2-phase drilling in 12-1/14” and 8-1/2” section.
- A total of 1500m of open hole drilled with continuous circulation.
- No stuck pipe events.
Star Energy / Schlumberger IPM Second well with NSD WWA-7 in Indonesia, 2017

- Drilled 3 sections, 17-1/2”, 12-1/4” and 8-1/2” section.
- Single phase used for the 17-1/2” section with 2-phase drilling in 12-1/4” and 8-1/2” section
- A total of 2015m of open hole drilled with continuous circulation.
- No stuck pipe events.
- 7th Well on PAD, Deepest and fastest well drilled on pad by over 3 days and 500m deeper than previously been able to achieve.
Utilizing CCS allowed STAR ENERGY to accomplish the following:

- Drilling with stands, compared to drilling in doubles conventionally due to need to make connections one single off bottom to allow drill string movement.
- Reduced the overall connection time from 35-45 mins to 10 mins, by eliminating need to excessively back ream prior to connection and reduce the time it takes to regain stable 2 phase drilling ratios.
- Substantial risk reduction of stuck pipe during connections, due to drilled solids drop out, or formation collapse due to cyclic pressure variations in the wellbore.
- No stuck pipe incidents.
- Allowed section to be drilled to planned TD. Previous well abandon with BHA lost in hole due to sever well bore instability.
SAE/ Halliburton IPM first well NSD SMT-H2 in Indonesia, 2018

- Drilled 26” hole section with 2-phase drilling medium.
- Maintained constant circulation over whole section
- A total of 298m of open hole drilled with continuous circulation.
- No stuck pipe events.
SAE/ Halliburton IPM Second well NSD SMT-F1 in Indonesia

- Drilled 2 sections 17-1/2” and 12-1/4” side.
- A combination of single phase and 2-phase fluids used in loss zones.
- A total of 1688m of open hole drilled with continuous circulation.
Thank You!

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