

DELTA-TEQ™

Low-pressure-impact drilling fluid

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Global Product Line Manager

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Industry challenges

Understanding the Challenges

- Poor ECD's management in narrow mud window
- Pressure Spikes resulting in breaking down formation
- Hole cleaning issues due to pressure limitations
- SAG
- Mud gelification leading to high surge pressures
- Massive losses
- NPT
- Increased drilling days
- Increased operation cost

DELTA-TEQ – Low-Pressure-Impact Drilling Fluid

- **Engineered to minimize the delta between ESD and ECD**
- **Low Hydraulic Pressure**
 - Enhanced ECD management
- **Rapid Set/Easy Break Profile**
 - Non-progressive gels structure
 - Avoid Pressure Spikes and Protect formation against Surge Pressures
- **“Viscosity Clutch”**
- **Optimized Low-Shear Rate Viscosity**
 - Improved Hole clean
- **Limiting High Shear Rate Viscosity**
 - Reduce “wasted” pressure and maximize flow rates and improve drilling efficiency

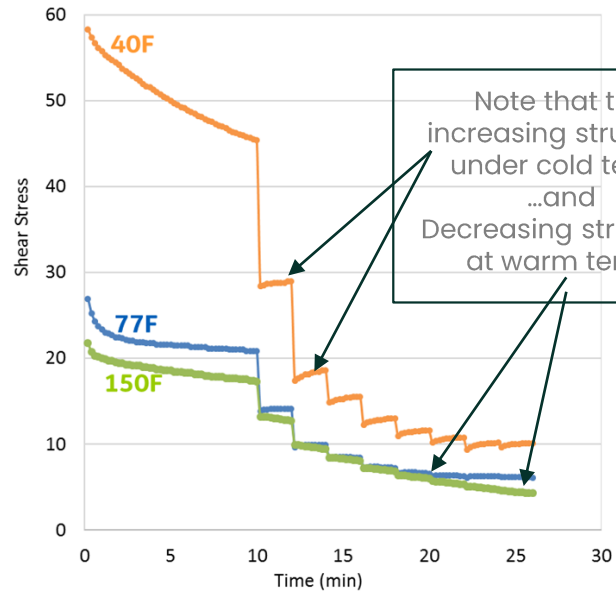
FRACTURE
GRADIENT

DELTA-TEQ: from research to application

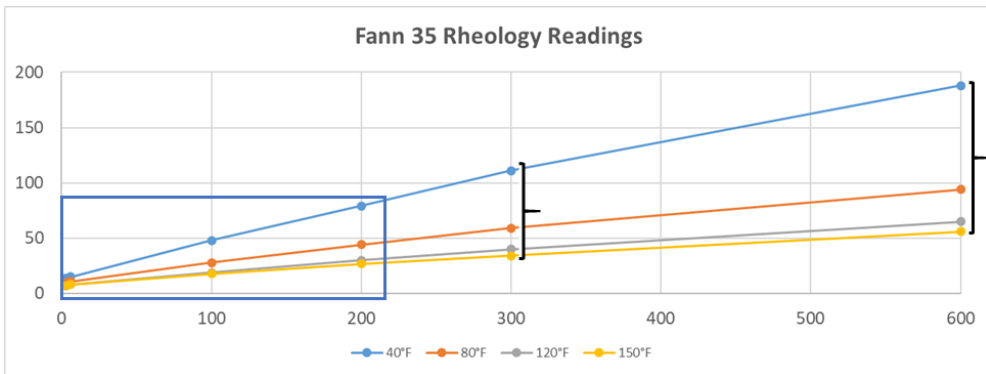
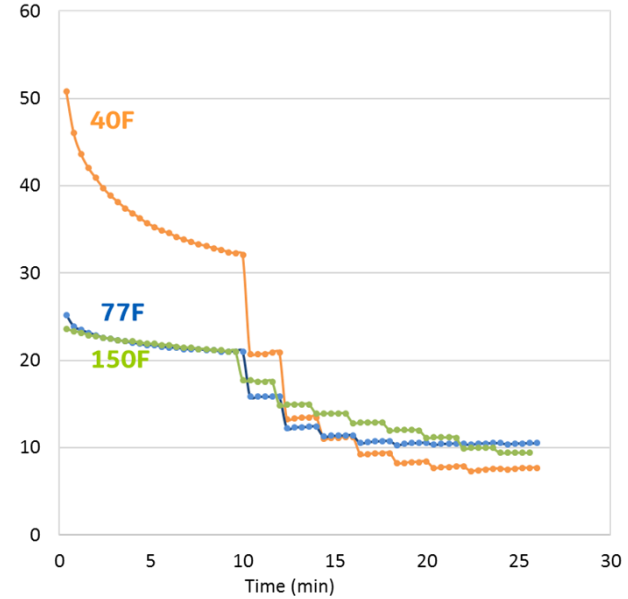
Lab Work

- **Historical Data (2017 – 2018)**
- + 900 formulation tested
- Environmental tests 4 times to ensure repeatability
- VSST < 0.50 ppg
- Contaminations, pilot conversion tested
- Performance comparisons against legacy benchmarks
- Elastomer compatibilities
- SAG stability between 0.50 to 0.53

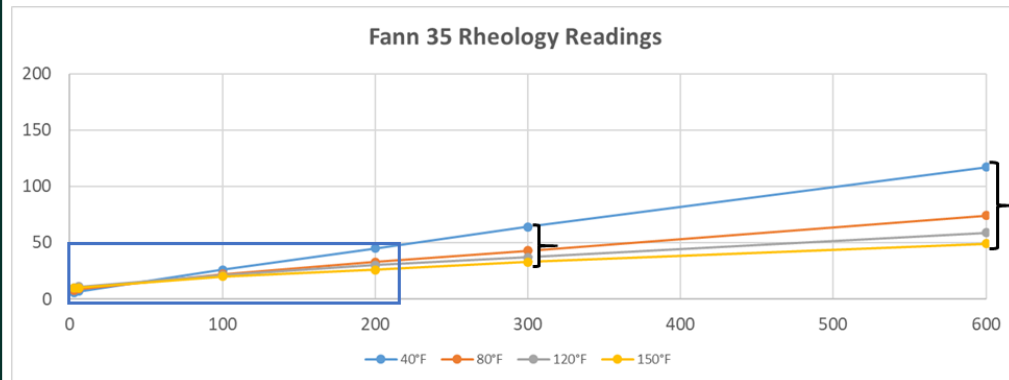
Rheology & step down test 12 ppg, 275F



The structure remains flatter with DELTA-TEQ across all temp ranges



Previous CR Generation



DELTA-TEQ

PV 40F: 31% less
PV 150F: 27% less

DELTA-TEQ™ Case histories from W Hemisphere

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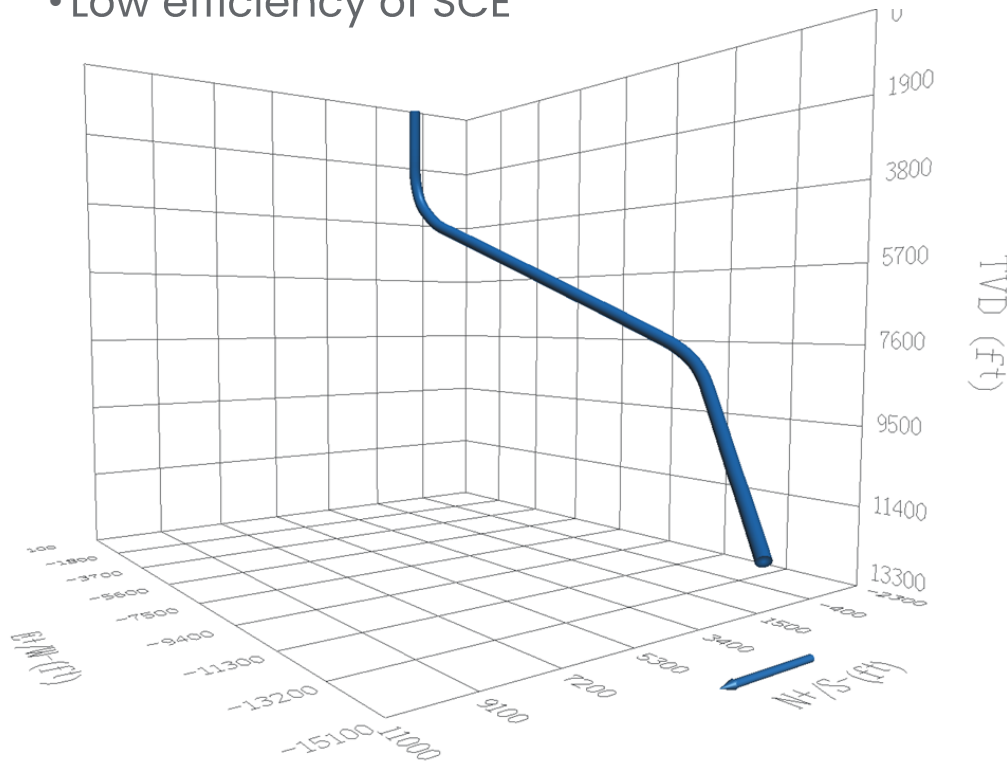
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DELTA-TEQ drilled challenging, large deviated well in GoM

CHALLENGE

- Offshore logistics on platform rig
- Hole-cleaning in 17-1/2", 60° borehole; pump limitations
- Low efficiency of SCE



SECTION SUMMARIES

17 ½" section with 60° Inclination

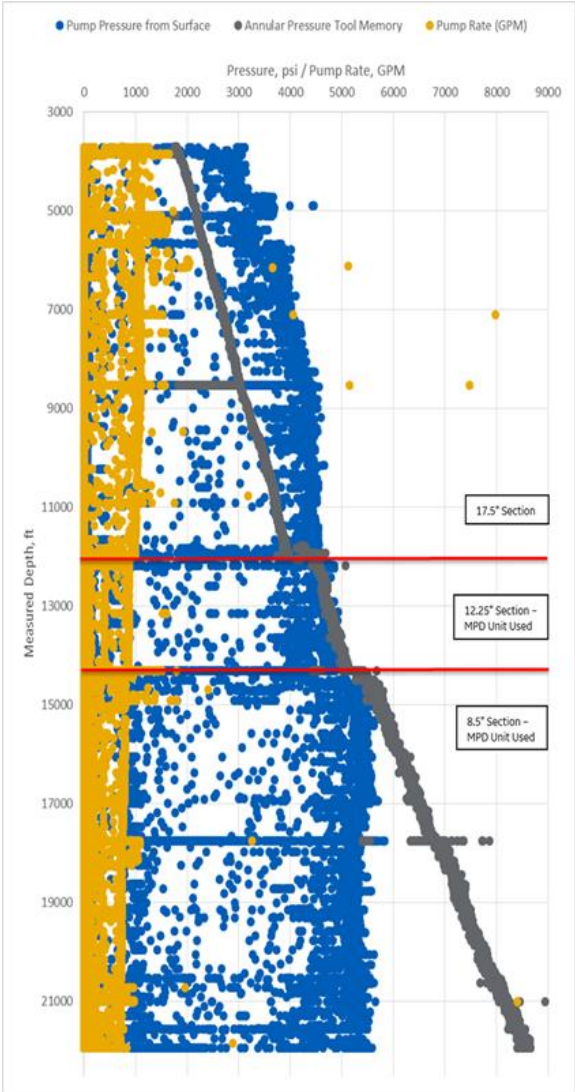
- Reduced HSRV allowed a larger pump liner, achieving the req'd Q_{min} of >1100 GPM
- Maintained ECD 0.5 ppg lower than the FG
- Remained highly stable, even after taking on water (10%) and solids (14%) contamination

12 ¼" and 8 ½" section with 66° Inclination.

- MPD was used to mitigate well control risks
- Density 11 ppg – 13.5 ppg
- Properties remained stable and consistent throughout the sections

Objectives were met and customer stated this well could not have been drilled without DELTA-TEQ DW

GoM application fluids data



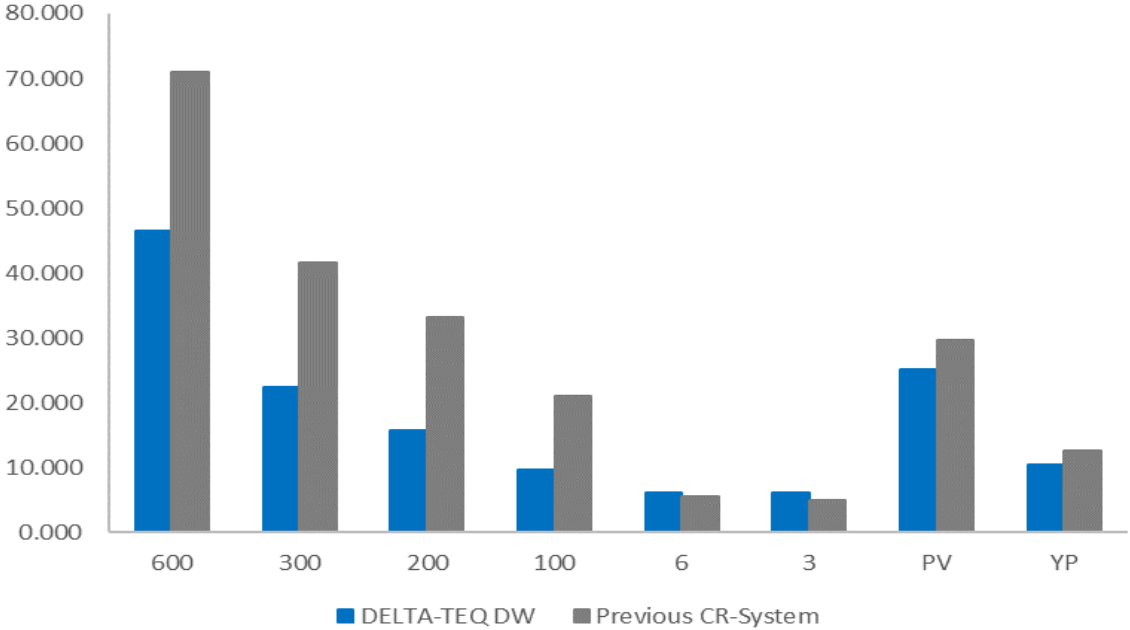
DELTA-TEQ

- Mud weigh 12 ppg
- 75/25 OWR
- LGS 10.4%

Prev. CR-System

- Mud weigh 12 ppg
- 75/25 OWR
- Fresh Lab Mud

HPHT Properties Standard Deviation



GoM Application SAG Data

Test data

- Mud weigh 11 ppg
- 7 days Static Test @ 200F
- SAG 0.5 ppg

	40°F	80°F	120°F	150°F
Plastic Visc, cP	134	78	46	32
Yield Point, lbf/100 ft ²	24	21	23	21
10 second Gel, lbf/100 ft ²	23	22	22	19
10 minute Gel, lbf/100 ft ²	53	48	42	32
30 minute Gel, lbf/100 ft ²	55	49	44	36
Electric Stability Meter (23D), Volts	382			
HHP @ 200°F, cc	4.4			
Static age density (bottom third), sg	1.382			
600 rpm Reading	292	177	115	85
300 rpm Reading	158	99	69	53
200 rpm Reading	111	71	51	41
100 rpm Reading	64	42	33	28
6 rpm Reading	18	13	14	13
3 rpm Reading	15	13	13	12

Test data

- Mud weigh 12.5 ppg
- 1 day / 24 hrs. Static Test @ 250F
- SAG 0.05 ppg

	40°F	80°F	120°F	150°F
Density, lbm/gal	12.5			
Plastic Visc, cP	122	69	44	31
Yield Point, lbf/100 ft ²	26	14	12	11
10 second Gel, lbf/100 ft ²	12	11	16	13
10 minute Gel, lbf/100 ft ²	33	37	35	29
30 minute Gel, lbf/100 ft ²	35	39	37	31
Electric Stability Meter (23D), Volts	490			
Density of bottom 1/3, lbm/gal	12.55			
600 rpm Reading	270	152	100	73
300 rpm Reading	148	83	56	42
200 rpm Reading	103	58	41	31
100 rpm Reading	55	32	25	20
6 rpm Reading	10	7	8	8
3 rpm Reading	9	6	7	7

Test data

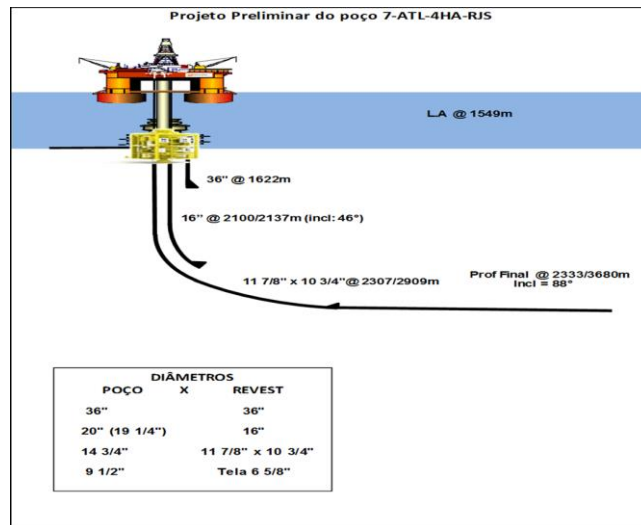
- Mud weigh 13.5 ppg
- 7 days Static Test @ 250F
- SAG 0.2 ppg

	40°F	80°F	120°F	150°F
Density, lbm/gal	13.5			
Plastic Visc, cP	100	60	40	30
Yield Point, lbf/100 ft ²	17	14	15	12
10 second Gel, lbf/100 ft ²	12	15	20	20
10 minute Gel, lbf/100 ft ²	34	42	38	39
30 minute Gel, lbf/100 ft ²	39	45	40	40
HHP @ 250°F, cc	6.8			
Electric Stability Meter (23D), Volts	1167			
Density of bottom 1/3, lbm/gal	13.7			
600 rpm Reading	217	134	95	72
300 rpm Reading	117	74	55	42
200 rpm Reading	82	52	40	32
100 rpm Reading	46	30	25	20
6 rpm Reading	9	8	9	10
3 rpm Reading	8	7	8	9

DELTA-TEQ DW improved ECD management, and AutoTrak™ efficiency in Brazil deepwater

CHALLENGE

- Narrow window Collapse vs Fracture Gradient 0.7 ppg
- Very soft formation
- Hole-cleaning in 14-3/4", 88° borehole; ECD limitations
- Severe losses while drilling and running casing
- High DLS for the BCS Pumps



OUTCOME

- Increase Flow Rate by 14% & ROP by 48% and no losses experienced
- Constant ECD behavior throughout the section
- Lowered ECD by 0.22 ppg compared to offset wells
- Easy to maintain while drilling
- 200 psi less pressure on Cement Operation compared with Offset well
- **MICRO-PRIME** applied successfully with desirable cleanness after 1 full circulation.

With DELTA-TEQ (SBM) was possible to confirm higher efficiency in AutoTrak sleeve behavior related to previous well in this section that indicates well in gauge. (*Project Manager – BH*)

Brazil Application Hydraulic simulation

	SBM	Previous CR-System	DELTA-TEQ™
ECD w cuttings	9.81	9.73	9.59
ECD wo cuttings	9.52	9.50	9.46
ΔP Annulus	203	172	117
ΔP Drill string	1362	1347	1325
SPP	2257	2208	2186
ΔP ECD - ESD	0.47	0.39	0.25

43% 32%

**IMPROVEMENT
IN ANNULAR ΔP**

SBM

Mud Weight 9.30 ppg

Csq Shoe Bottom

	ppg	ppg
ECD w/ Cuttings	9.54	9.81
ECD wo/ Cutting	9.40	9.52
ESD	9.34	9.34
Pore Pressure	0.00	0.00
Fracture Pressure	0.00	0.00

Circulation Data

Flowrate 700 USgal/m

Riser Flowrate 300 USgal/m

ROP 10.00 m/hr

RPM 100 RPM

TFA 1.3530 in²

Bit Type

WOB 15.00 kibr

Choke Pressure psi

SPP 2257 psi

System Pressure Loss

Drill String	1362 psi
Motor No-Load	0 psi
Motor DP Op	0 psi
MWD	430 psi
Bit	199 psi
Annulus	203 psi
Surf Equipment	63 psi

Previous CR-System

Mud Weight 9.30 ppg

Csq Shoe Bottom

	ppg	ppg
ECD w/ Cuttings	9.51	9.73
ECD wo/ Cutting	9.39	9.50
ESD	9.34	9.34
Pore Pressure	0.00	0.00
Fracture Pressure	0.00	0.00

Circulation Data

Flowrate 700 USgal/m

Riser Flowrate 300 USgal/m

ROP 10.00 m/hr

RPM 100 RPM

TFA 1.3530 in²

Bit Type

WOB 15.00 kibr

Choke Pressure psi

SPP 2208 psi

System Pressure Loss

Drill String	1347 psi
Motor No-Load	0 psi
Motor DP Op	0 psi
MWD	430 psi
Bit	199 psi
Annulus	172 psi
Surf Equipment	61 psi

DELTA-TEQ™

Mud Weight 9.30 ppg

Csq Shoe Bottom

	ppg	ppg
ECD w/ Cuttings	9.45	9.59
ECD wo/ Cutting	9.36	9.46
ESD	9.34	9.34
Pore Pressure	0.00	0.00
Fracture Pressure	0.00	0.00

Circulation Data

Flowrate 700 USgal/m

Riser Flowrate 300 USgal/m

ROP 10.00 m/hr

RPM 100 RPM

TFA 1.3530 in²

Bit Type

WOB 15.00 kibr

Choke Pressure psi

SPP 2186 psi

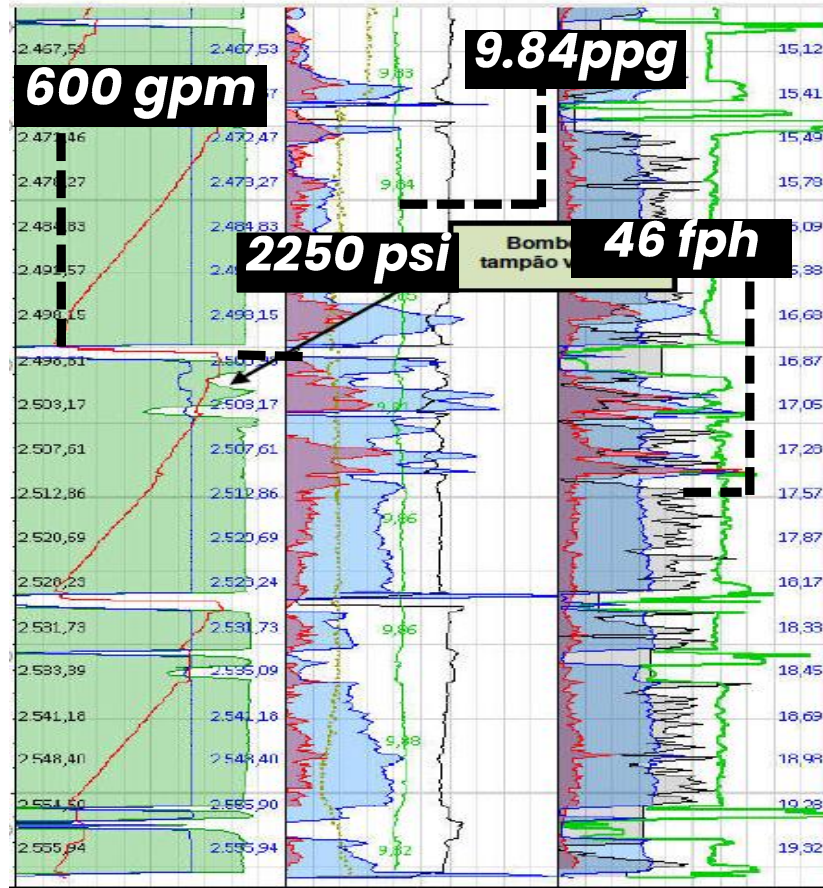
System Pressure Loss

Drill String	1375 psi
Motor No-Load	0 psi
Motor DP Op	0 psi
MWD	432 psi
Bit	199 psi
Annulus	117 psi
Surf Equipment	63 psi

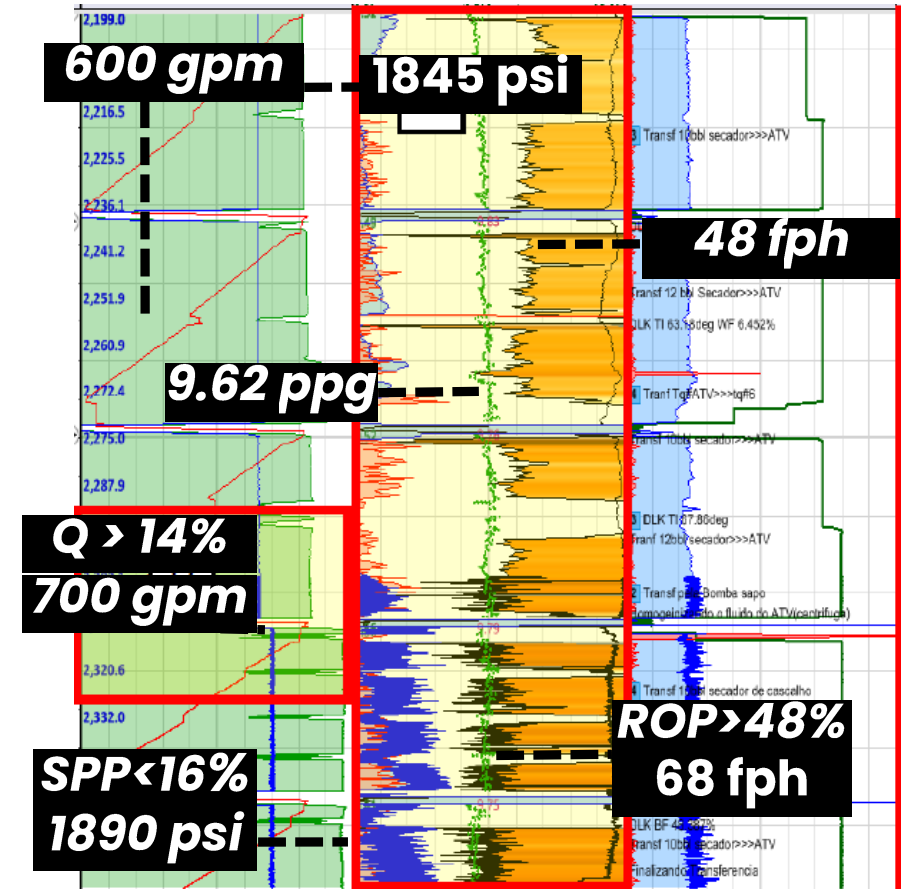
All case details identical except the fluid system

Brazil application CoPilot report

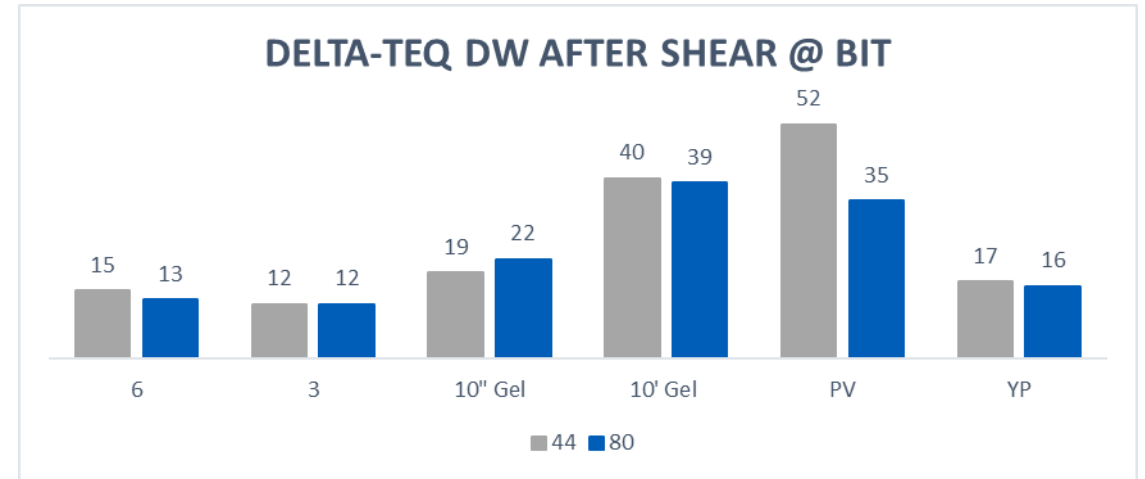
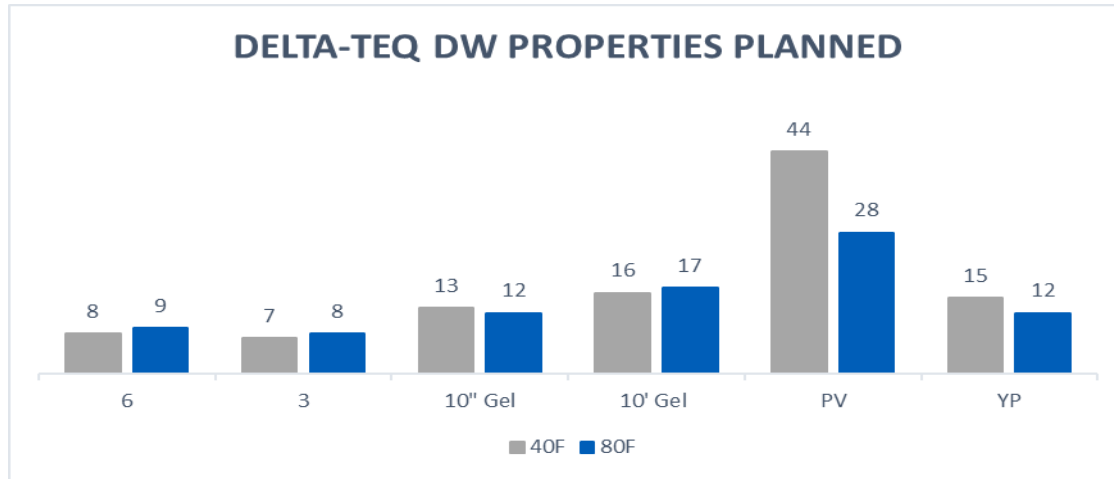
OFFSET WELL



DELTA-TEQ

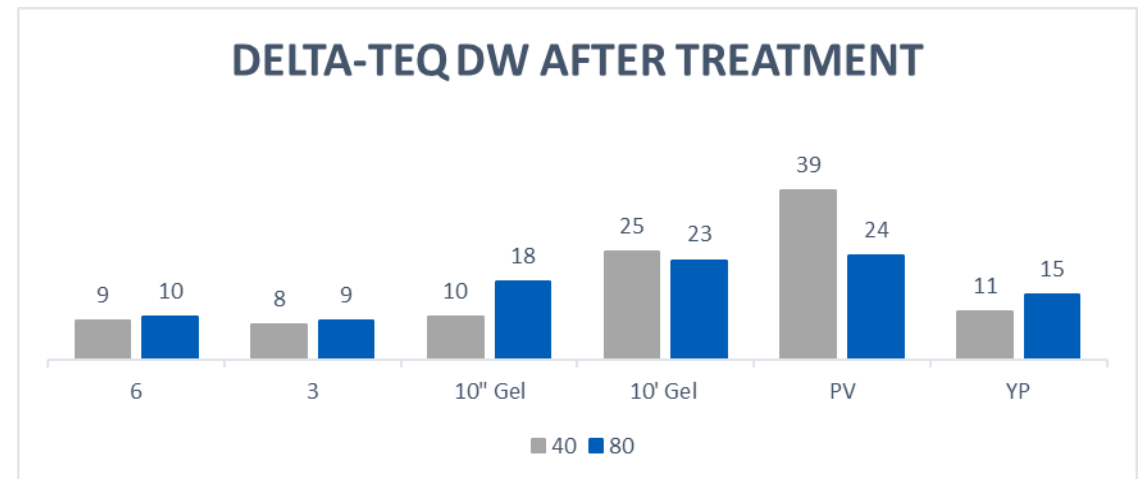


Brazil application rheology behavior and treatment

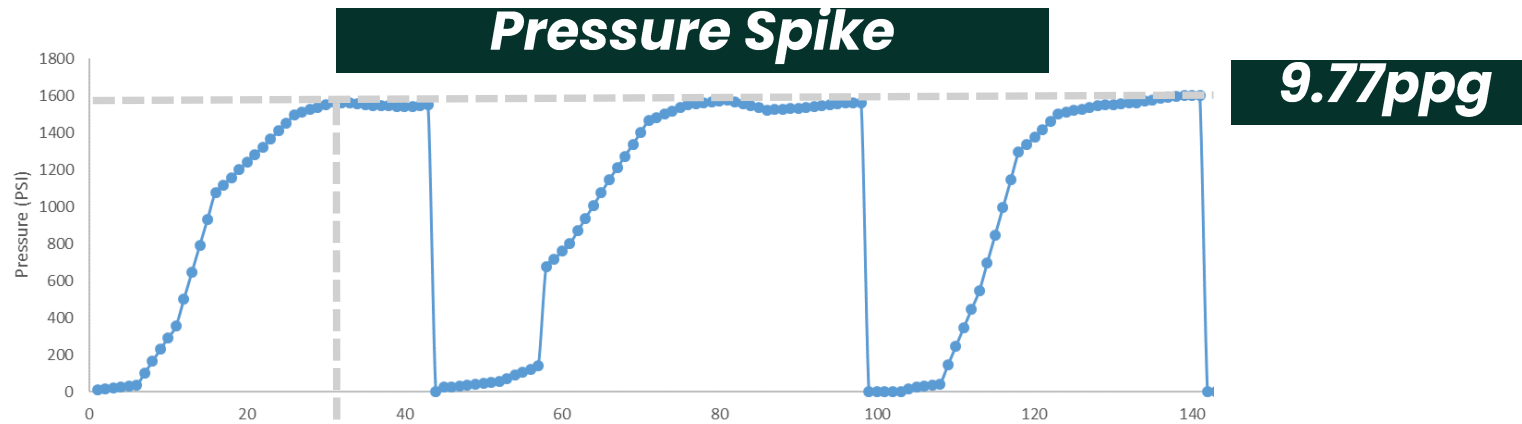


TREATMENT

- 5% Based Fluid
- 0.5 ppb Low Temperature Rheology Modifier

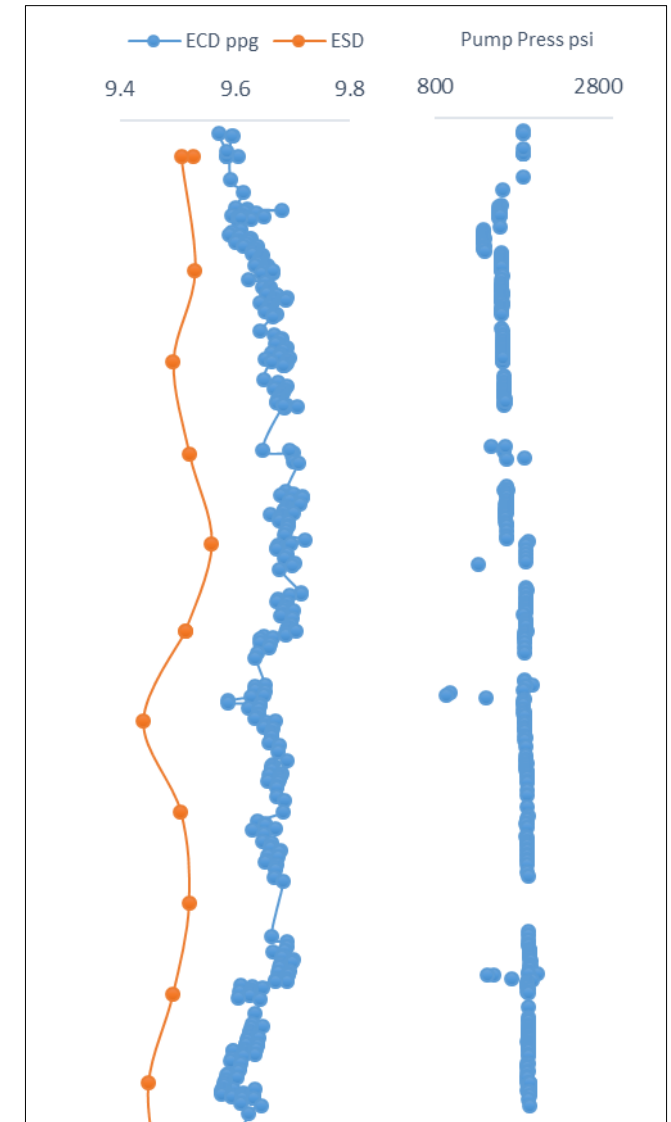


Brazil application pressure analysis



30 sec to stabilize Pressure

	SPP	ECD	ESD	ECD-ESD
Max	2085.853	9.721	9.559	0.162
Min	1414.083	9.572	9.432	0.140
Average	1884.740	9.642	9.491	0.151



DELTA-DRILL™ (LTMO) Delivered ERD well in Colombia

CHALLENGES

- Extended Reach well (16,888 ft MD, 9500 ft TVD, 10926 ft Horizontal displacement) with 76° Inclination.
 - Stuck pipe in 8 ½" x 9 ½" section
 - Directional BHA lost in hole
 - Stuck 5" Liner
 - Wellbore instability: Cavings and Losses
- Project was suspended due to this major drilling problems

BAKER HUGHES SOLUTIONS

- Use of Low Tox Oil
- **DELTA-DRILL™**
- **NANOSHIELD™** for wellbore stability.

OUTCOMES

- Zero DCF NPT, spills or HSE issues
- Reduced significantly time on trips, compared to previous well.
- No fluid losses while drilling
- No Hole Cleaning or barite sagging issues.



DELTA-TEQ™ Technology

- **Innovative Technology for most challenges wells**
- **Optimized hole cleaning with Viscosity Clutch**
- **Low Impact Pressure Technology**
- **Environmentally acceptable**
- **Permit customers to reduce NPT**
- **Extend the critical drilling window**
- **Flexible, robust, & highly stable fluids formulation**

FRACTURE GRADIENT

Baker Hughes 