
TENEX
Pioneering Materials-based Chemical Technologies for
the Oil & Gas Industry

# Questions

1. Water cut from surrounding pads vs this pad
2. Landing zone(s) for all wells
3. Frac design(s)
4. Bubble point pressure in this area
5. Initial reservoir pressure
6. Any potential out-of-zone deviation
7. Water analysis (same as offset pads?) - help to decide source of water
8. Oil analysis in this pad and offset pads in available (estimated paraffin content? Does the oil look different from offset wells?
9. Surface temperature of frac fluid
10. Trend in WC and GOR since the well was put on production

# FullSTIM

## Tailored Specialty Chemical Packages to Restimulate Producing Wells

# FullSTIM: ALL IN ONE PLACE

- **FullSTIM packages include:**
  1. **Gel/Polymers** (i.e., gel, xl-gel, polyacramide, xanthan, other)
  2. **Hard Inorganic scale** (i.e., iron oxides)
  3. **Organic scale/disposition** (i.e., paraffin & asphaltene)
  4. **Wettability Modification**
  5. **Foaming agents (diverters or Miscible CO2-EOR) ➔ TF1/2**
  6. **Heavy oil Viscosity ➔ CF30/40/50**

**Specialty Blends for each well**

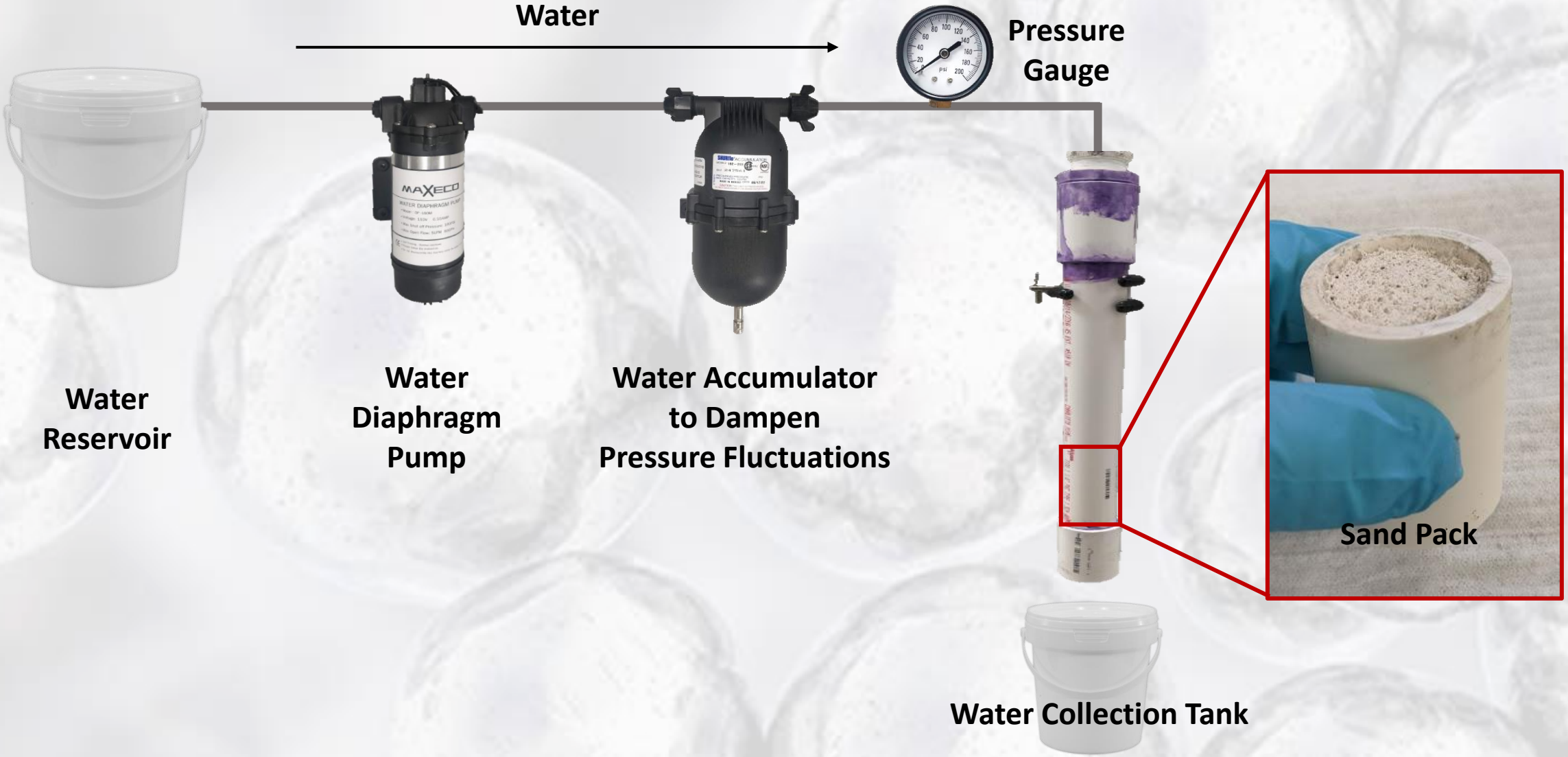
# FullSTIM | Gel Breakers

**Designed to dissolve polymers and gels on the surface or in the formation.**


# Effective on All Common Oilfield Polymers

| Solution | Before (funnel viscosity) | After 5 min (funnel viscosity) | After 24 hr. (funnel viscosity) | Water (100 ml) (funnel viscosity) |
|---|---|---|---|---|
| **Xanthan Gum** | 00 :17 sec | 00:08 sec | 00:03 sec | 00:02 sec |
| **Guar Gum** | 00 :16 sec | 00:03 sec | 00:02 sec | |
| **Xl-Gel** | Clogged funnel Didn't flow | 00:07 sec | 00:05 sec | |
| **HVFR** | 00:27 | 00:03 | 00:02 | |

# Regained Permeability Testing Rig



# Regained Permeability Test Results

| | Core Sample |
|---|---|
| Mineral Content | 100% Sand |
| Particle Size | 40/140 Mesh |
| **Pre-Damage time at 1 L** | **00:00:28** |
| **Damage time at 100 ml gel at 8 gpt** | **00:01:00** |
| **Permeability Loss (after Damage)** | **53.3%** |
| **Post-Treatment at 20 gpt Gel Breaker** | **00:00:26** |
| **Permeability Gain (after Damage)** | **108 %** |

# FullSTIM | Scale Breakers

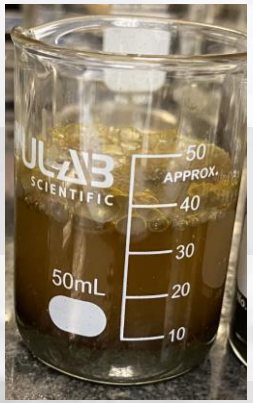
**Designed to dissolve hard inorganic scales on the surface or in the formation.**

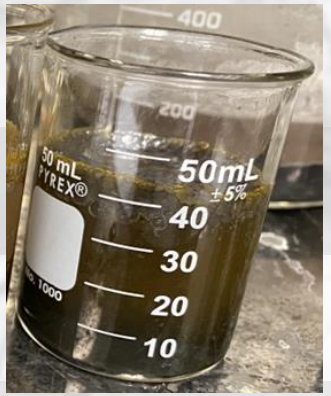
Before

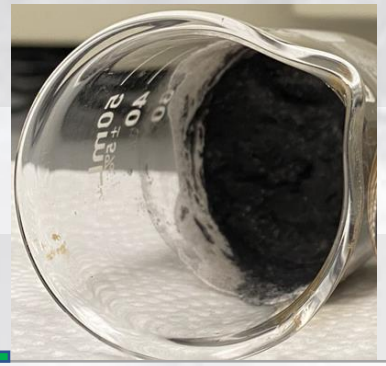
After

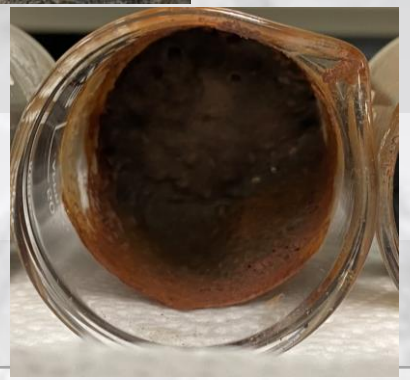
# Static Iron Oxide Dissolution Results

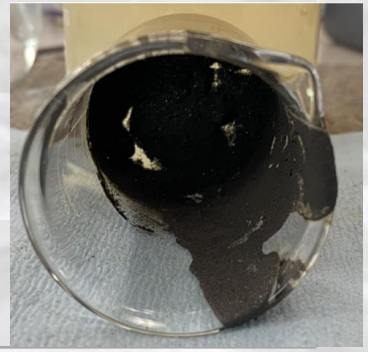
| | HOT WATER | 15% HCl | TSB-1 |
|---|---|---|---|
| Reaction | No | Subpar dissolving, generated gases and corrosion | Effective dissolving, no gases with little corrosion |
| Scale Dissolution | 10 grams Iron Scale; 0 | 10 grams Iron Scale; 0.66 grams | 10 grams Iron Scale; 3.97 grams |

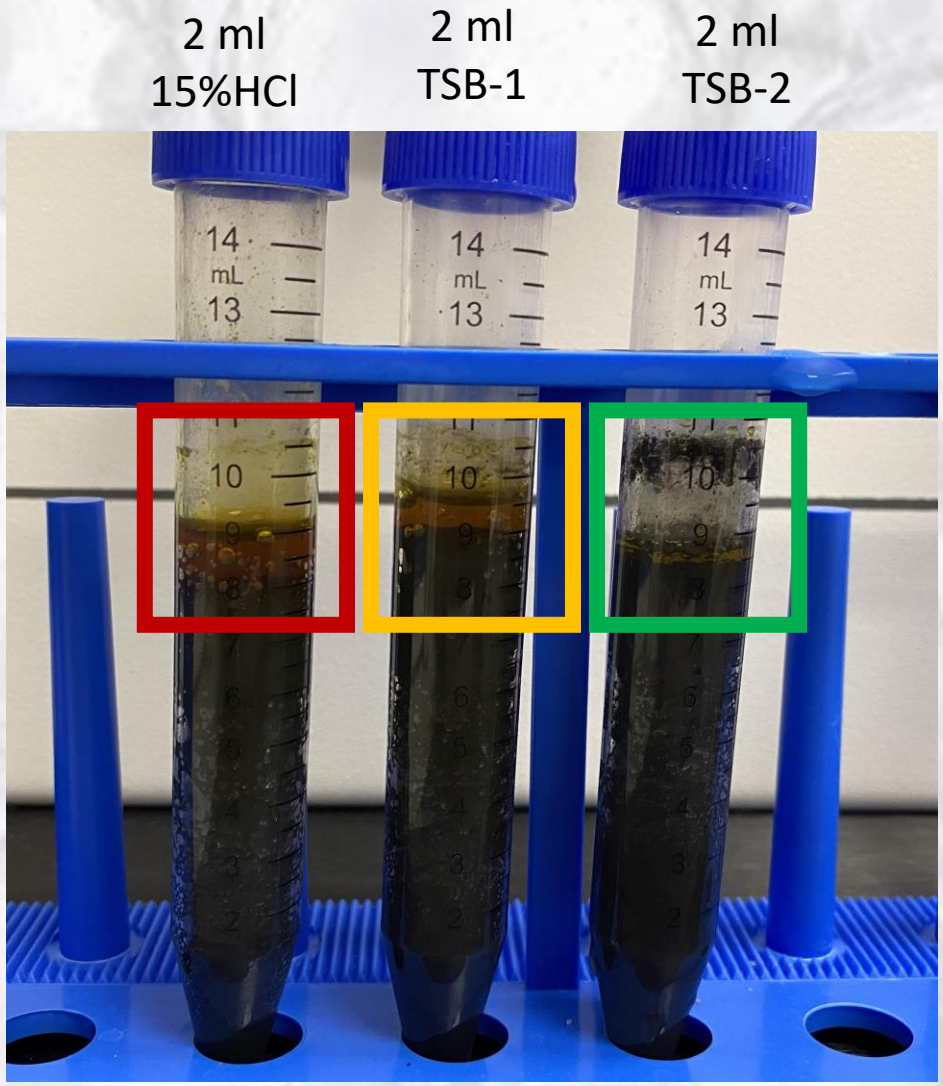




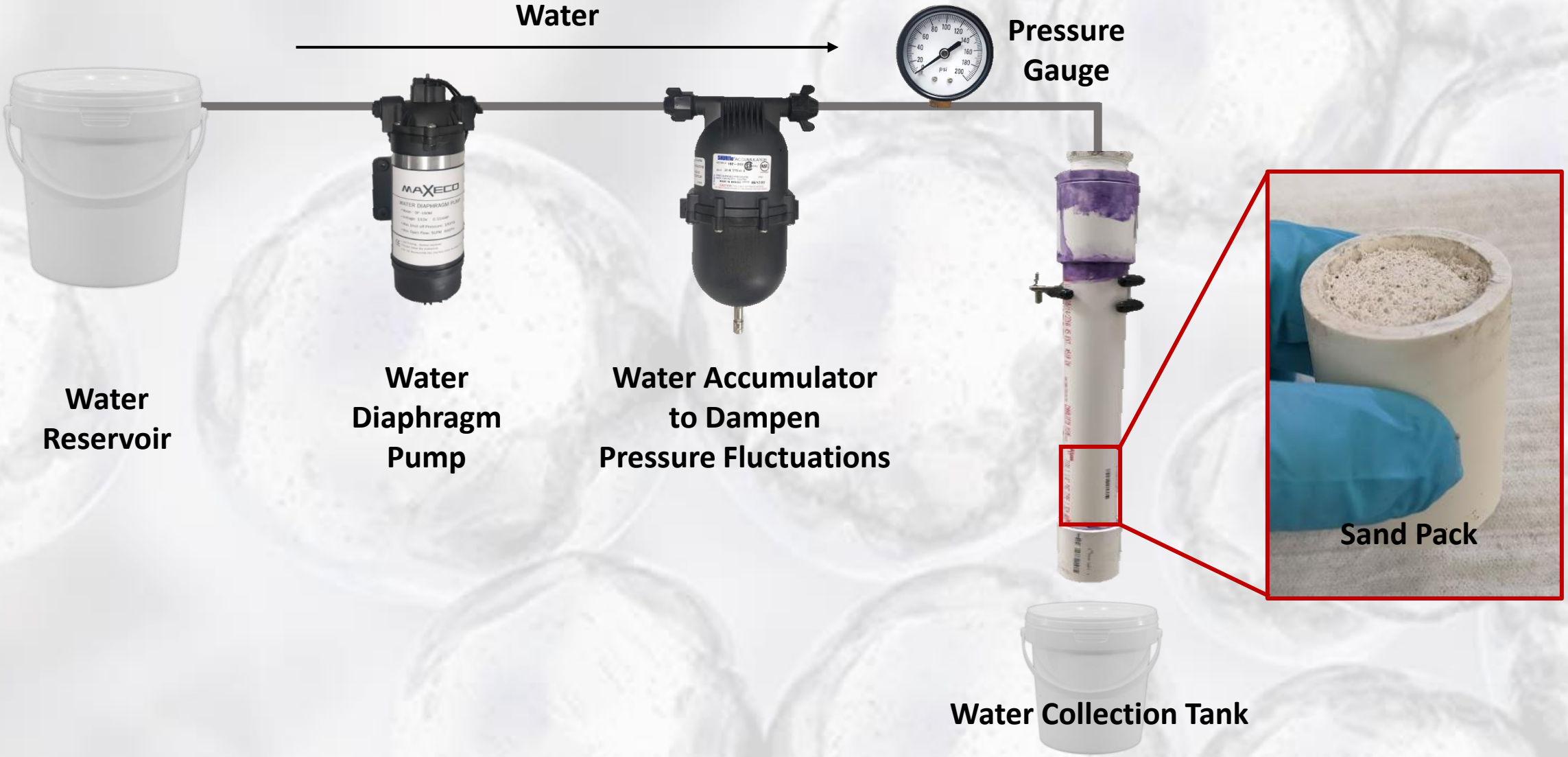
# Static Spontaneous Penetration/Soaking Test

- 8 ml of Iron Oxide was packed inside testing tube then 2 ml of 15%HCl, TBS-1 & TSB-2 were added respectively and soaked for 4 hrs at temperature of 120-160 deg F.

- **Penetration Results:**
  - 15% HCl penetration: **0-10%**
  - TSB-1 penetration: **50-60%**
  - TSB-2 penetration: **80-90%**



# Regained Permeability Testing Rig



# Regained Permeability Test

## Plugging (Before Treatment)

| | Sample#1 | Sample#2 |
|---|---|---|
| Mineral Content | 90% quartz/10% clay | 100% Sand |
| Particle Size | 40/140 Mesh | 40/140 Mesh |
| Pre-Damage time at 1 L | 00:04:21 | 00:00:01 |
| Post-Damage time at 1 L | 01:40:00 | 00:02:45 |
| **Permeability Loss (after Damage)** | **97.9%** | **99.4%** |

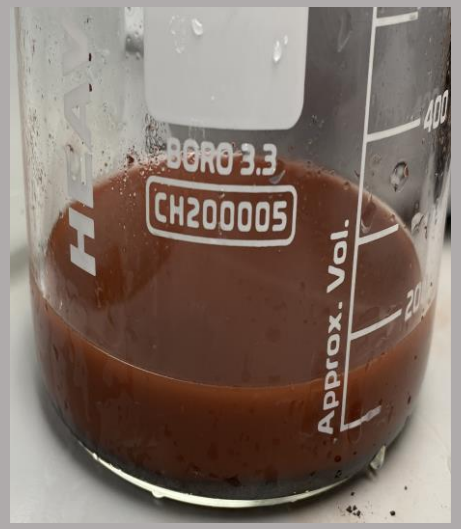
# Regained Permeability Test (Cont'd)

## Unplugging (After Treatment with TSB-2)

| | Sample#1 | Sample#2 |
|---|---|---|
| Soaking Time | 4 hrs | 24 hrs |
| Post-Damage time at 1 L | 01:40:00 | 00:02:45 |
| Time to flow 1 L (after soaking in TSB-2) | 00:22:00 | 00:00:26 |
| **Permeability Gain (After TSB-2 Treatment)** | **455%** | **635%** |

# Regained Permeability Test (Cont'd)

## TSB-2 Effect (After-Soaking Images)

| Sample#1<br>(After 4 hrs Soaking in TSB-2) | Sample#2<br>(After 24 hrs Soaking in TSB-2) |
|---|---|
|  |   |
| Only inorganic scales were dissolved and passed through 200 mesh size | Inorganic scales and sand were dissolved and passed through 200 mesh size |

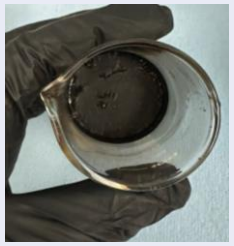
# FullSTIM | CeraFlO™

**Designed to dissolve and inhibit paraffin and asphaltene** in the formation, wellbore, pipelines, transfer lines, well metallurgies, downhole equipment, and difficult-to-reach locations.

## CeraFlO™:

- Dissolves
- Inhibits
- Lowers heavy oil viscosity (increase mobility.

# Dissolution Test (Ambient Conditions)

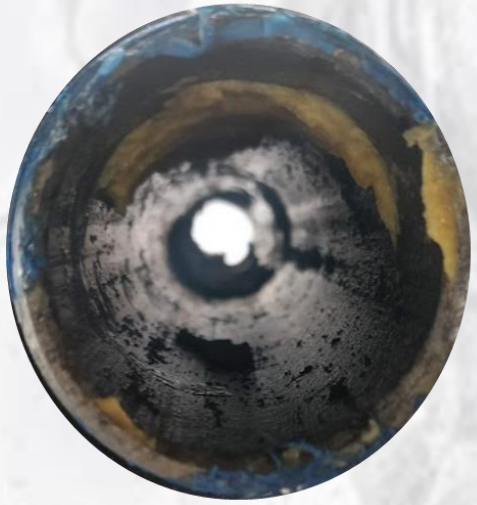
| Solutions | Solutions in beaker after test | Filtration test | Deposition test |
|---|---|---|---|
| CeraFLO |  |  |  |
| Xylene |  |  |  |

# Yard Test Results

Pipe 1

Pipe 2

Before



Pipe 1

Pipe 2

After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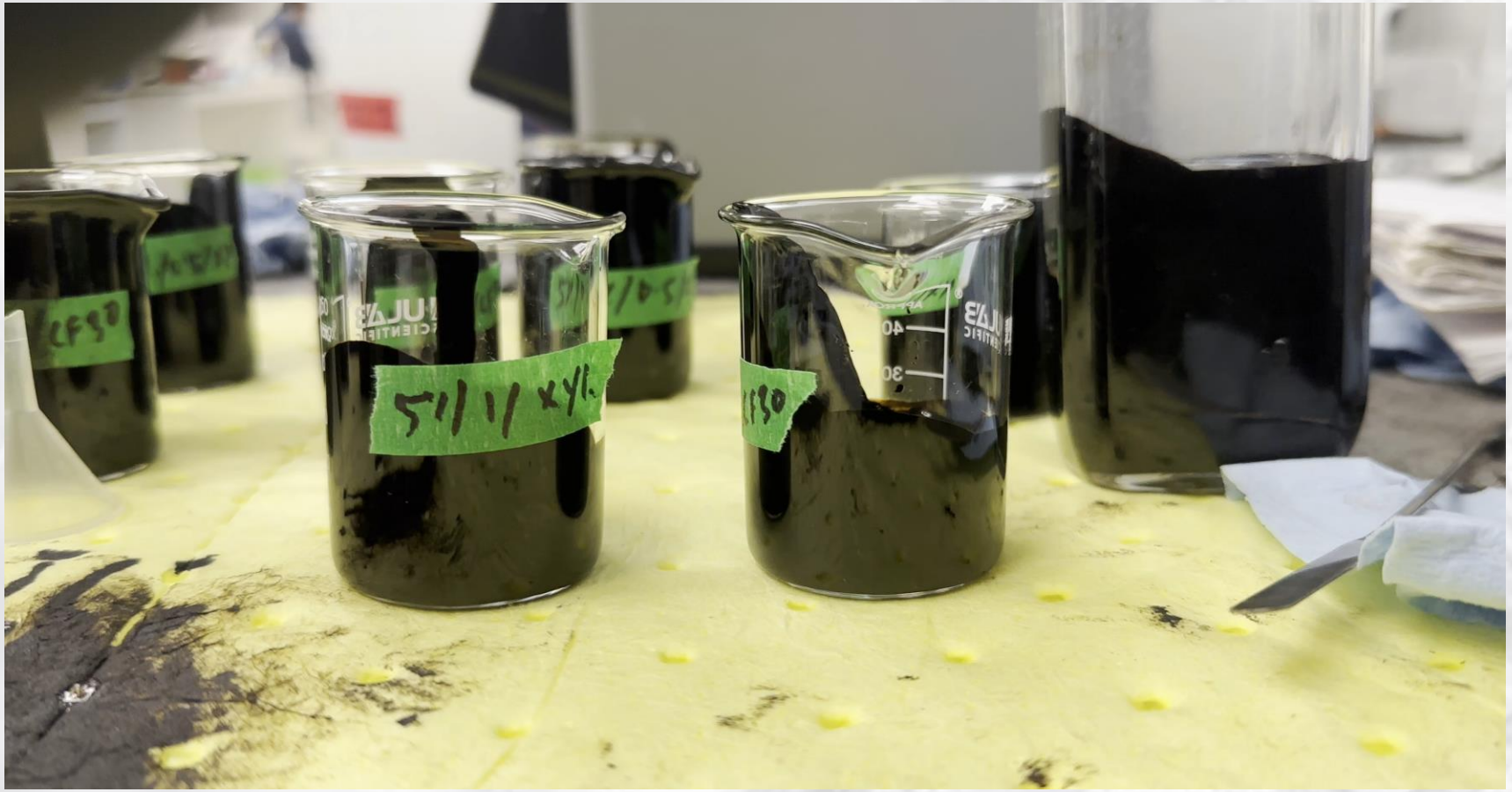
# Inhibition Test Results

- Test on 10% Asphaltene solids in crude oil

| Solidification /Plugging | Control | Xylene | CF-30 | CF-50 |
|---|---|---|---|---|
| The time it takes to form a thick layer around the beaker surface making flow for the whole mixture stagnant | **20 min** | **33 min** | **152 min** | **170 min** |

# Videos for Inhibition Test (1 gpt, 5% Asphaltenes solid)

- Test performed 28 hours after heating the mixture.
- Left beaker: xylene & right beaker: CeraFLO



# Asphaltenic Crude Viscosity Changes

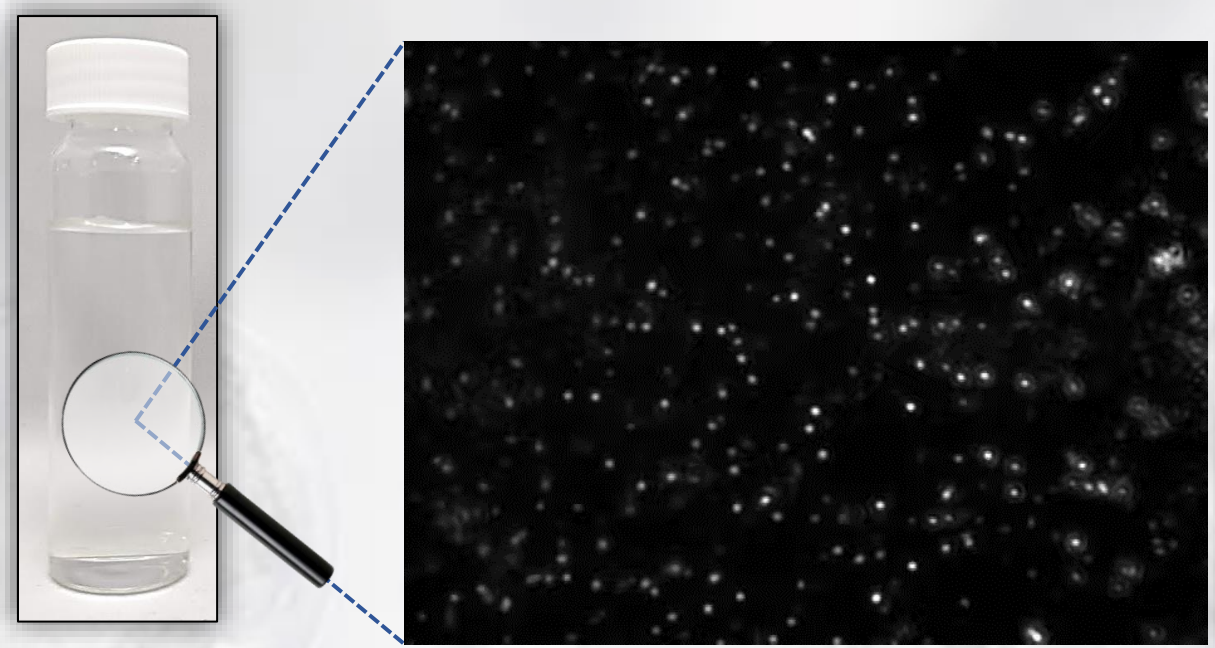
Viscosity test through the funnel pour test after 5hrs.

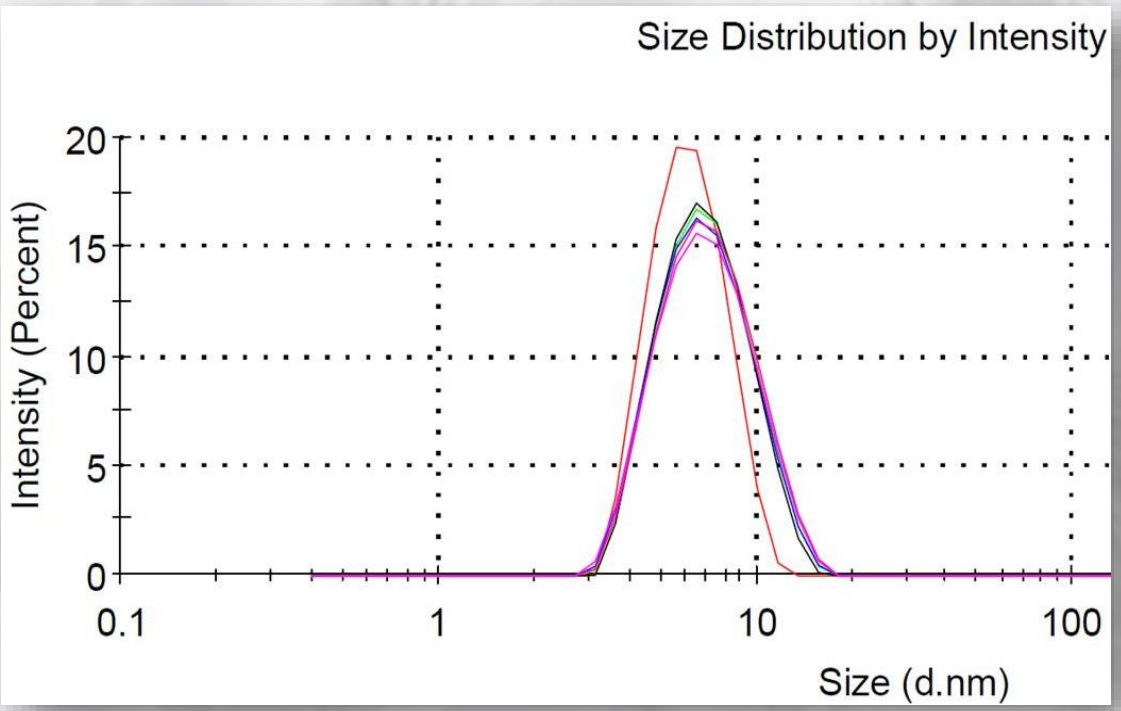
| Concentration (gpt/ppm) | Time taken for 100 ml crude oil (+ 2% asphaltene) to flow through a funnel (sec) | | | |
|---|---|---|---|---|
| | Control | Xylene | CF50 | CF30 |
| 0.1 gpt/100ppm | 83 | 72 (13% drop in viscosity) | 49 (40% drop in viscosity) | 44 (47% drop in viscosity) |
| 0.5 gpt/500ppm | | 56 (32% drop in viscosity) | 34 (59% drop in viscosity) | 29 (65% drop in viscosity) |

# NanoCLEAR®

## Tailored Metal-Oxide Nanofluids for Production Enhancement

# NanoCLEAR® : The Power of Nanoparticles

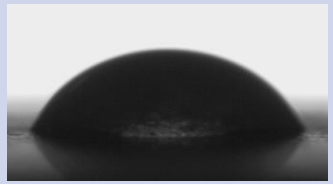
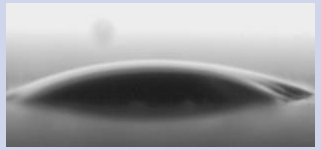


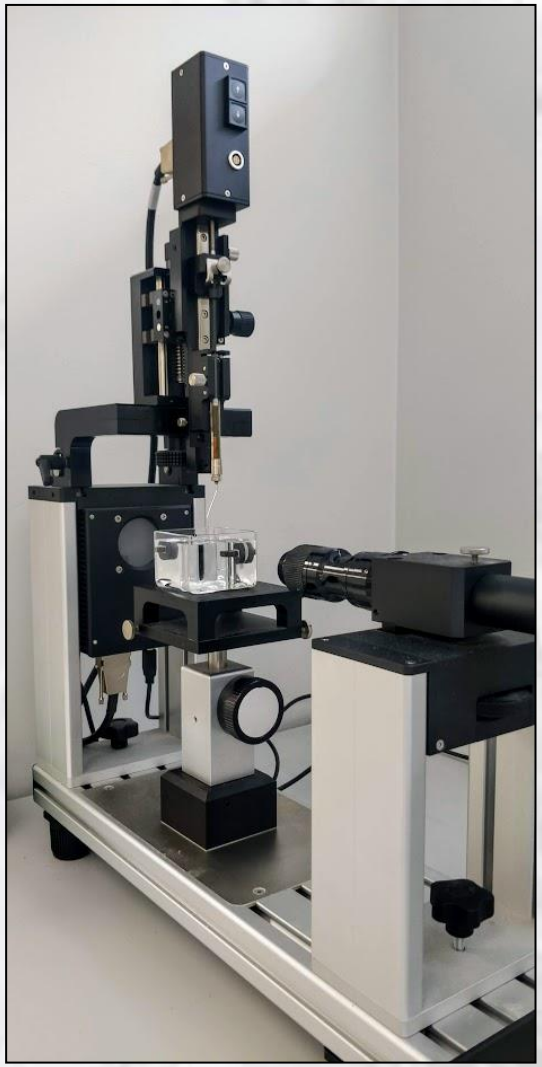



**Tailored metal-oxide nanoparticles that withstand harsh reservoir conditions**

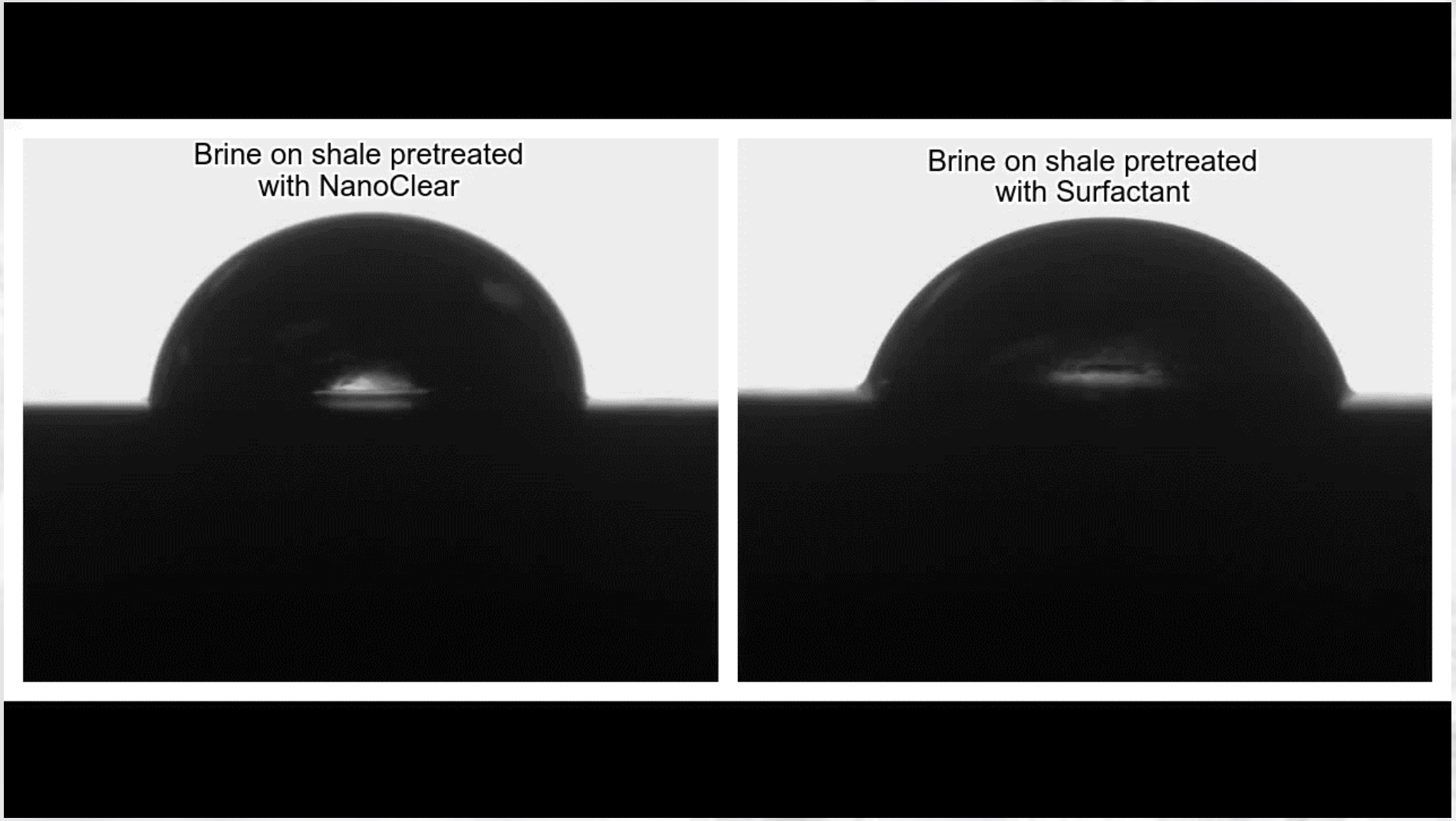
**Nanoparticle-based formulas with size of 3-11 nm**

# Long-term Wettability Alteration Reduces Condensate blockage

| Fluid | Contact Angle | Shape |
|---|---|---|
| Fresh water only | 74.26° |  |
| NanoCLEAR® V1 | 20.98° |  |
| NanoCLEAR® NC51 | 17.82° |  |
| NanoCLEAR® XP14 | 15.05° |  |



# Terminal Contact Angle Demo



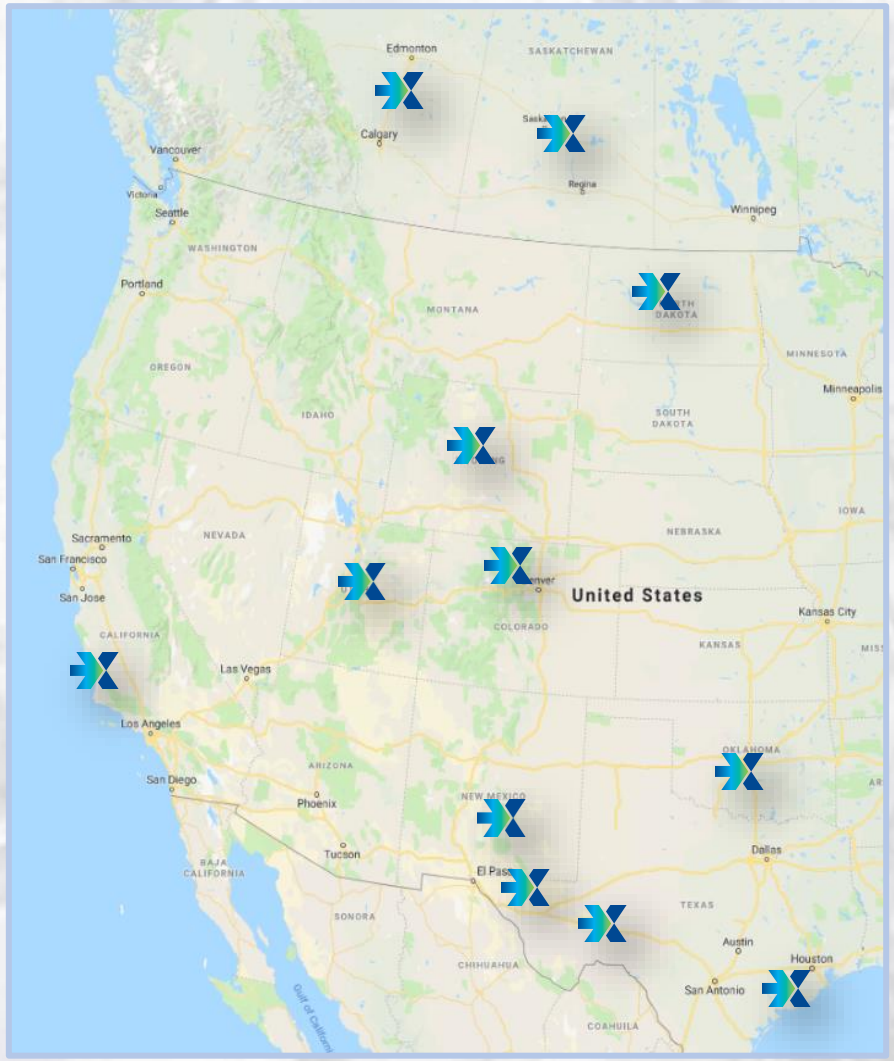
# NanoCLEAR® : Applications and Field History

## NanoClear® Proven Applications:

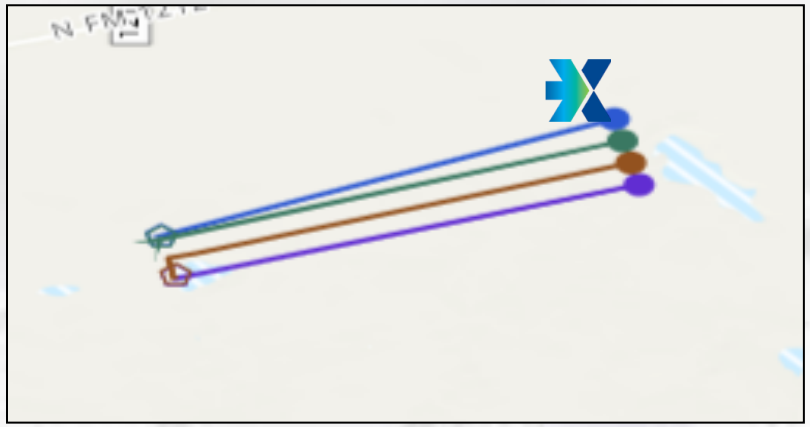
- **New fracs:** additive to common frac fluids
- **Exciting wells:**
  - Stand-alone stimulation treatment
  - Pumped with acids (acid fracs or matrix acidizing)

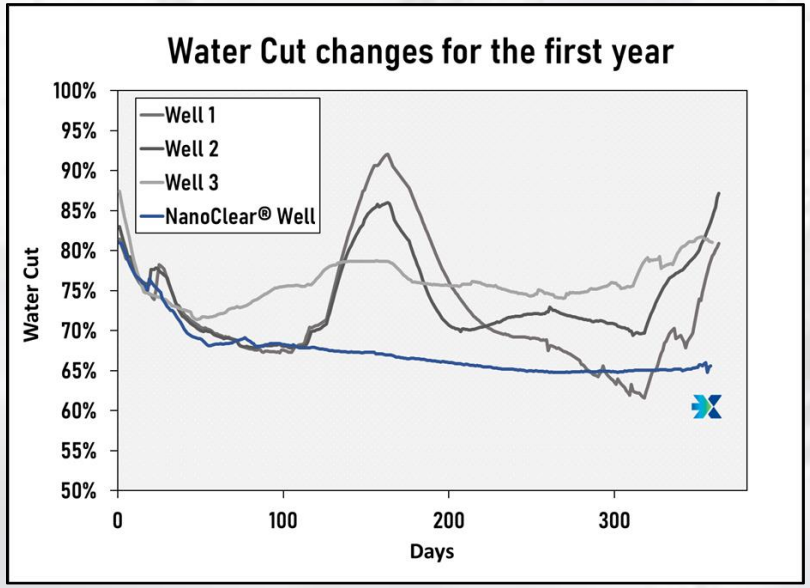
## NanoClear® Track Record:

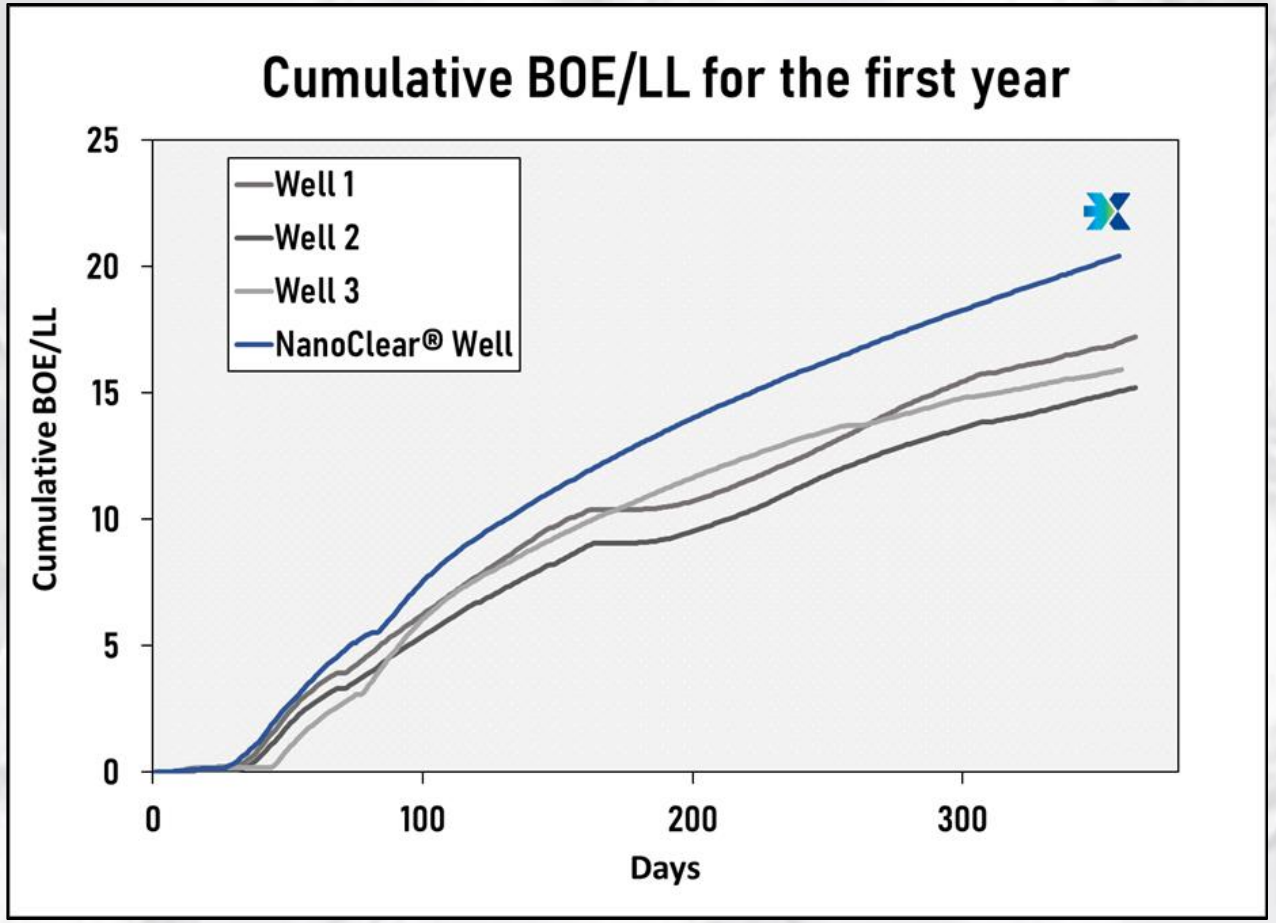
- First well treated in Nov. 2017
- Hundreds of wells treated to date
- Multiple E&P's are continuously pumping different applications



# New Frac Case Study: Wolfcamp (B), Permian Basin

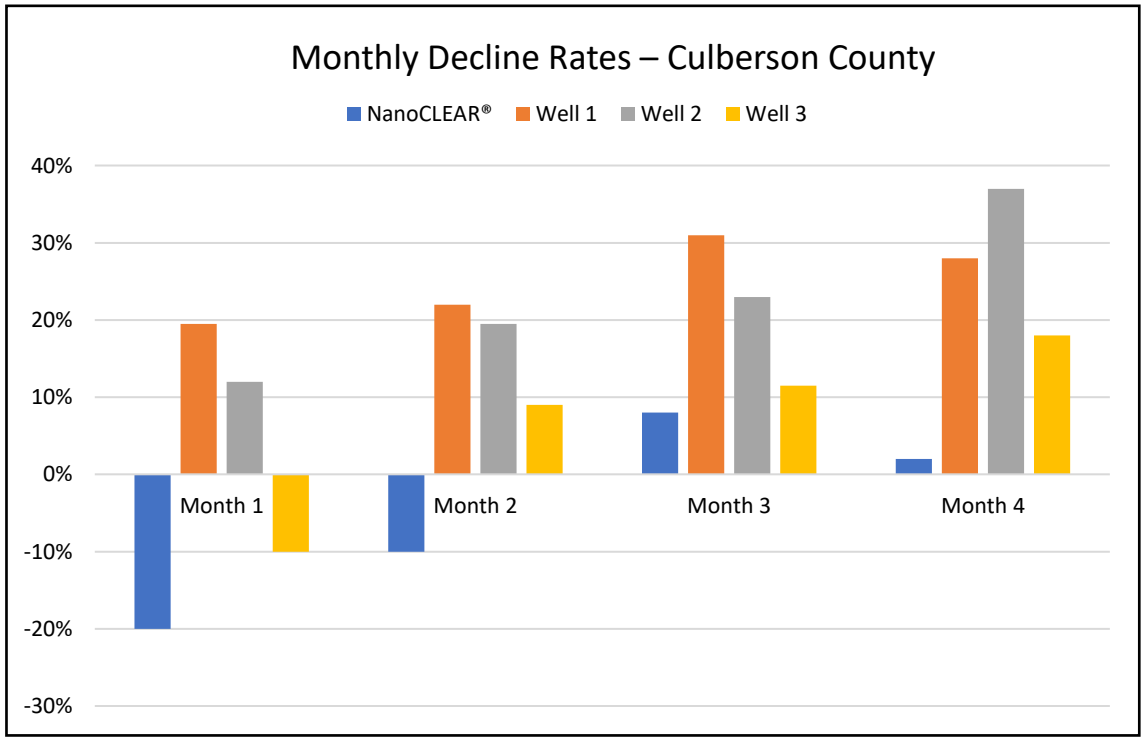


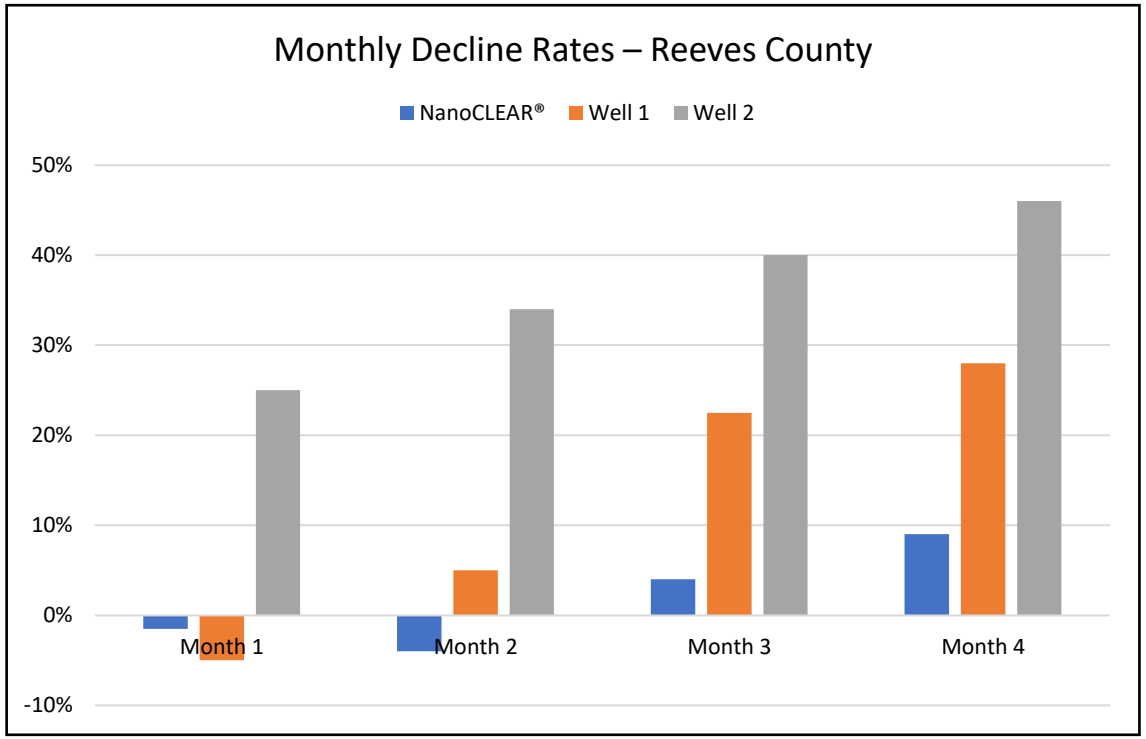


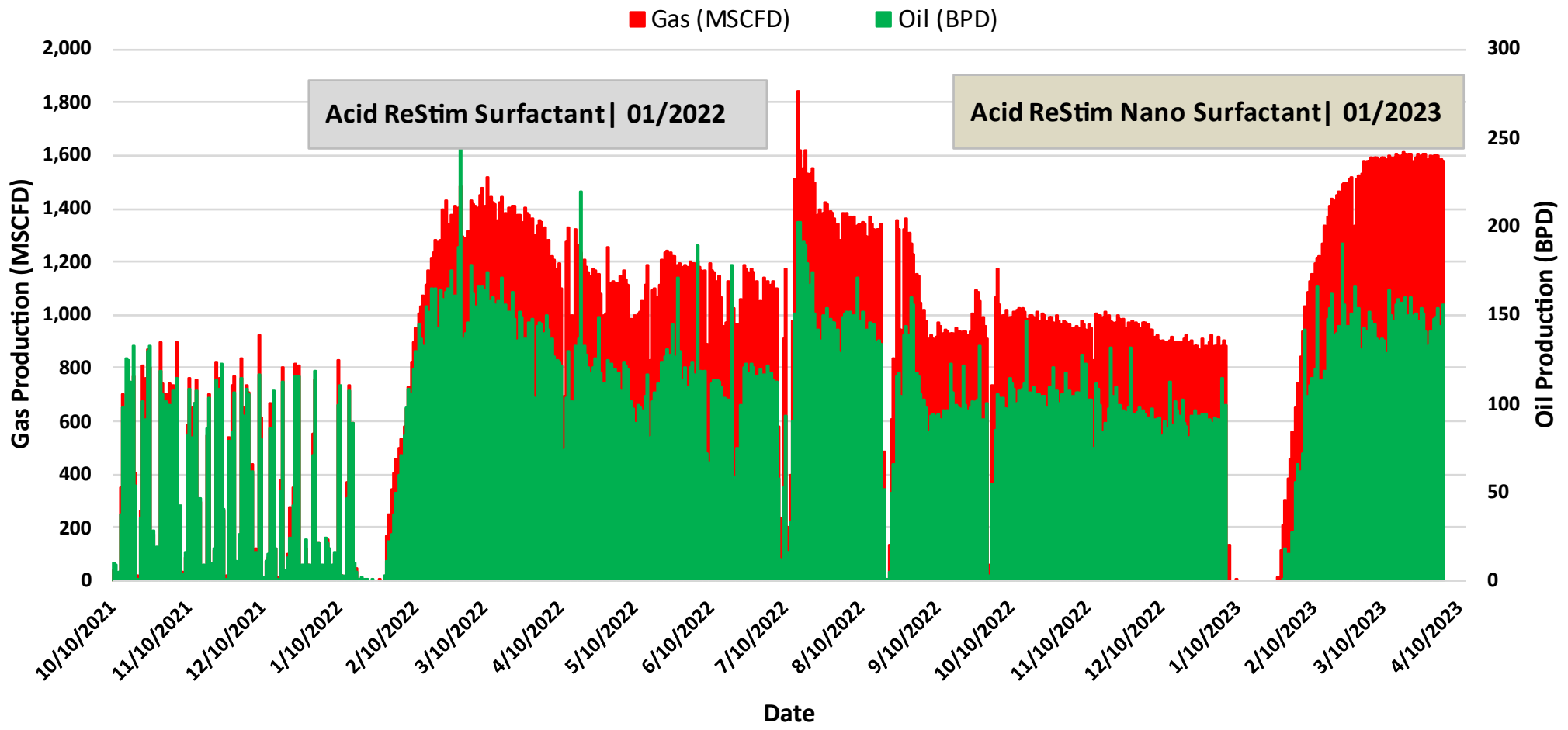



# Acid Frac Case Study

- In Culberson County test, NanoCLEAR® well only had 2% decline comparted to 18%, 28% and 37% declines from the surfactant wells over 4 months.
- In Reeves County test, NanoCLEAR® well only had 9% decline comparted to 28% and 46% declines from the surfactant wells over 4 months.



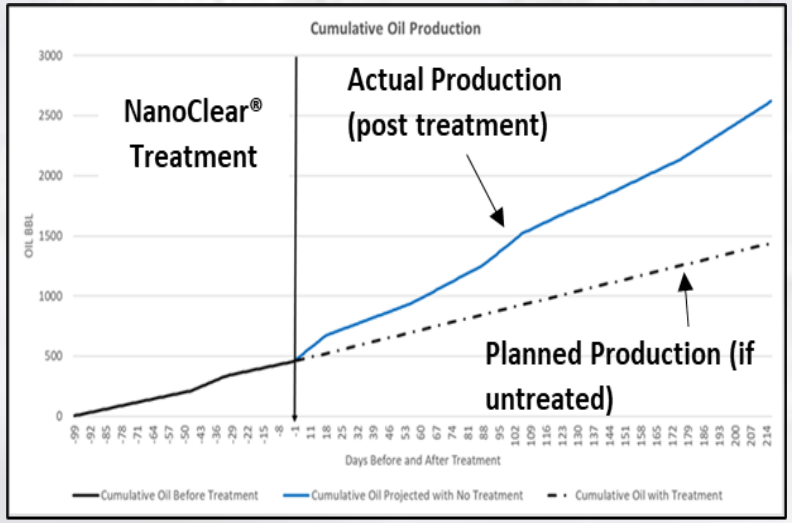



| | Well B Test 1 - Surfactant | | | Well B Test 2 - TMO Nanofluid | | |
|---|---|---|---|---|---|---|
| Month | Oil | Gas | BOE | Oil | Gas | BOE |
| 1 | -6% | 14% | 5% | 6% | 16% | 12% |
| 2 | -17% | 4% | -5% | 5% | 15% | 11% |

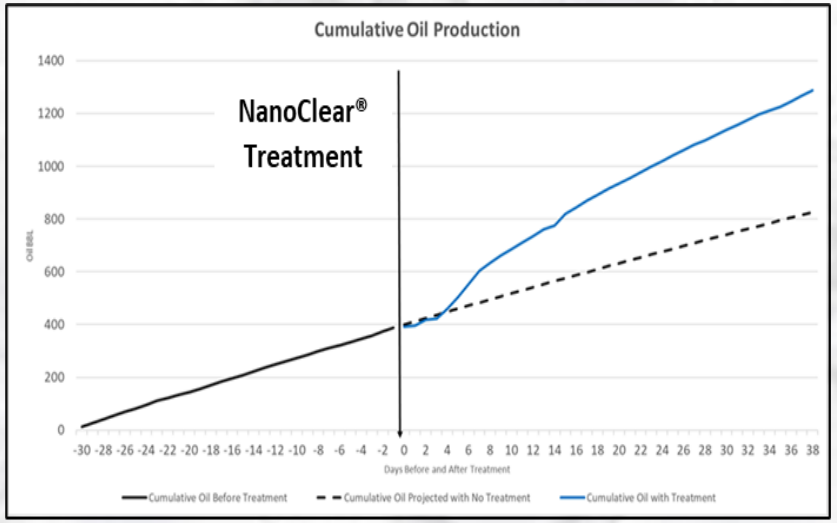
# Stand-Alone Stimulation Case Studies

| APPARENT CROSS-BASIN APPLICABILITY | Well 1 | Well 2 | Well 3 |
|---|---|---|---|
| Basin | Permian, TX | Uinta, UT | Deep Basin, AB |
| Formation | Spraberry/Wolfcamp | Multiple | Glauconite |
| Rock Type | Shale + Sand/Limestone | Sandstone & Carbonate | Sandstone |
| Well Type | Vertical | Vertical | Horizontal |
| Porosity | 10% | 10% | 10% |
| Oil API | 40° | 32° | 26° |
| TVD/MD | 10,750 ft | 6,020 ft | 6,312 ft / 11,237 ft |
| NanoClear® Qty | 1,380 gals | 1,110 gals | 1,380 gals |

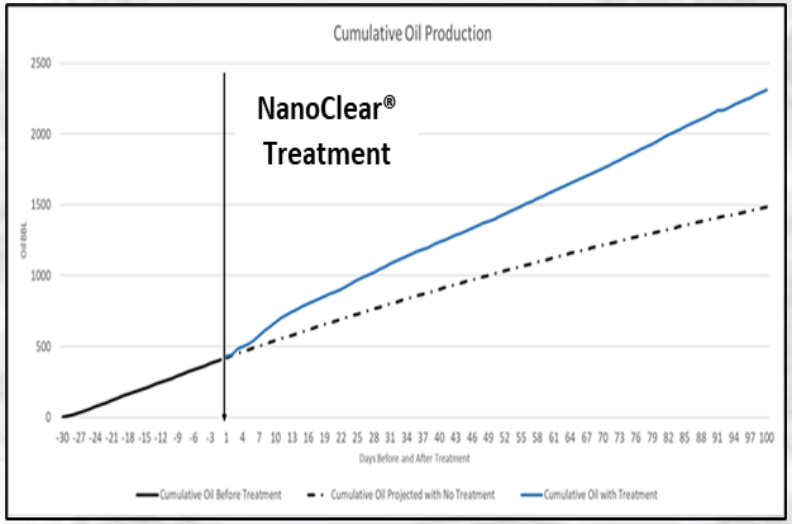
| TREATMENT RESULTS | Well 1 | | Well 2 | | Well 3 | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| Measurement Period | 107 days | 237 days | 30 days | 38 days | 30 days | 100 days |
| Avg Oil Production | 14 bbl/day | 19 bbl/day | 13 bbl/day | 24 bbl/day | 14 bbl/day | 19 bbl/day |
| % Avg Oil Increase | | 36% | | 85% | | 36% |
| Water Cut | 71% | 56% | 37% | 40% | 26% | 29% |
| Days to ROI | | 71 days | | 27 days | | 38 days |




Well 1



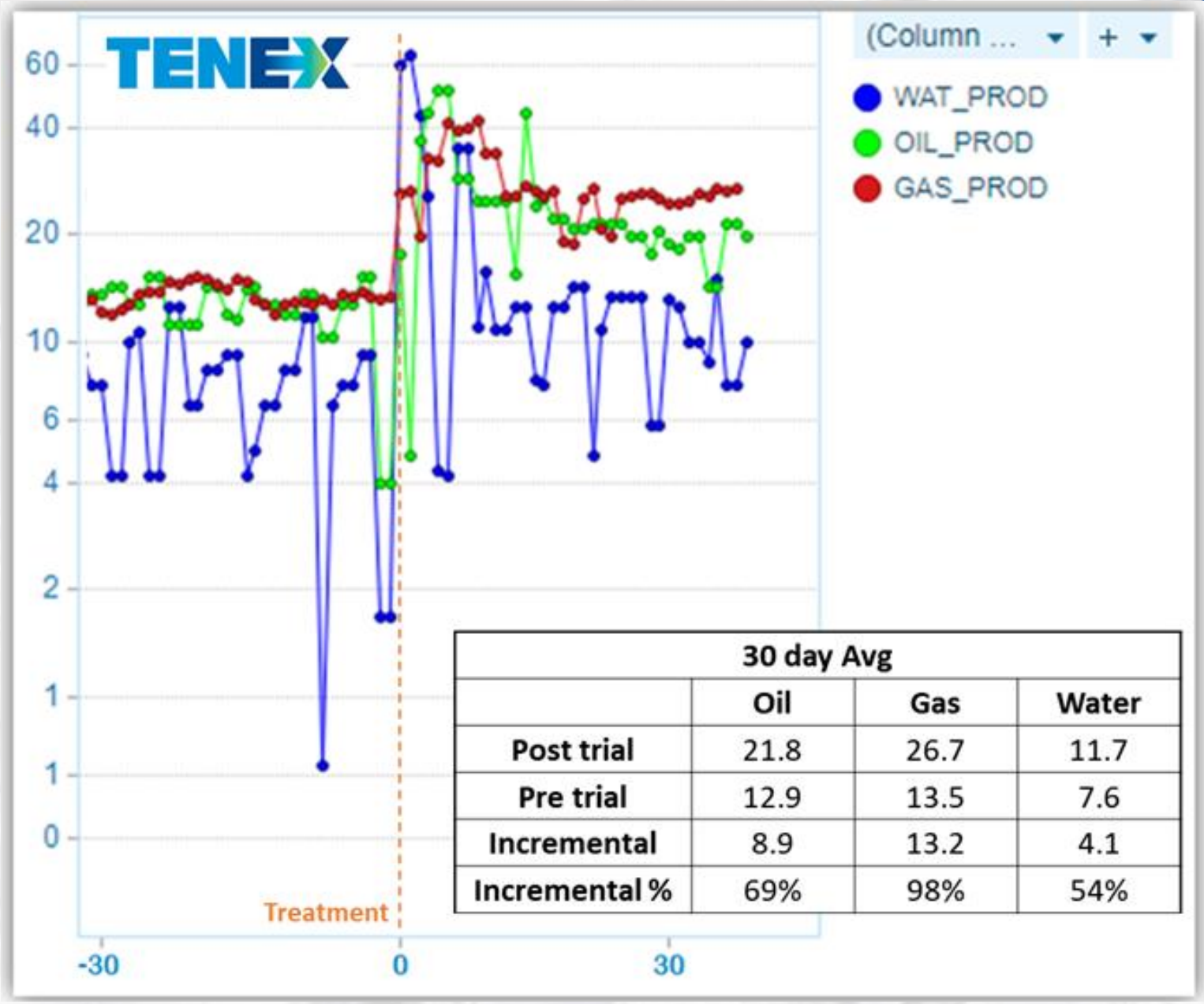

Well 2




Well 3

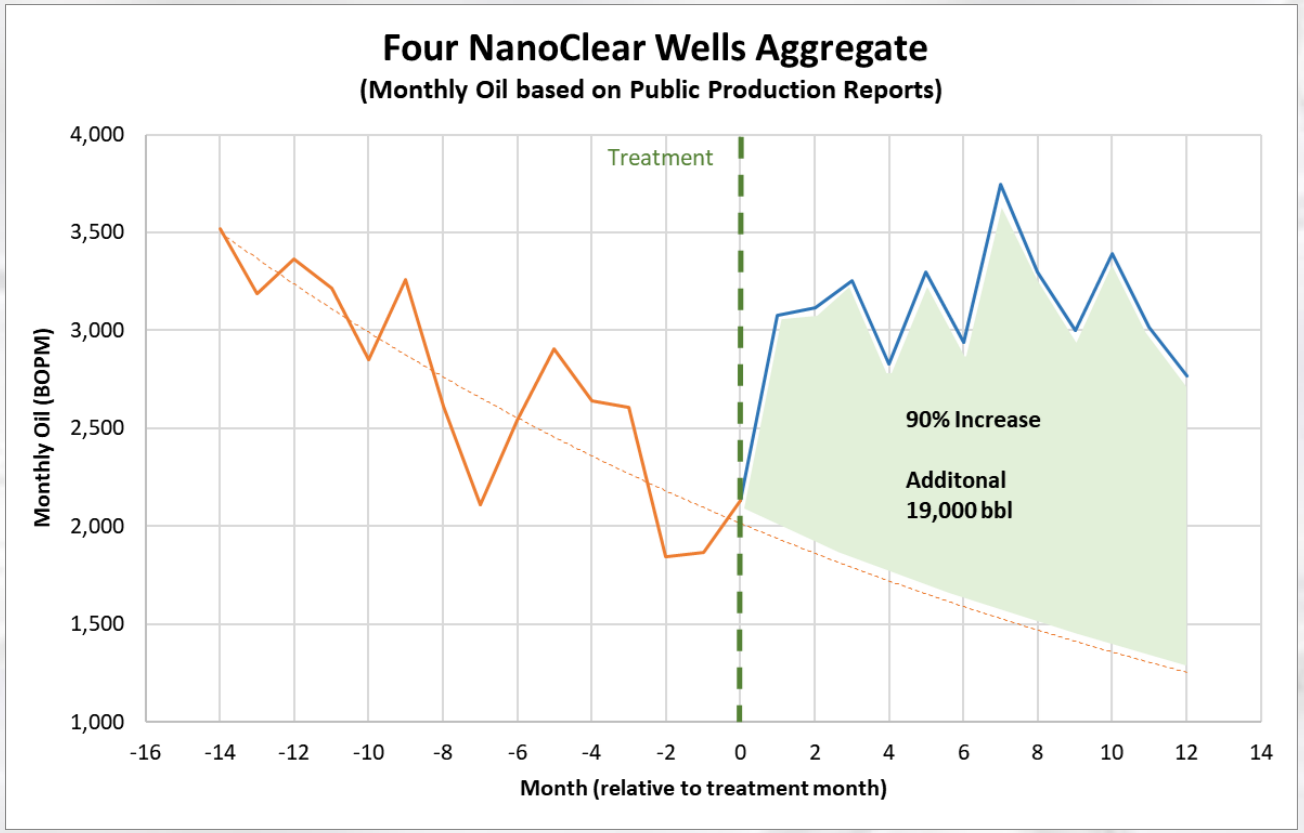
# Re-Stim Multizone Vertical Well – Uinta Basin

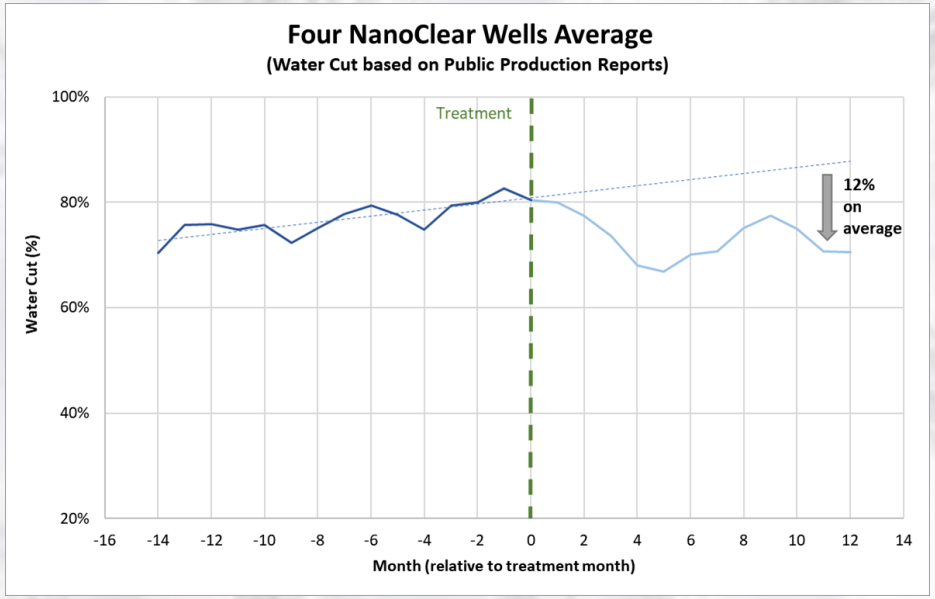
- Lithology: Sandstone and Carbonate
- Depth: 10,400 ft
- API: 30
- Artificial Lift: Sucker Rod




| 30 day Avg | | | |
|---|---|---|---|
| | Oil | Gas | Water |
| Post trial | 21.8 | 26.7 | 11.7 |
| Pre trial | 12.9 | 13.5 | 7.6 |
| Incremental | 8.9 | 13.2 | 4.1 |
| Incremental % | 69% | 98% | 54% |

# 4 Re-Stim wells – Avalon/Delaware



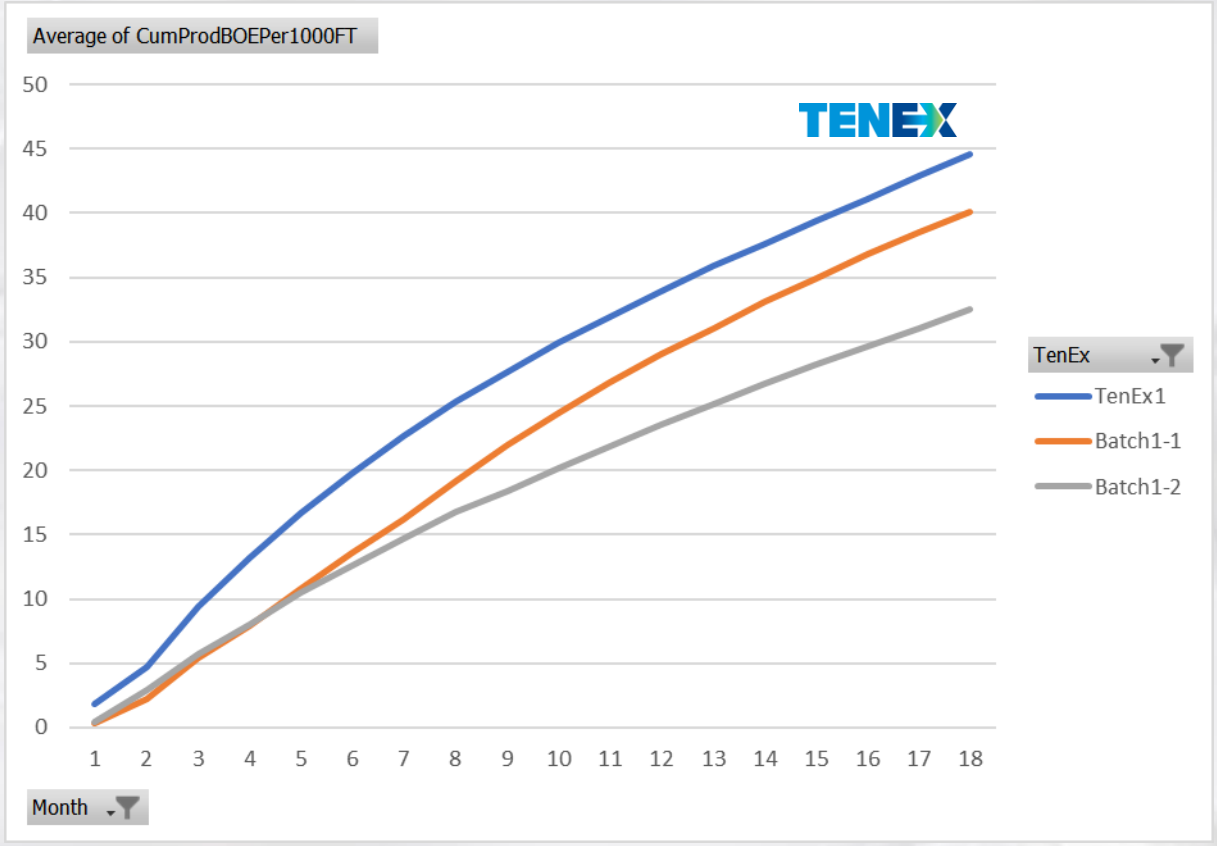




- Lithology: Carbonate
- Depth: 3500-5000 ft
- API: 35
- Artificial Lift: Sucker Rod

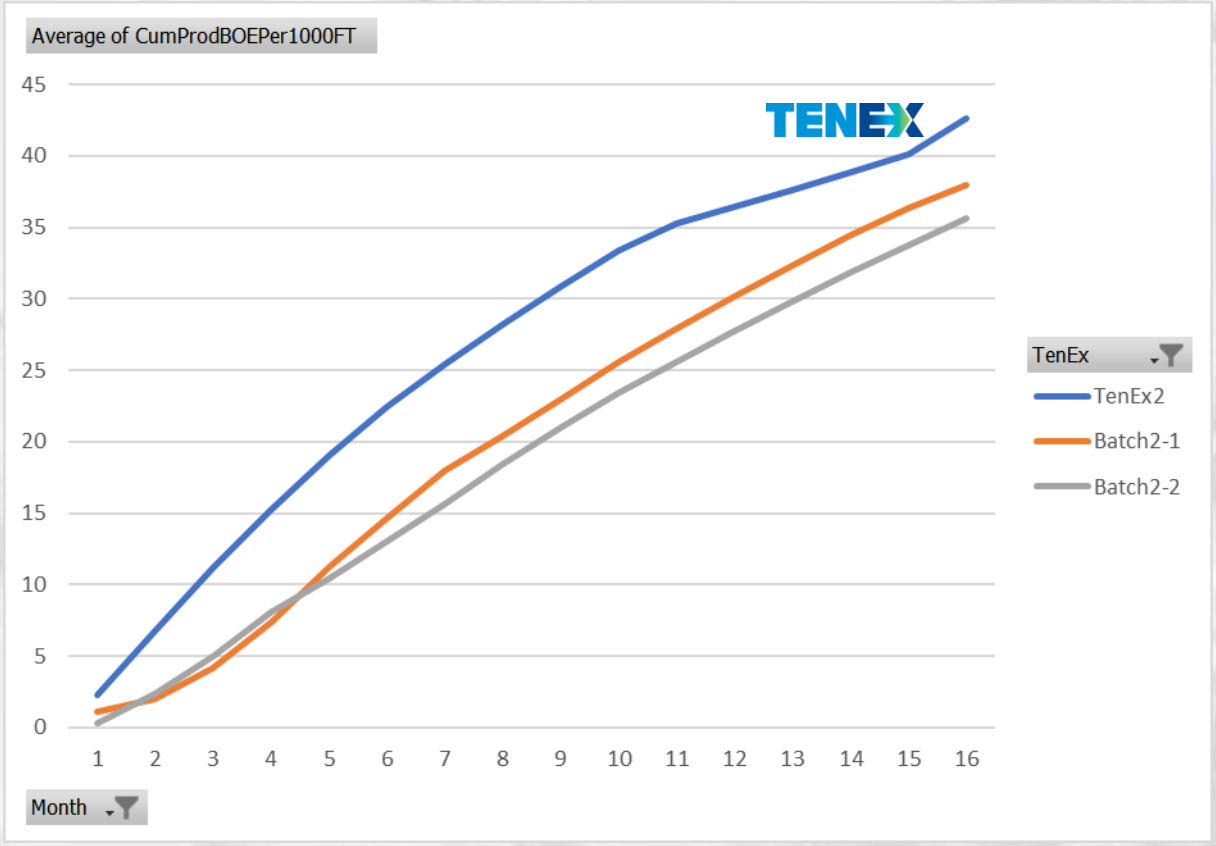
# New Frac Case Study: Montney Formation

| Well | Formation | TVD | TenEx | Comment |
|---|---|---|---|---|
| 100/09-13-077-12W6/00 | MONT | 7435.5 | TenEx1 | TenEx Group 1 |
| 100/16-13-077-12W6/00 | MONT | 7413.7 | TenEx1 | |
| 103/08-13-077-12W6/00 | MONT | 7450.2 | TenEx1 | |
| 100/14-04-079-12W6/00 | MONT | 7280.9 | TenEx2 | TenEx Group 2 |
| 102/13-04-079-12W6/00 | MONT | 7284.2 | TenEx2 | |
| 102/15-04-079-12W6/00 | MONT | 7269.7 | TenEx2 | |
| 102/16-05-079-12W6/00 | MONT | 7274.9 | TenEx2 | |
| 102/14-04-079-12W6/00 | MONT | 7113.2 | TenEx2 | |
| 100/12-26-077-12W6/00 | MONT | 7392.9 | Batch1-1 | Closest group to TenEx group 1 |
| 102/13-26-077-12W6/00 | MONT | 7369.5 | Batch1-2 | Second closest to TenEx group 1 |
| 100/13-27-077-12W6/02 | MONT | 7469.0 | Batch1-2 | |
| 100/13-35-077-12W6/00 | MONT | 7408.5 | Batch1-2 | |
| 100/03-30-077-11W6/00 | MONT | 7410.9 | Batch1-2 | |
| 100/04-30-077-11W6/00 | MONT | 7430.8 | Batch1-2 | |
| 100/15-34-077-12W6/00 | MONT | 7413.5 | Batch1-2 | |
| 100/03-27-077-12W6/00 | MONT | 7439.7 | Batch1-2 | |
| 102/08-13-077-12W6/00 | MONT | 7425.2 | Batch1-2 | |
| 102/01-13-077-12W6/00 | MONT | 7444.8 | Batch1-2 | |
| 103/13-22-077-12W6/00 | MONT | 7455.9 | Batch1-2 | |
| 100/02-13-077-12W6/00 | MONT | 7498.5 | Batch1-2 | |
| 100/16-05-079-12W6/00 | MONT | 7032.8 | Batch2-1 | Closest group to TenEx group 2 |
| 100/15-05-079-12W6/00 | MONT | 7053.7 | Batch2-1 | |
| 100/06-28-078-12W6/00 | MONT | 7117.4 | Batch2-1 | |
| 102/13-05-079-12W6/00 | MONT | 7067.8 | Batch2-1 | |
| 100/14-05-079-12W6/00 | MONT | 7038.7 | Batch2-1 | |
| 100/05-28-078-12W6/00 | MONT | 7164.0 | Batch2-1 | |
| 103/13-05-079-12W6/00 | MONT | 7074.7 | Batch2-1 | |
| 102/09-27-078-12W6/02 | MONT | 7079.1 | Batch2-2 | Second closest to TenEx group 2 |
| 102/13-26-078-12W6/00 | MONT | 7053.0 | Batch2-2 | |
| 103/09-27-078-12W6/00 | MONT | 7073.6 | Batch2-2 | |
| 103/13-26-078-12W6/00 | MONT | 7079.7 | Batch2-2 | |
| 100/16-04-079-12W6/00 | MONT | 7026.7 | Batch2-2 | |
| 100/15-04-079-12W6/00 | MONT | 7064.0 | Batch2-2 | |

# New Frac Case Study: Montney Formation




Group 1




Group 2

# FOAMERS

## Robust FOAMERS Designed to Work at Real-World Harsh Conditions

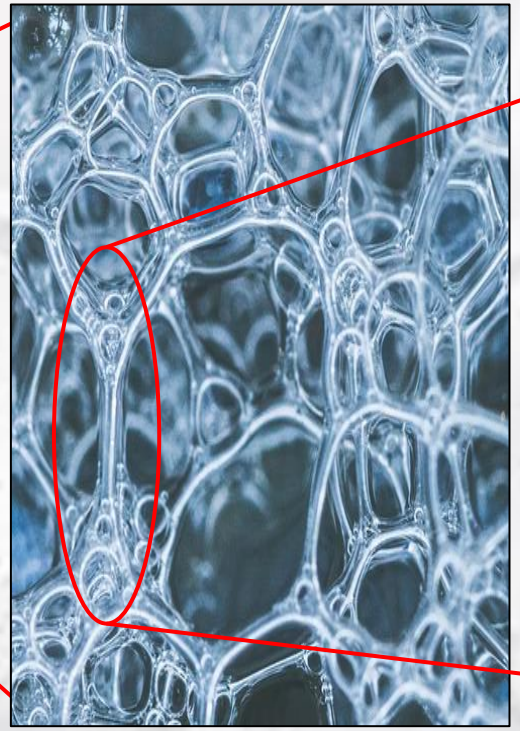
Suman Khanal / Abdulaziz Ellafi

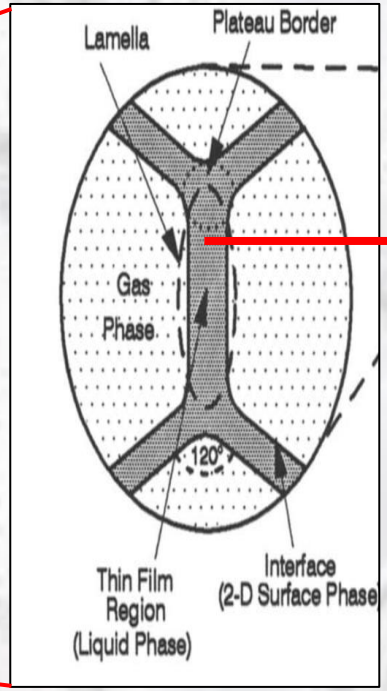
# Motivation

- Typical foamers may not have good stability at harsh conditions.
  - They break down easily at high temperature and salinity at the presence of crude oil

- The ideal foamer:
  1. Generates the MOST amount of foam
  2. Its generated foam is stable for as long as possible
  3. Can withstand hard conditions of salinity and temperature
  4. Can also reduce IFT/CA (for EOR applications)

# Technology Idea

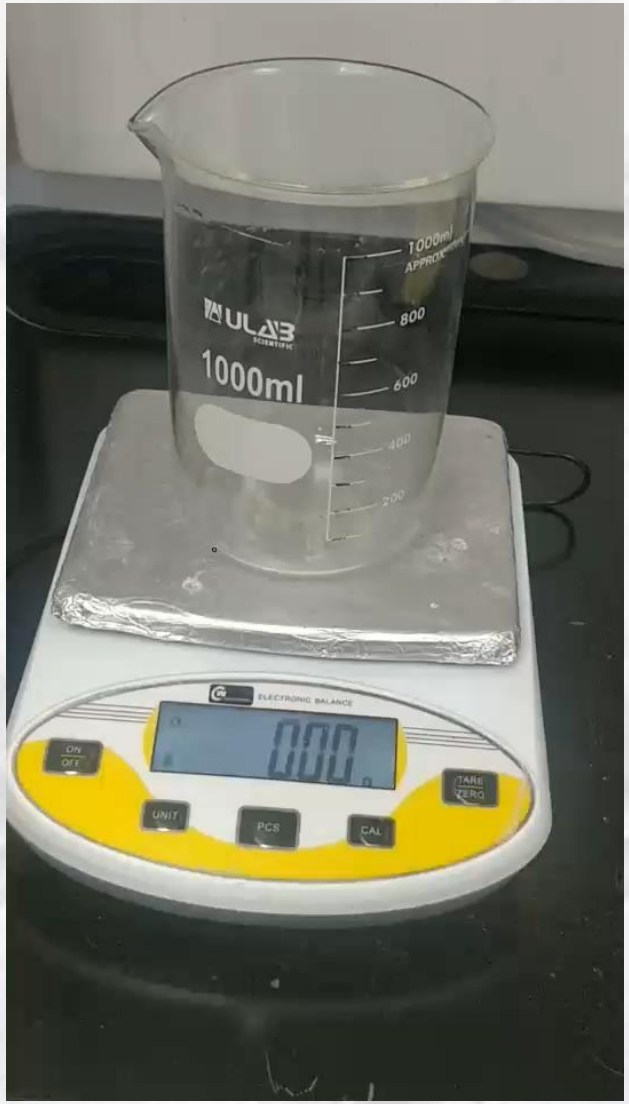





**Need to strengthen lamella**

- Foam bubbles are more stable when the lamella cannot be easily destructed.
- We use both foam boosting AND dual-foam stabilizing mechanisms.

# Experimental Procedure (Video)



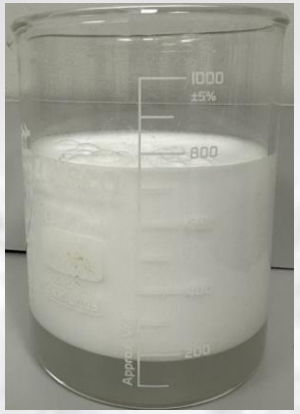
# Bulk Foam Stability Testing

- Bulk foam stability was tested on new foaming additives.
- The water (with the additive) was pre-heated and an overhead mixer was used to create an initial foam column.
- The foam was kept inside an oven and its half-life was recorded.
- Testing was done for a total of 6 hours.
- The foam half-life was measured by visual observation.
- Other commercial foaming additives on the market were included in the tests to directly compare their performance to Tenex's foaming additives.

| Parameters | Value |
|---|---|
| Shear Rate | 1,000 rpm |
| Shear Time | 10 minutes |
| Dosage | 10 gpt actives |
| Temperature | 160F |
| Brine Salinity | 110,000 ppm TDS (3% divalent ions) |

# Foam Volume/Height Testing

**Product C1 (Commercial Foamer)**




750 ml

**Product C2 (Commercial Foamer)**


800 ml

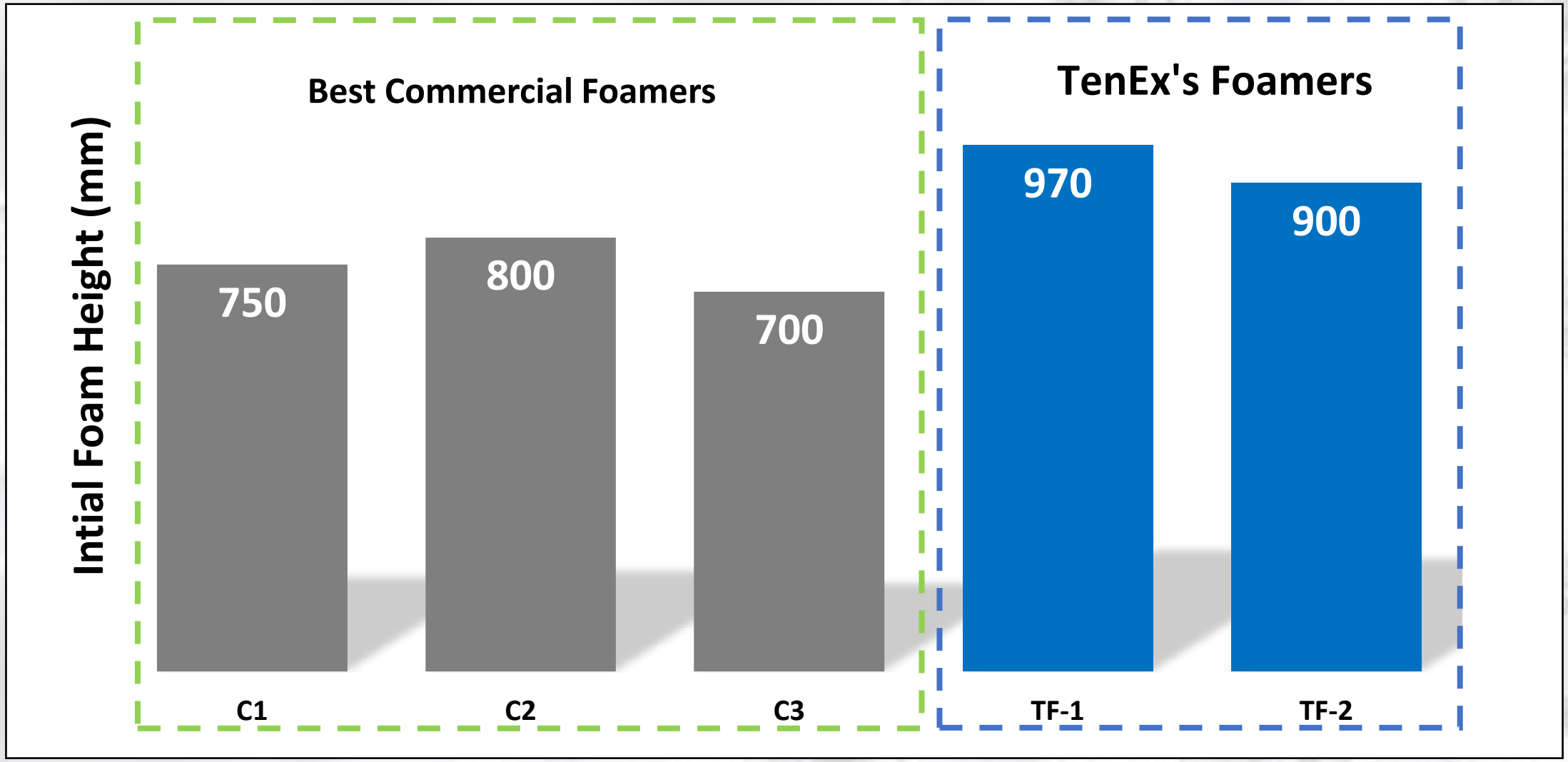
**Product TF-1 (Tenex's Foamer)**

970 ml

**Product TF-2 (Tenex's Foamer)**

900 ml

# Initial Foam Heights



# Bulk Stability Testing Results

**Product C1 (Commercial Foamer)**


t = 0


t = 5 minutes


t = 1 hr


t = 1.5 hr


t = 3 hr

**Product TF-1 (Tenex's Foamer)**


t=0


t=1hr


t=2hr


t=3hr


t=5.5 hr

# Bulk Stability Testing Results

**Product C1 (Commercial Foamer)**


t = 0


t = 5 minutes


t = 1 hr


t = 1.5 hr


t = 3 hr

**Product TF-2 (Tenex's Foamer)**


t=0

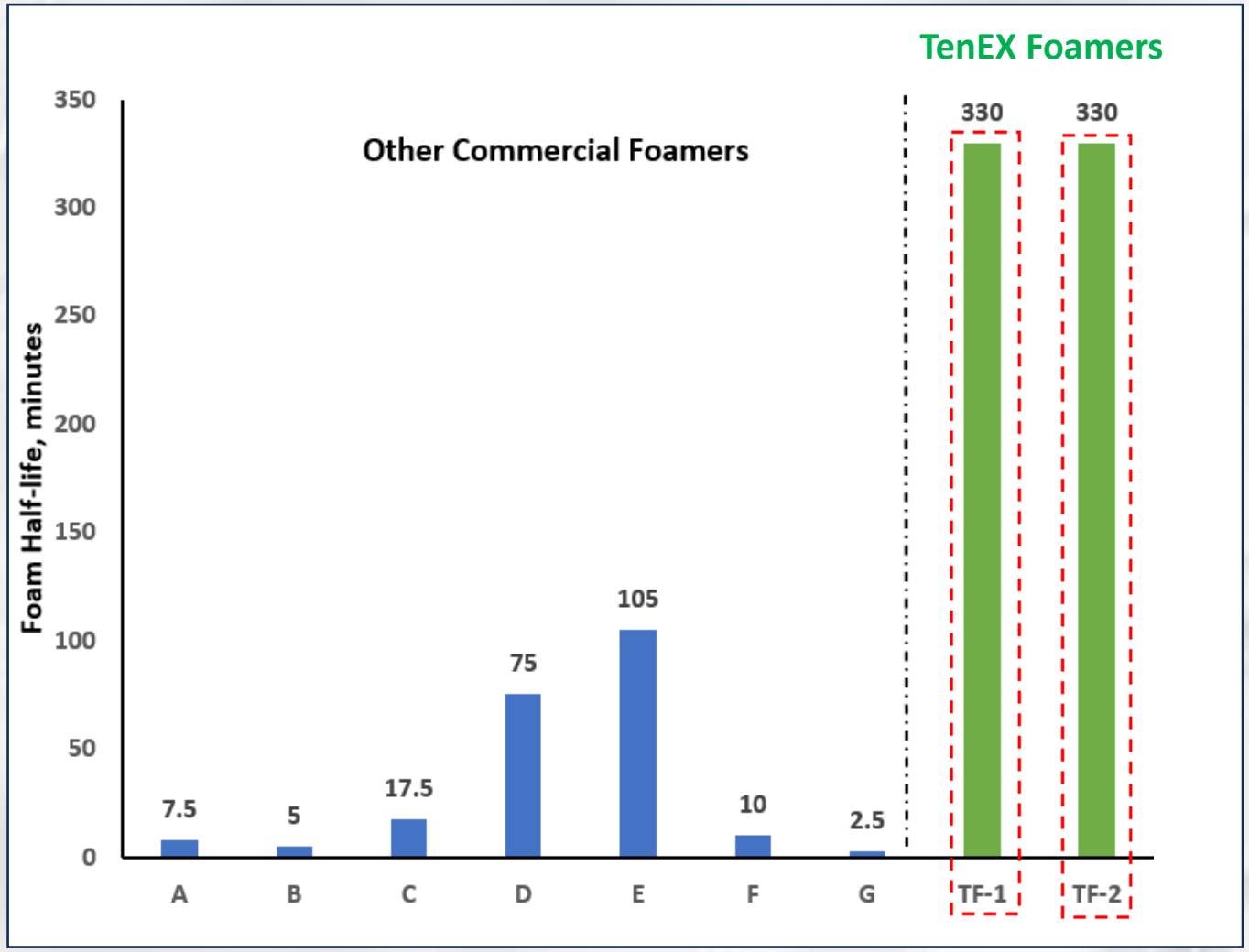

t=1hr

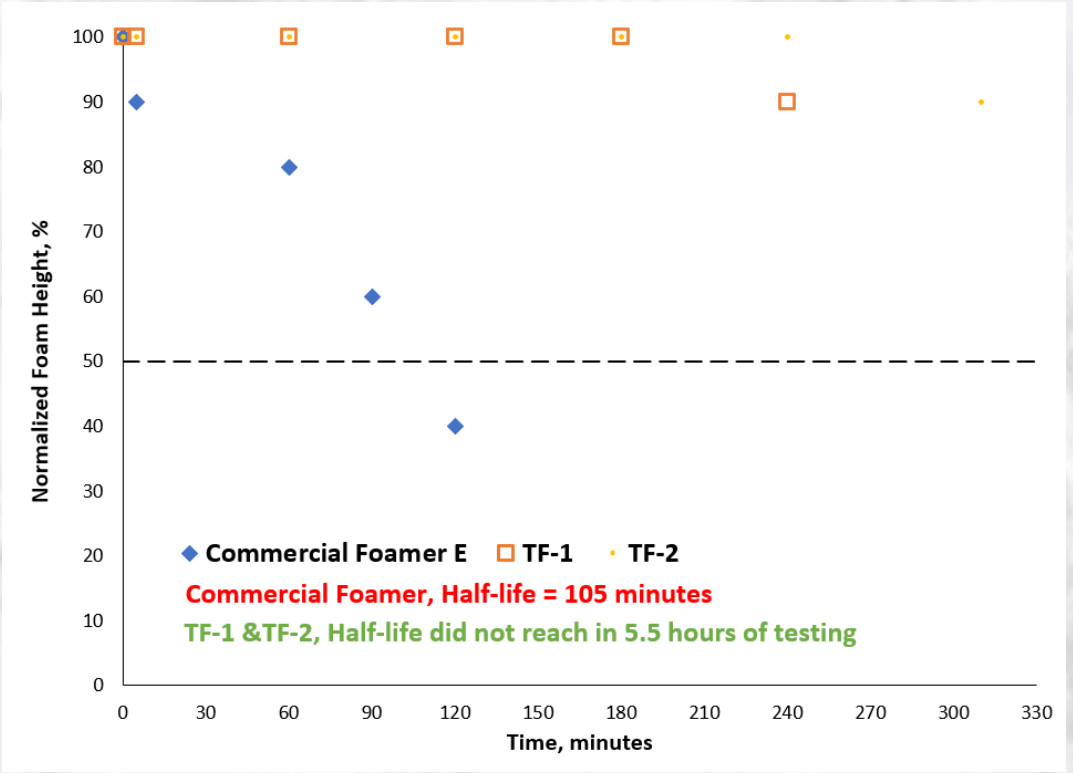

t=2hr


t=3hr


t=5.5 hr

# Foam Half-life



# Oil-water Bulk Foam Stability Testing

- Bulk foam stability was tested on new foaming additives.
- The water (with the additive) was pre-heated and an overhead mixer was used to create an initial foam column and then oil was added in the volumetric ratio of 10:1 respectively.
- Light crude oil from Wolfcamp formation was used.
- The foam was kept inside an oven and its half-life was recorded.
- Testing was done for a total of 3 hours.
- The foam half-life was measured by visual observation.
- Other commercial foaming additives on the market were included in the tests to directly compare their performance to Tenex's foaming additives.

| Parameters | Value |
|---|---|
| Shear Rate | 1,250 rpm |
| Shear Time | 15 minutes |
| Dosage | 50 gpt actives |
| Temperature | 160F |
| Brine Salinity | 110,000 ppm TDS (3% divalent ions) |
| Water: oil ratio | 10:1 |

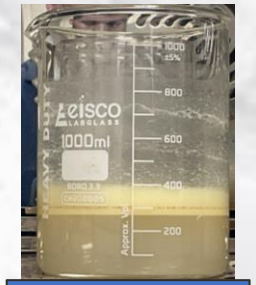
# Oil-water Bulk Stability Testing Results

**Product E (Commercial Foamer)**

t=0

t=10mins


t=15mins



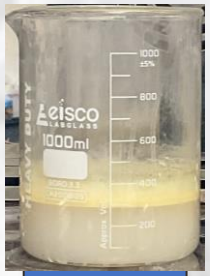

t=31mins

**Product TF-1 (Tenex's Foamer)**

t=0

t=1hr

t=1hrs 30 mins

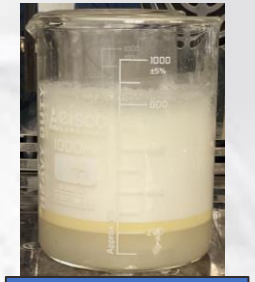



t=2hrs

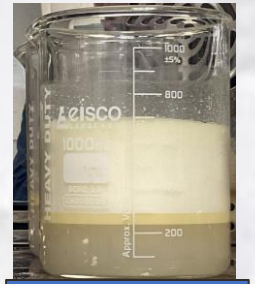
# Oil-water Bulk Stability Testing Results

**Product E (Commercial Foamer)**

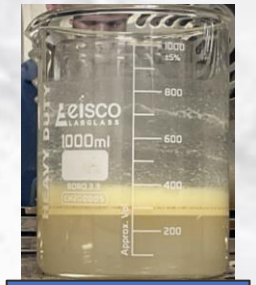
t=0



t=10mins



t=15mins



t=31mins

**Product TF-2 (Tenex's Foamer)**

t=0

t=1hr

t=1hrs 30 mins

t=2hrs 33 mins

SCAN ME

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sales@tenextechnologies.com