

HALLIBURTON

Customized fluids for drilling challenging reservoir section and running production sand screens

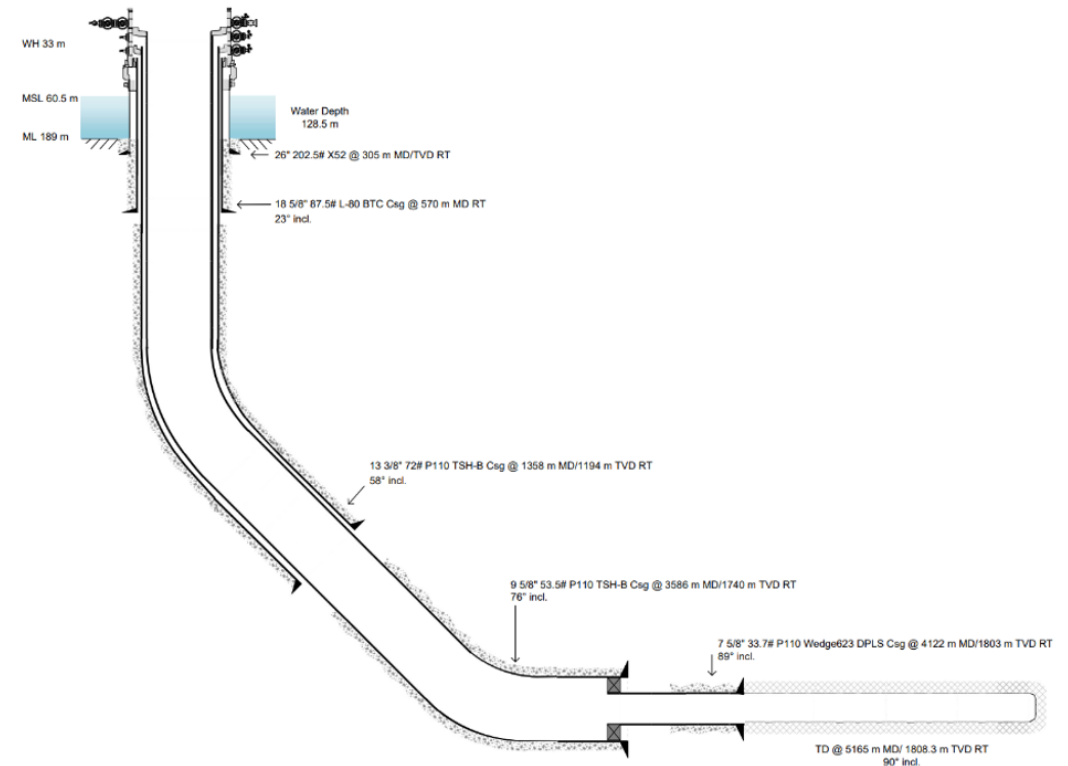
Norwegian Continental Shelf, platform drilling.

Dr D. Nelson McMillan, Country Technical Manager

Reservoir drilling and completion fluid design

Halliburton Baroid – NCS operation, platform drilling.

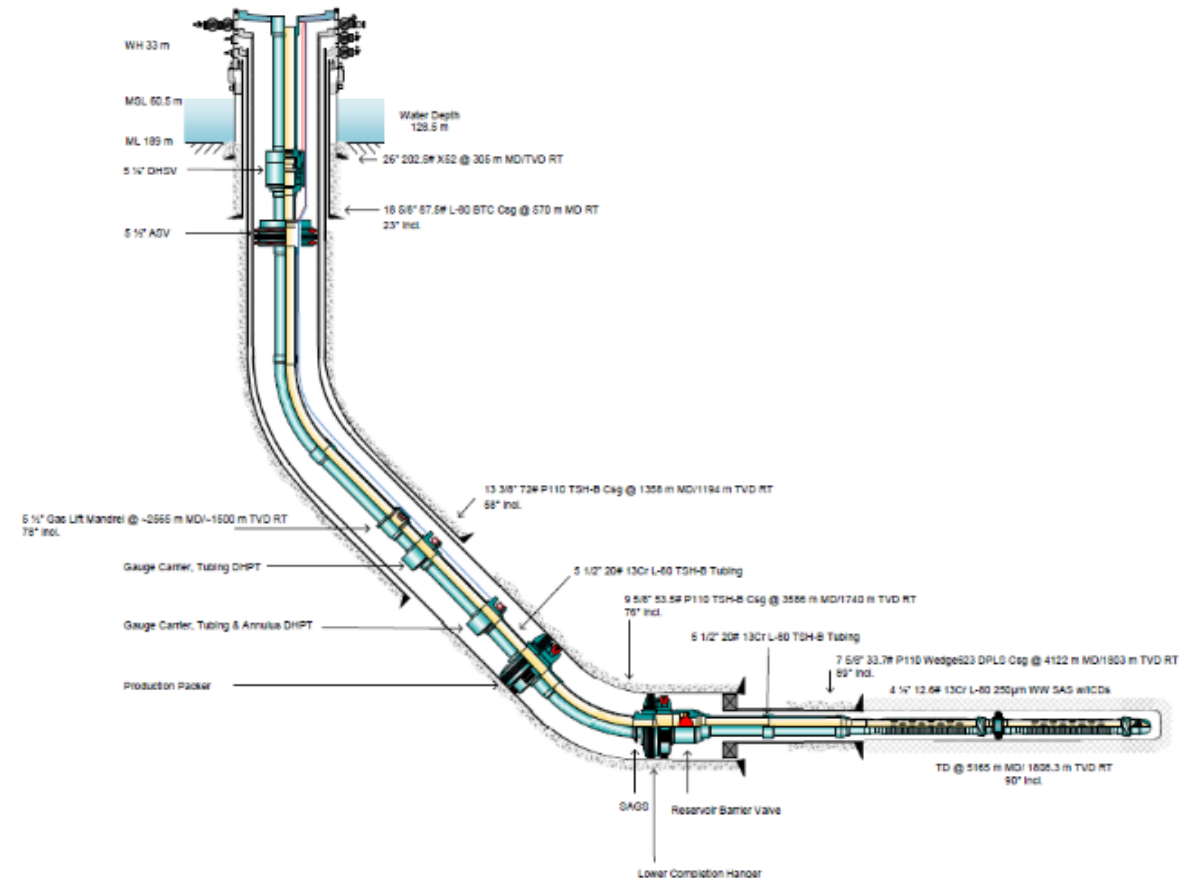
- Introduction – Develop fluid strategies to successfully drill and complete narrow margin wells.
 - Horizontal well profile.
 - Managed Pressure Drilling with multiple fluid sets.
 - Historical challenges with fluid stability due to low shear environment, breaking of gels etc., barite sag
 - Wellbore collapse induced by sag?



Reservoir drilling and completion fluid design

Halliburton Baroid – NCS operation, platform drilling.

- Low density fluid for drilling, higher density tripping/screen running fluid.
- Multi-stage displacements make maintaining an even mud weight challenging.
- Screen Running Fluid conditioned to minimize risk of plugging the SAS.
- Open hole exposure time at TD increases risk of hole collapse/failure to land SAS.



Main Challenges

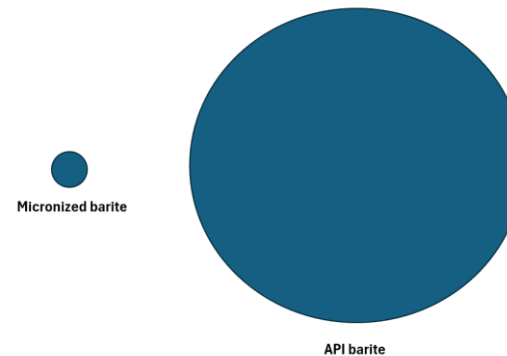
Halliburton Baroid – NCS operation, platform drilling.

- **2 Main Challenges**
 - **(1) Managed Pressure Drilling**
 - Separate drilling and tripping fluids
 - Managing fluid density and stability during multi-stage displacements.
 - Under-displacement
 - Low pump rates during displacement – inefficient displacements.
 - Low pump rates when circulating fluid in well to PST spec.
 - **(2) PST (production screen testing) fluid preparation**
 - Production screens run in hole in fluid that will not plug the screens resulting in completion damage/poor productivity.
 - Preparing fluid offshore (essentially screening the active fluid over shakers) to PST specification is time consuming and **on critical path**.
 - With sensitive formations exposed in the reservoir section there can be a deterioration in hole condition **over time**.
 - Preparing such fluid at the LMP at **low ambient winter temperatures** has been a challenge with conventional screening technology.

Managed Pressure Drilling

Halliburton Baroid – NCS operation, platform drilling.

- **Developed Solutions (1) – MPD/Narrow Margin**
 - OCF IEF system selected – low ECD, high yet fragile gels.
 - Micronized barite as weighting agent.
 - Mitigates against weighting agent settling in low shear environment.
 - Task force established including operator, rig contractor and service providers.
 - Close collaboration between fluids provider and MPD provider for modelling hydraulics and ECD.
 - Optimize the multi-stage displacement



OCF IEF - Low Pressure to Break Gels on Connections

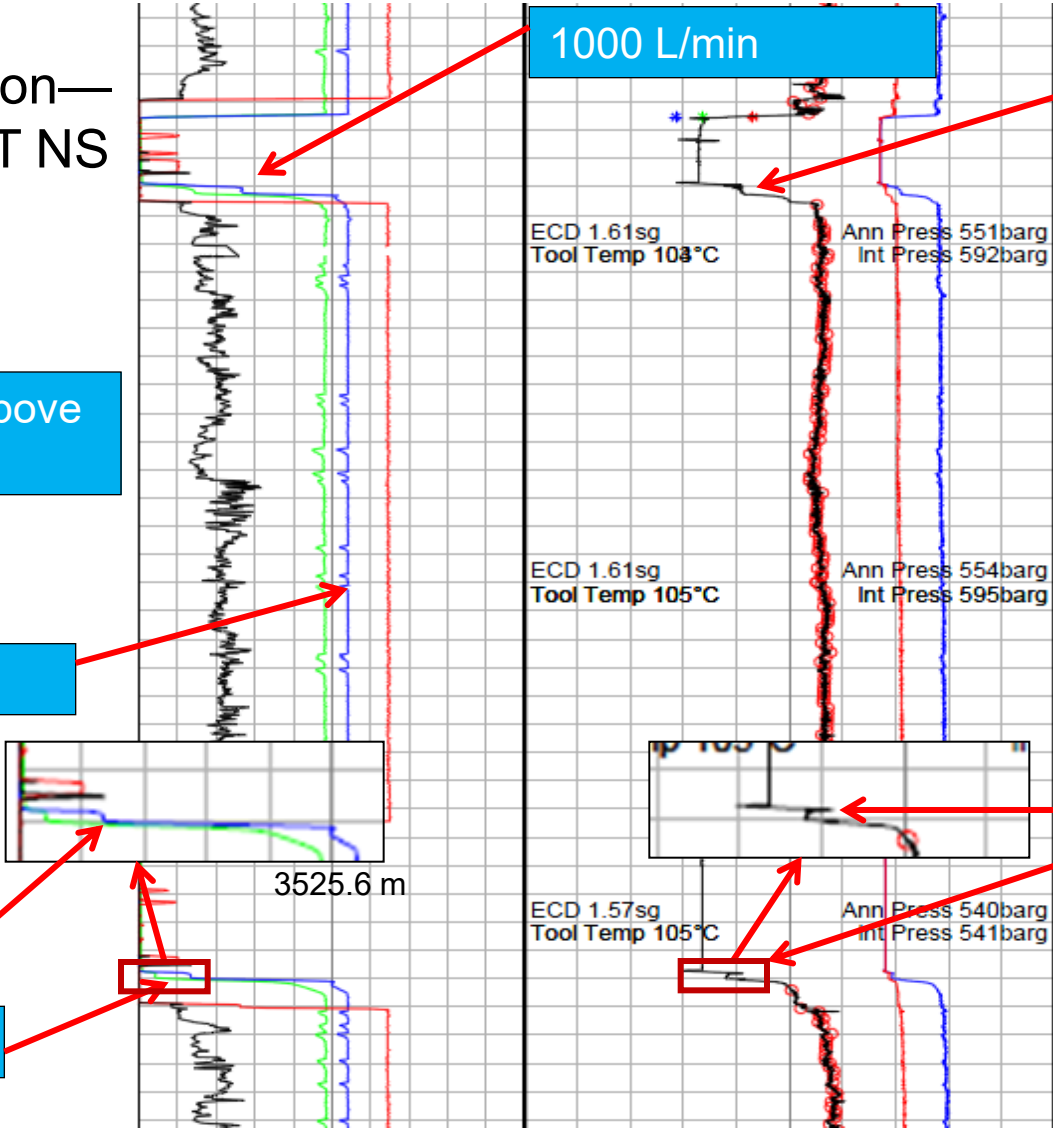
8 1/2-in. Hole section—
1.57 sg INNOVERT NS

No pressure spikes above
ECD (2160 L/min)

2160 L/min

500 L/min

0 4000 L/min



Fragile gels
1000 L/min

Staging pumps

Fragile gels
500 L/min

Pressure while
drilling log

Managed Pressure Drilling

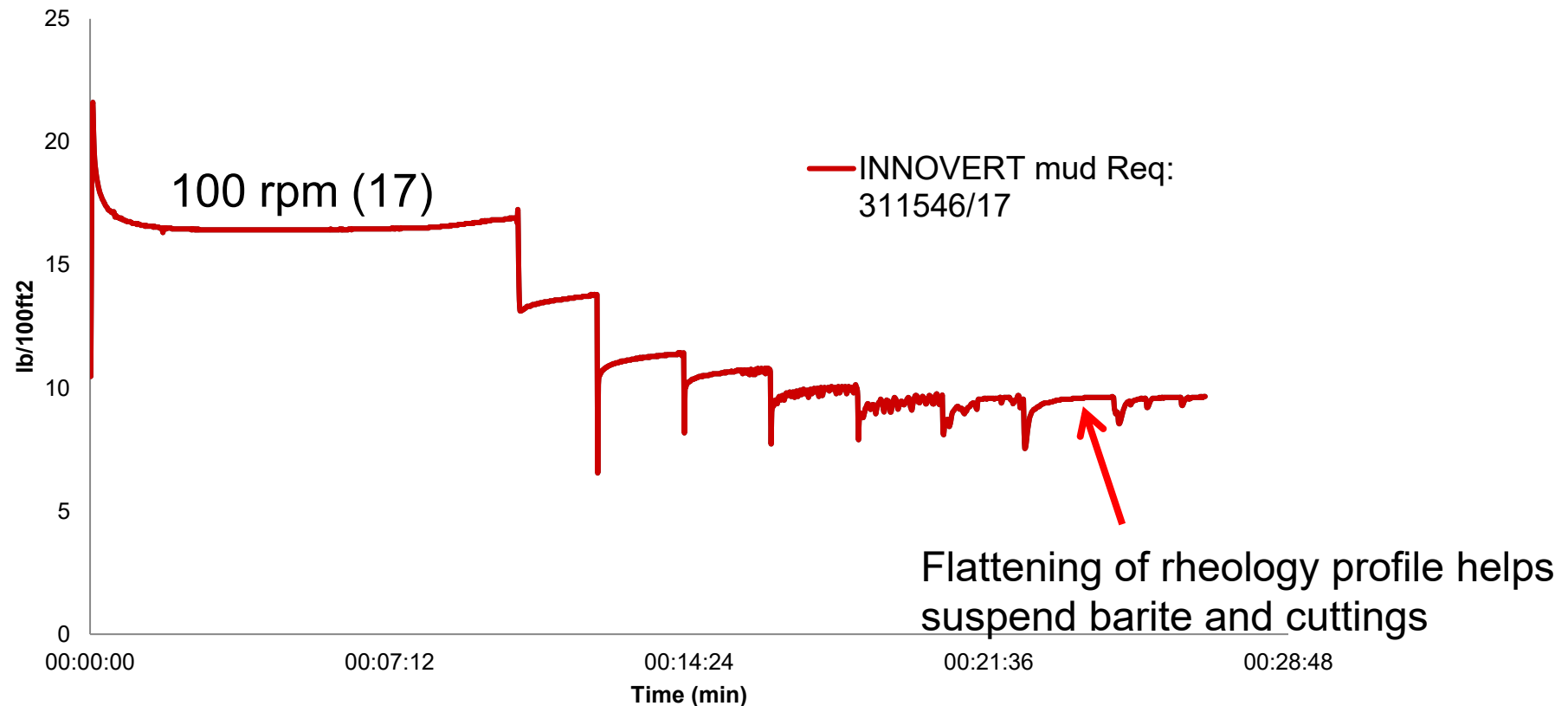
Halliburton Baroid – NCS operation, platform drilling.

- **Developed Solutions Further**
 - Sometimes even micronized barite will sag!
 - 1.10 SG drilling fluid & 1.40 SG tripping/screen running fluid.
 - Sag event during fluid displacements on first well.
 - Formulation was modified to improve low shear suspension.
 - Additional suspension support required.

Managed Pressure Drilling

Halliburton Baroid – NCS operation, platform drilling.

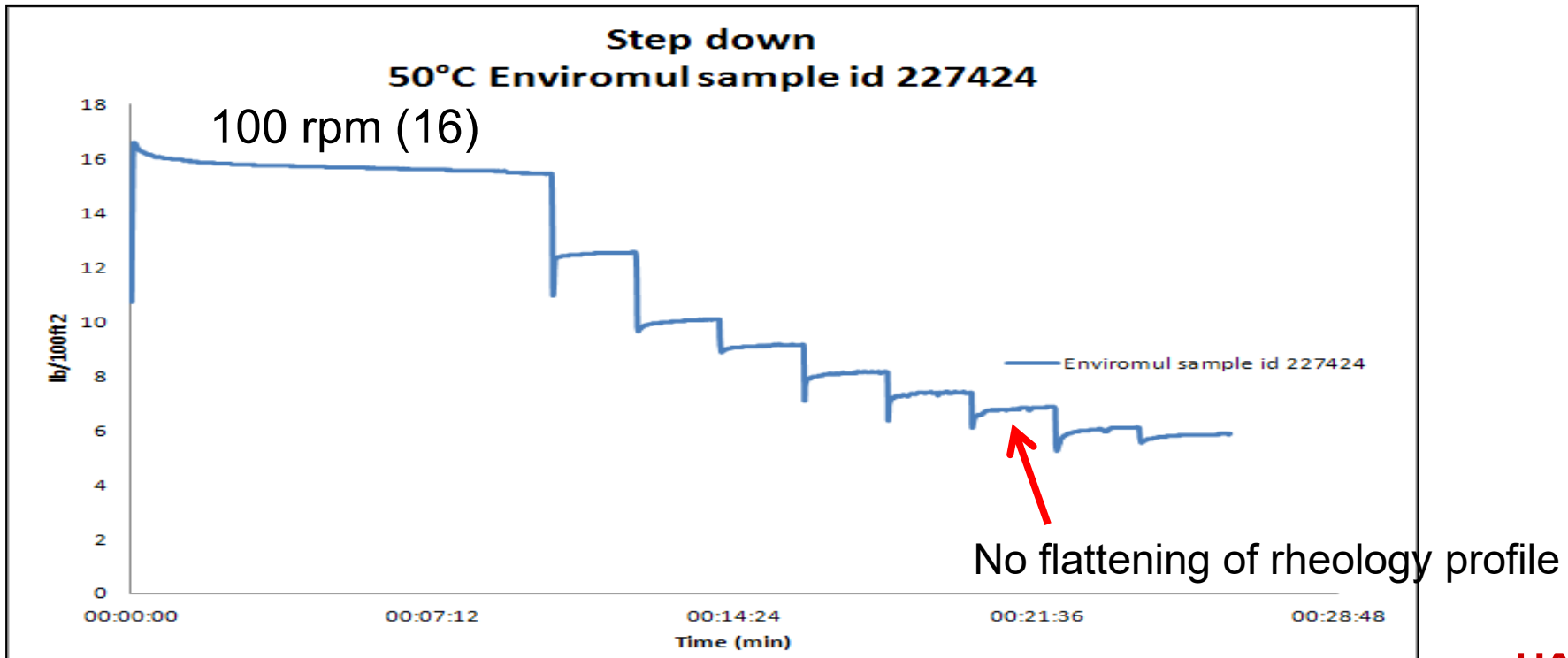
- Brookfield Stepdown Rheology – OCF IEF low shear rate rheologies



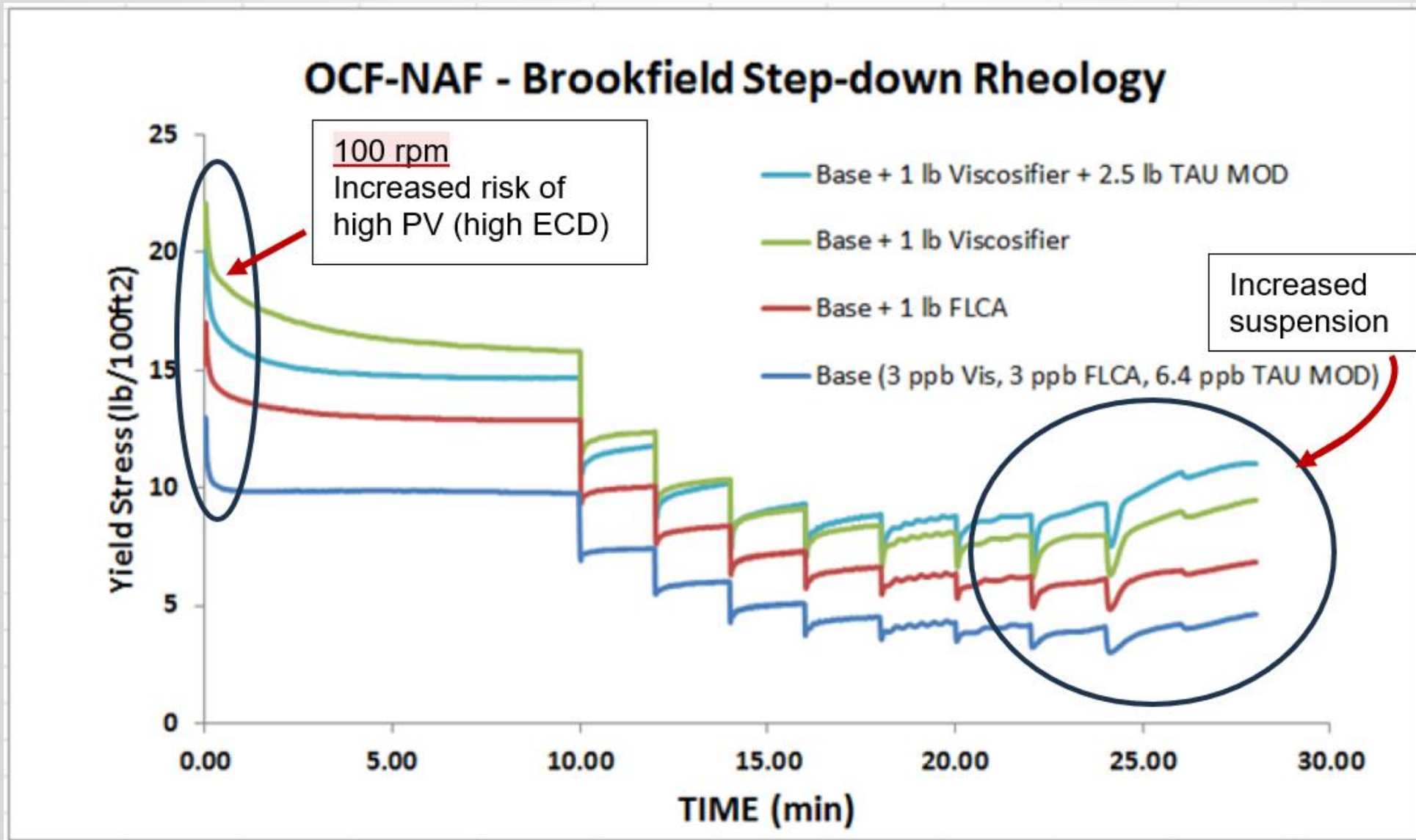
Managed Pressure Drilling

Halliburton Baroid – NCS operation, platform drilling.

- Brookfield Stepdown Rheology – Conventional IEF low shear rate rheologies



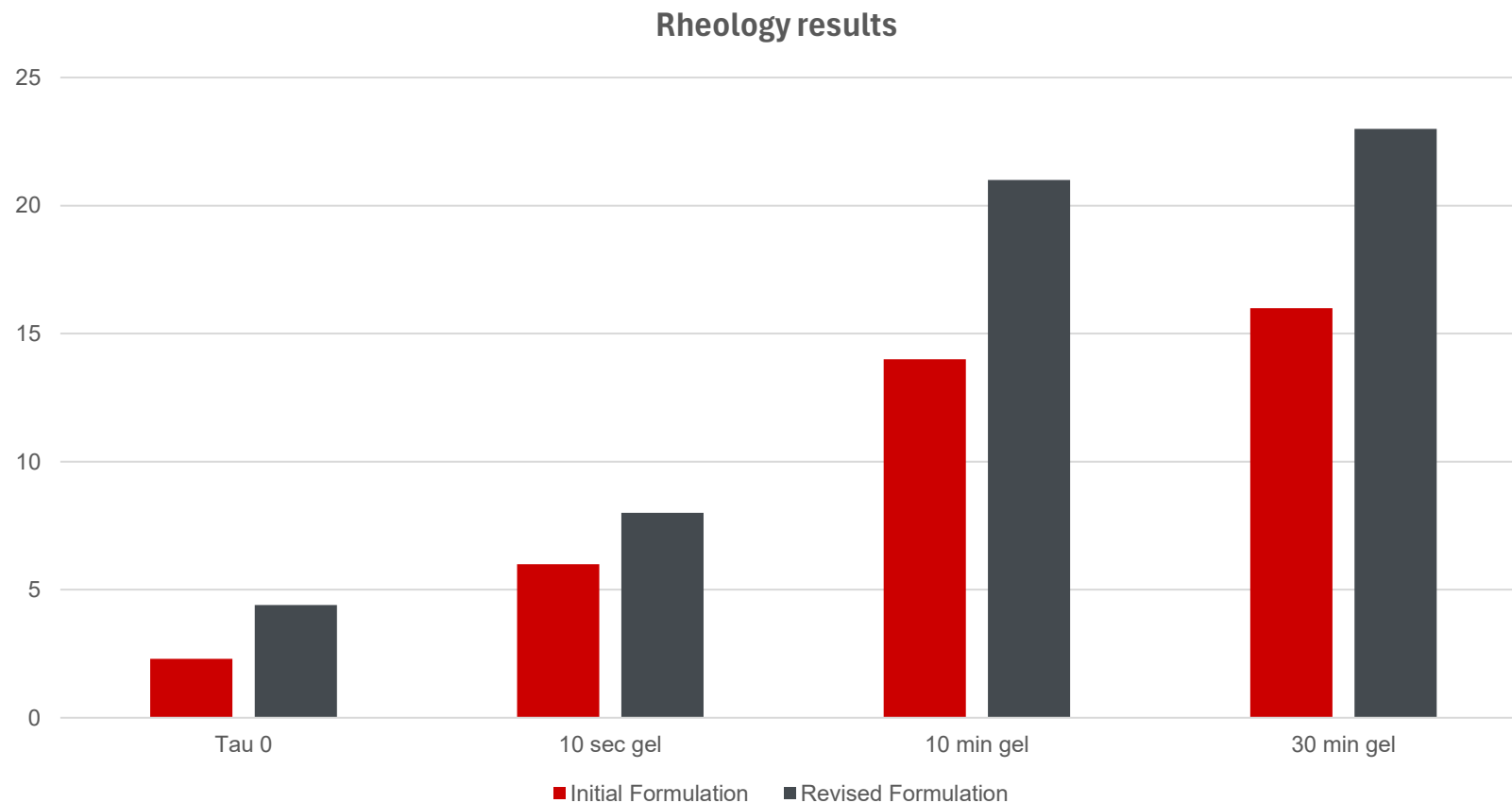
Brookfield Stepdown Rheology



Fluid Stability

Halliburton Baroid – NCS operation, platform drilling.

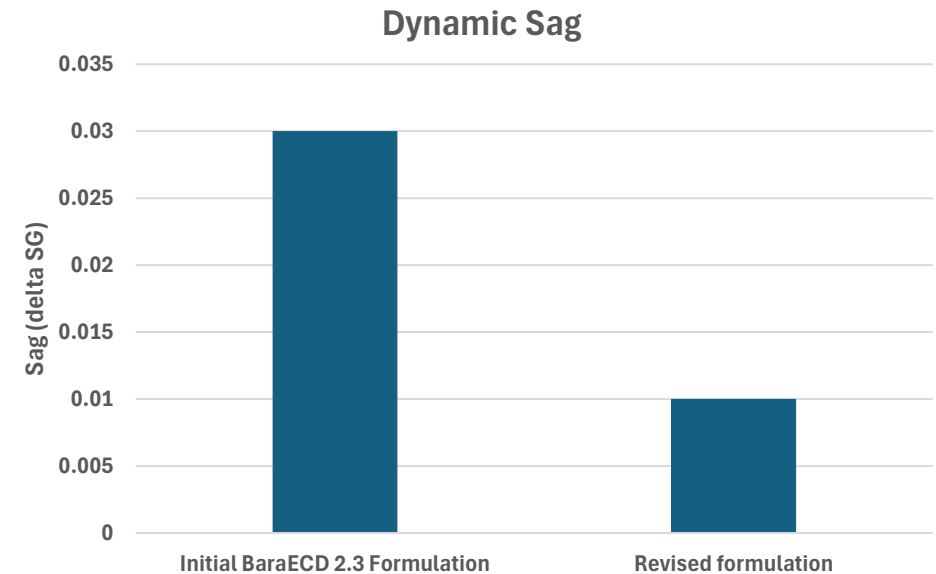
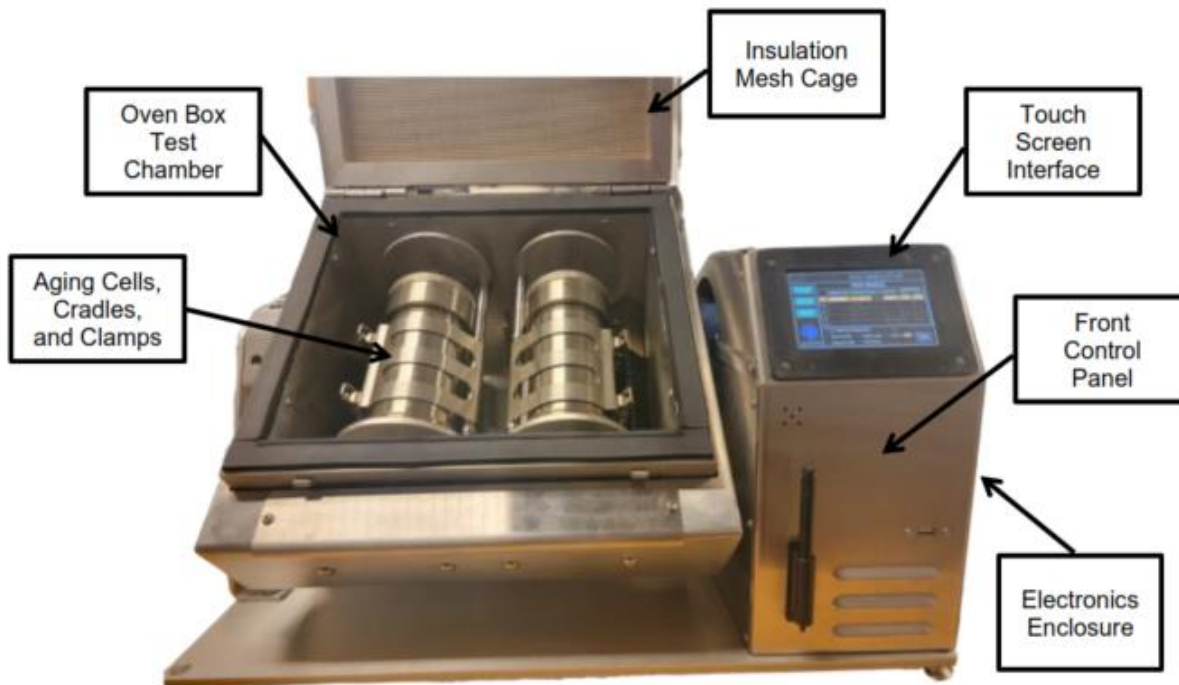
- **Formulation enhanced with Suspension Package II**



Fluid Stability

Halliburton Baroid – NCS operation, platform drilling.

- **Baroid's Dynamic Sag Simulator**
 - Measure the fluid's ability to suspend barite under dynamic conditions and inclination
 - Run at 80 deg C (BHT), 60rpm, 45 deg inclination for 16 hours



PST-ready fluid delivered from Liquid Mud Plant

Halliburton Baroid – NCS operation, platform drilling.

- **Challenge 2 – PST fluid preparation**

- Tripping fluid circulated over 325 mesh screens to meet PST spec
- Fluid volume handling limitations required this to be on critical path
- Rig and well solids negatively impact on time taken – 72 hours
- Additional time hole is left open prior to running screens
- Significant additional costs to the operation
- Previously, mixing SRF at LMP not without issues
 - Cold temperatures impacting on products yielding
 - LMPs not spotlessly clean
 - Long time taken to screen over shakers to meet PST spec
 - Loading PST spec fluid after solids-laden fluids
 - Poor communication

PST-ready fluid delivered from Liquid Mud Plant

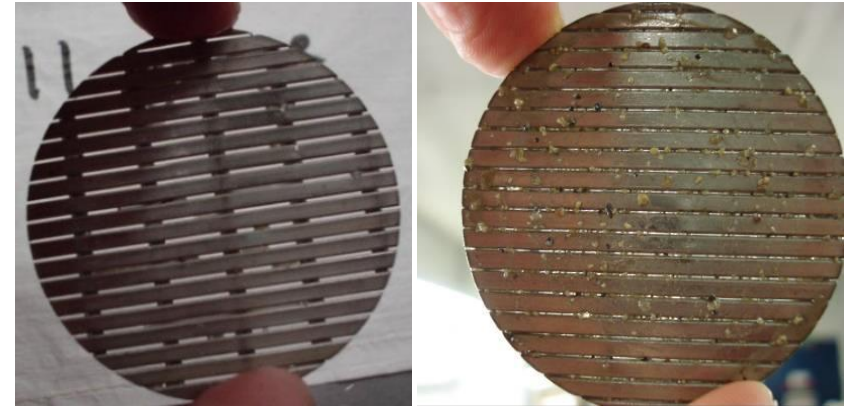
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Fully assembled PST equipment



PST cell with 1.93" (49mm)
screen coupon inserted



Examples of screen coupon before and
after test

- 250-micron wire-wrapped screen
- 3 x 1 litre at 10 psi
- No indications of screen plugging
 - (time/particles)

PST-ready fluid delivered from Liquid Mud Plant

Halliburton Baroid – NCS operation, platform drilling.

- **Developed Solutions (2) – PST fluid in the LMP**
 - MudCube installed at Risavika LMP to screen fluid to PST
 - Works with a screening belt under negative pressure, mitigating low temperature issues.
 - Rigorous testing regime implemented to ensure that fluid is prepared to the customer's required standard.
 - Fluid shipment from LMP to rig to be managed under strict conditions to avoid contamination. High awareness and co-operation amongst rig crew to isolate fluid in dedicated pits.
 - Effective communication



Customized fluids for reservoir drilling and completion

Halliburton Baroid – NCS operation, platform drilling.

- **Results**

- Stable fluid column throughout operation providing a stable well bore in which to run screens.
- PST fluid transferred from LMP, to supply vessel, to rig pits without contamination.
- Rig time saving of approximately 72 hours compared to previous wells.
- Significantly less open hole exposure time.
- Fluid successfully displaced into well and screens run in hole without issue.
- Since introducing this method, the wells are producing at or above expectations.



THANK YOU



Example Fragile Gel Measurement – BaraECD 3.3

- SPE 178946

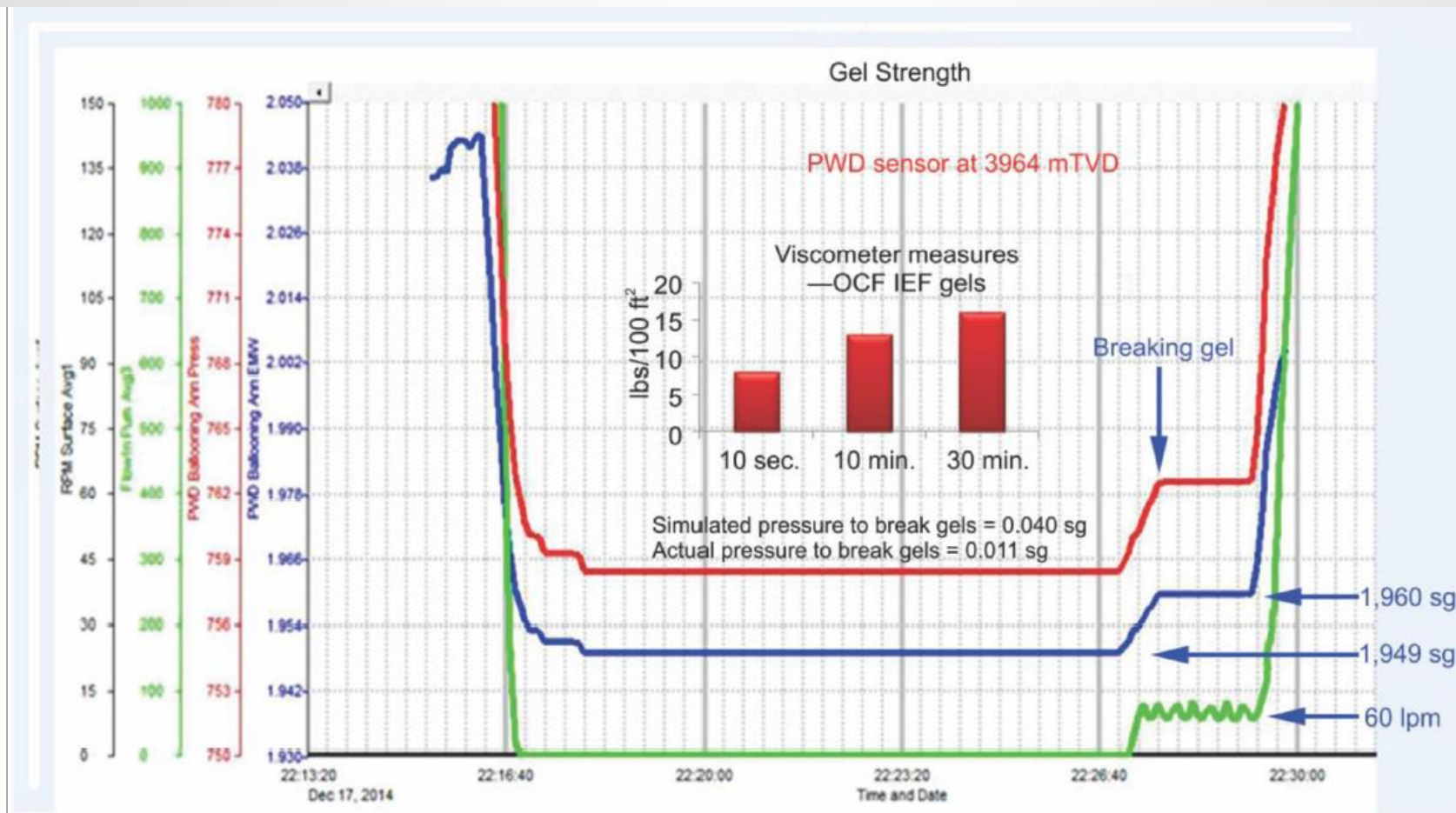


Figure 7—Gel strength test conducted in order to verify the OCF IEF's fragile gel structure and the low pressure required to break gels on connections.