Screenless Sand Control Completion

Onshore Colombia Case Histories

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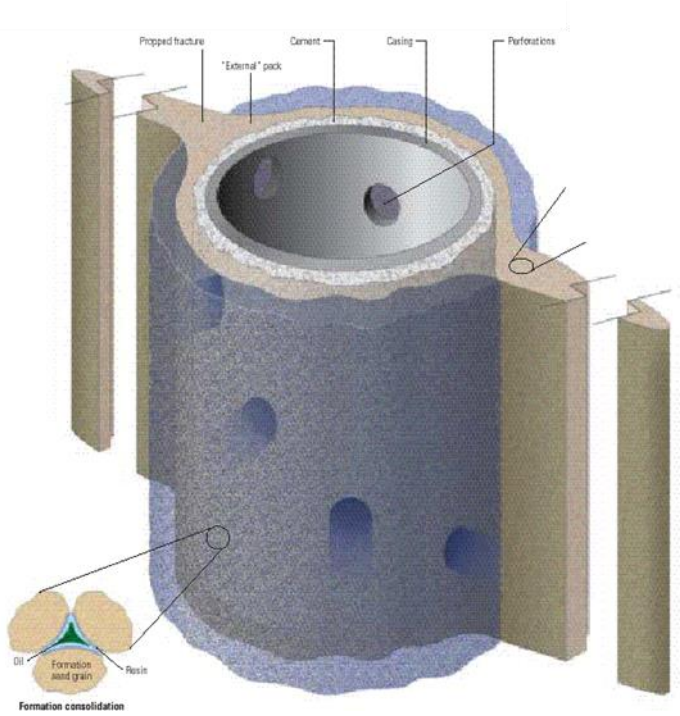
Screenless Sand Control Completions

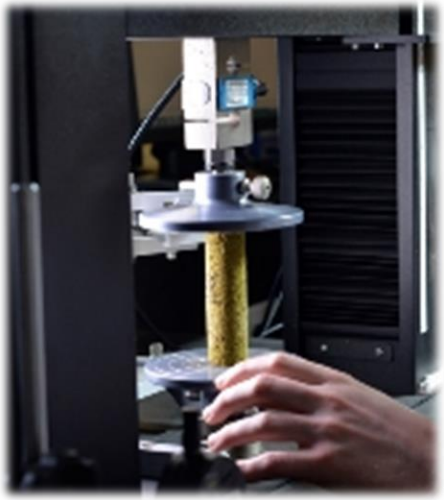
- Formation sand is held back by a proppant pack in the hydraulic fracture, voids behind casing (if present) and perforations
  - Sand Control and Stimulation
- Relay on a self supported proppant pack, rather than screens
  - Regular and “extreme” conditions
  - Full wellbore access
- Any kind of well: new completions and remedial
  - No completion jewelry: reduced cost of completion
  - No rig, minimum coiled tubing intervention: reduced cost of intervention



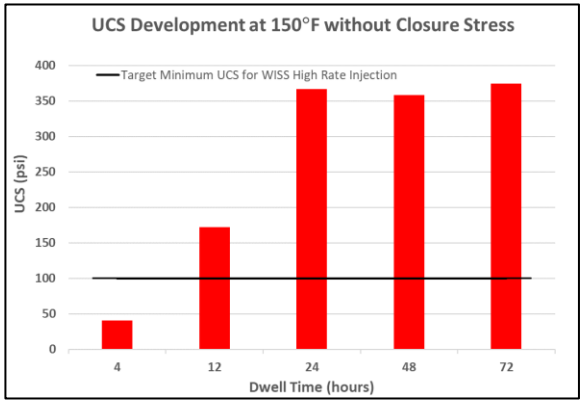
Self Supported Activated Proppant (SSAP)

- SSAP creates a highly permeable self supported consolidated pack at “extreme” conditions
  - Low stress
  - Low temperature
  - Very high injection or production rates
- SSAP forms an in-situ filter for effective screenless sand control

Highly permeable SSAP pack



SSAP plug in UCS test press



UCS vs time

Sand Control remedial applications in Colombia

Mature field

- Characteristics
  - No sand control in initial completion
  - Small reserves
  - Wellbore with integrity issues
  - Artificial lift
- Challenges
  - Fix sand production issues
  - Protect artificial lift pumps
  - Cost effective intervention
  - High water cuts
  - Formation damage

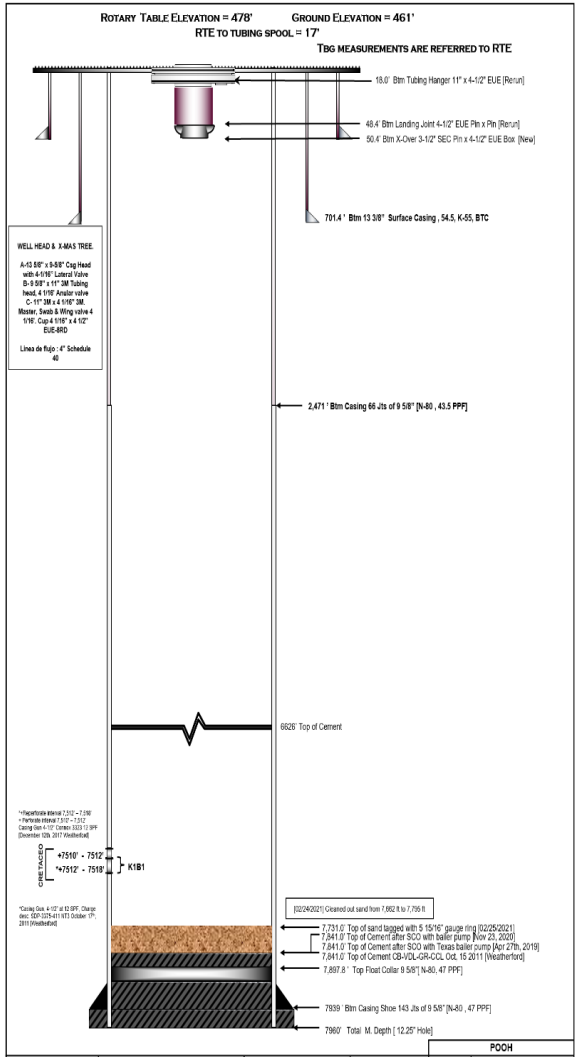
SSAP

- Delivers
  - Consolidated pack in voids and areas without stress
  - Effective screenless sand control
  - Stimulation
  - Minimum intervention: OPEX vs. CAPEX
    - Potentially rigless or Coiled Tubing intervention

Screenless HRWP – Colombia – Well 1

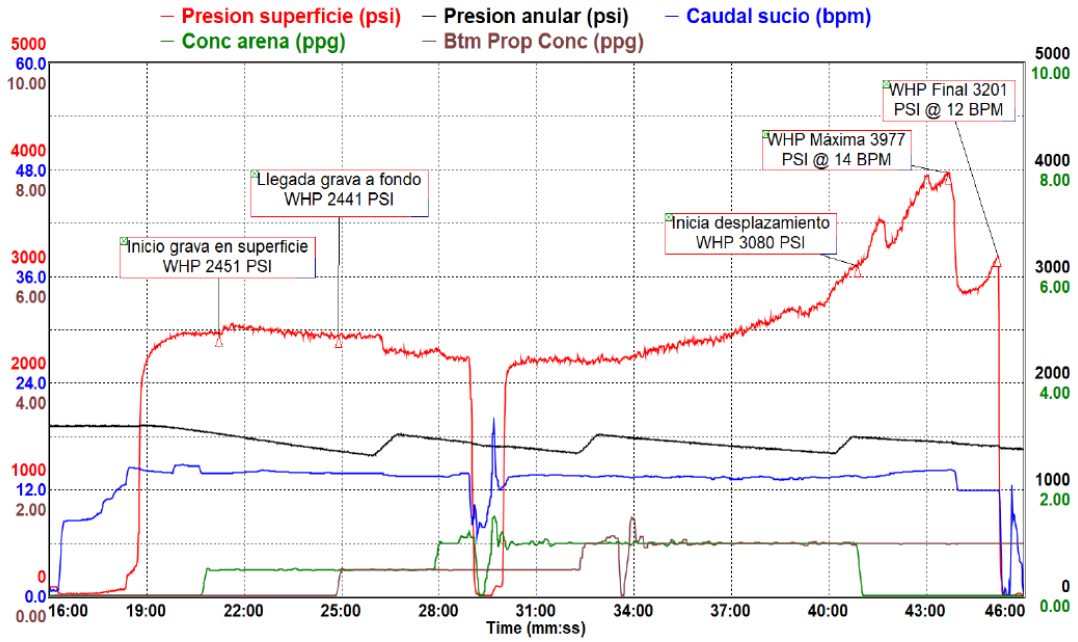
- High water cut well with sand production
  - Completed in 2011, single zone, 9 5/8” casing, ESP artificial lift
  - 7,510 – 7,518 ft existing perfs, BHST 203°F
  - K = 660 mD, Pr=1,400 psi (0.18 psi/ft)
  - FG=0.46 psi/ft (estimated)

- Challenges
  - ESP damage caused by formation sand, frequent ESPs changeouts
  - Existing perforations 12 SPF + 12 SPF reperf
  - Void behind casing suspected (no stress)
  - Formation damage due to matrix collapse
  - Nearby water: 90% water cut



Screenless HRWP – Colombia – Well 1

- Solution: Screenless HRWP
  - Pulled ESP, cleaned out to TD , run workstring & packer
  - Performed injectivity test with brine: determine frac extension rate (FER)
  - Place HRWP with 1% NH_4Cl @ 14 BPM (2 BPM above FER)



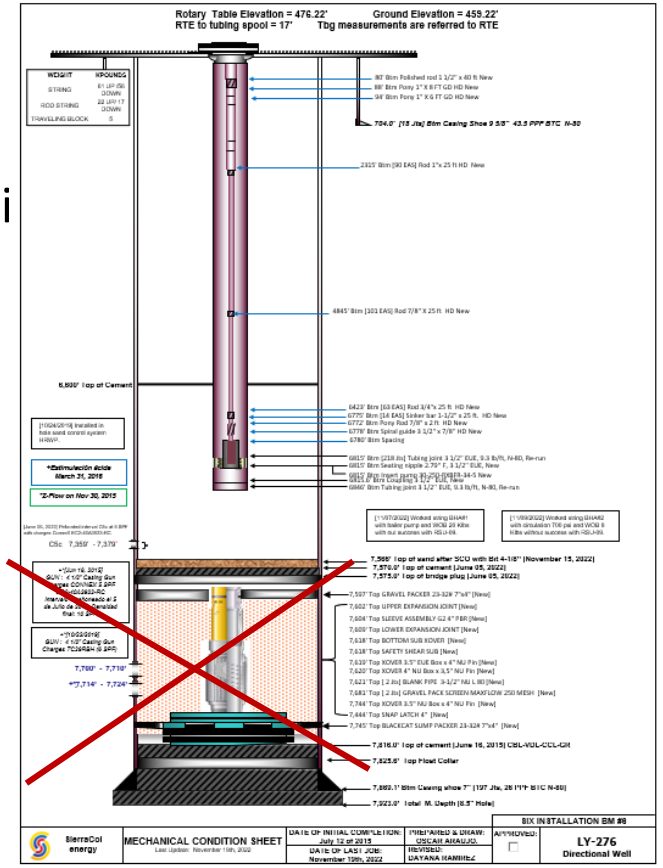
- 6,400 lb planned 0.5 – 1.0 PPA
- Pad 2,100 gal
- Slurry 11,400 gal
- 8,900 lb SSAP placed (1,100 lb/ft of perfs)
- P_{net} 1,600 psi (from treating pressure)

- Results
  - Sand free production
  - 3,000 BPD, no change to water cut (90%)

Screenless HRWP – Colombia – Well 2

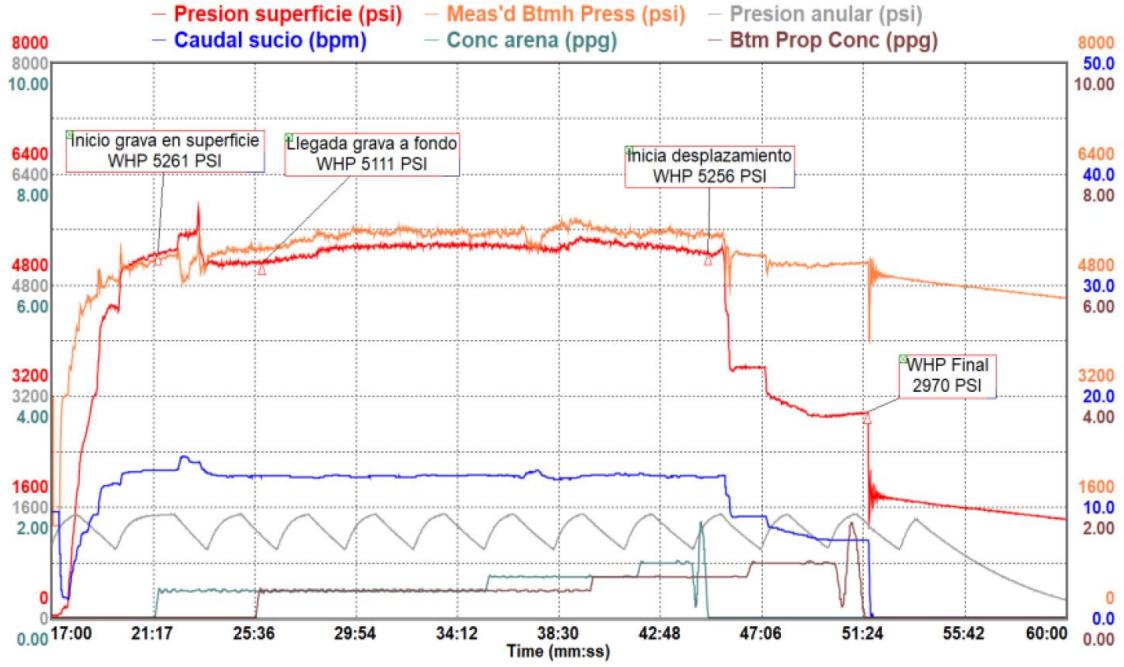
- High water cut well with sand production
  - Recompleted in June 2022, single zone, 9 5/8” casing, ESP artificial lift
  - 7,359 – 7,379 ft existing perfs, BHST 191°F
  - K = 160 mD (10 mD from minifrac), Pr=1,200 psi (1,000 psi from injection test 0.13 psi/ft)
  - FG=0.45 psi/ft (from SRT)

- Challenges
  - ESP damage caused by formation sand, shut in due to sanding out 30 days after last pump change
  - Existing perforations 5 SPF
  - Void behind casing suspected (no stress)
  - Formation damage due to matrix collapse
  - Nearby water: 60% water cut



Screenless HRWP – Colombia – Well 2

- Solution: Screenless HRWP
  - Pulled ESP, cleaned out to TD, run workstring & packer
  - Performed injectivity test with brine: determine frac extension rate (FER)
  - Place HRWP with 1% NH_4Cl @ 13 BPM (3 BPM above FER)



- Conservative design due to NWB restriction: 6,400 lb, 1 PPA max.
- 13 BPM (3 BPM above FER)
- Pad 2,100 gal
- Slurry 12,300 gal
- 7,700 lb SSAP @ 0.5-1.6 PPA (400 lb/ft of perfs)
- P_{net} 200 psi (ISIP job vs. injection test)

- Results:
  - Sand free production
  - No change to water cut

SSAP

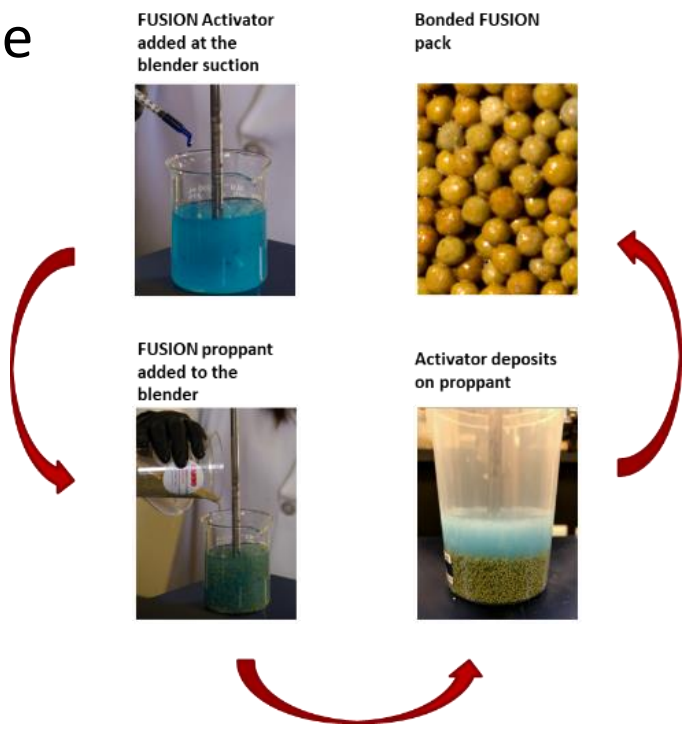
Self Supported Activated Proppant

What are Extreme Conditions for Proppant Pack Stability?

- Very high injection or production rates
  - High shear applied to the proppant will destabilize the pack, break it and carry and produce proppant to surface
- Low temperature
  - Regular RCPs need the use of Low Temperature Curing Activators (LTCA) below 160°F (70°C)
  - Below 120°F (50°C) LTCAs are ineffective
- Low stress
  - Low stress prevents effective bonding, despite the resin curing
  - Effective stress son proppant during shut in must be assessed to determine optimum resin coating systems, considering pressure in the frac will be in balance with formation pressure during shut-in
  - Effective stress on proppant below 1,000 psi will not create sufficient grain-to-gran contact for effective bonding

How does SSAP work?

- SSAP is a two-component reactive system
  - Resin coating applied to the proppant
  - Activator pumped with the carrier fluid
- SSAP resin coating chemically reacts with the SSAP Activator to form the bonds
  - Activator absorbs on the proppant due to the Hydrophobic nature of the activator
- Develops strong resilient pack at low temperature and stress
  - From 25°C (77°F) to >600°F
  - From 0 psi to any stress
- UCS and working time are a function of
  - BHT, Shut-in time
  - Stress on proppant
  - Activator concentration: designed based on well conditions and carrier fluid



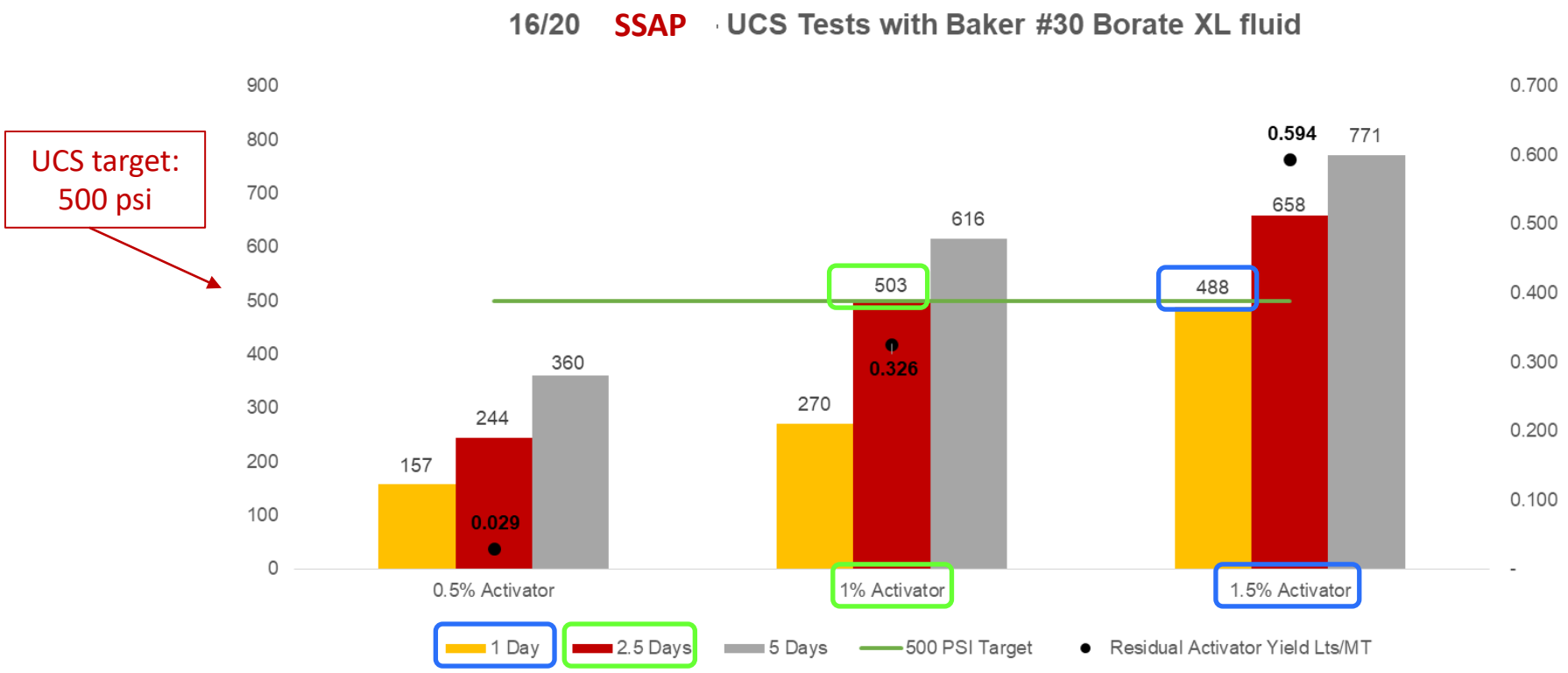
SSAP working time

- Time it takes to start to develop UCS inside casing/tubing/coiled tubing after the proppant has been placed
- Working time is a function of BHT at the end of pumping, typically very close to carrier fluid surface temperature
- Cool down caused by the operation must be accounted for to estimate BHT

Activator Loading	Working Time (hh:mm)					
	100°F 38°C	130°F 54°C	150°F 65°C	160°F 71°C	180°F 82°C	200°F 93°C
2.25 wt%	24 - 48	12	3 – 4	2:30	1:45	1:00

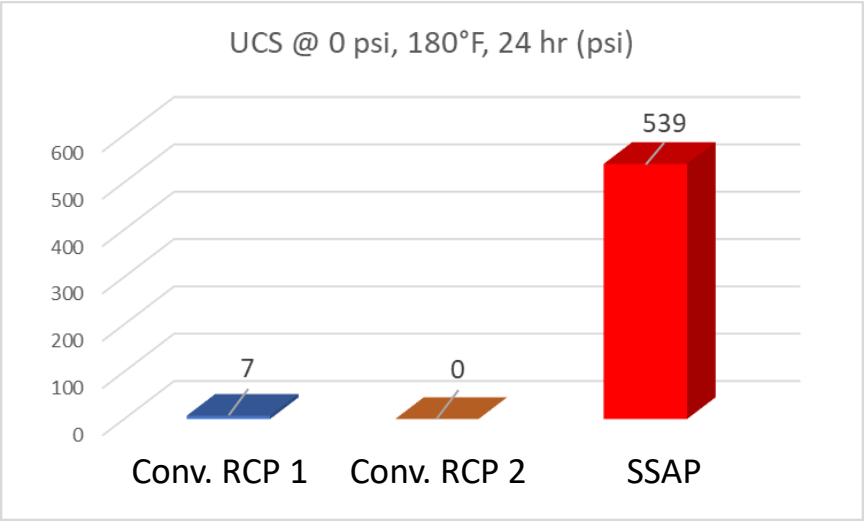
SSAP UCS

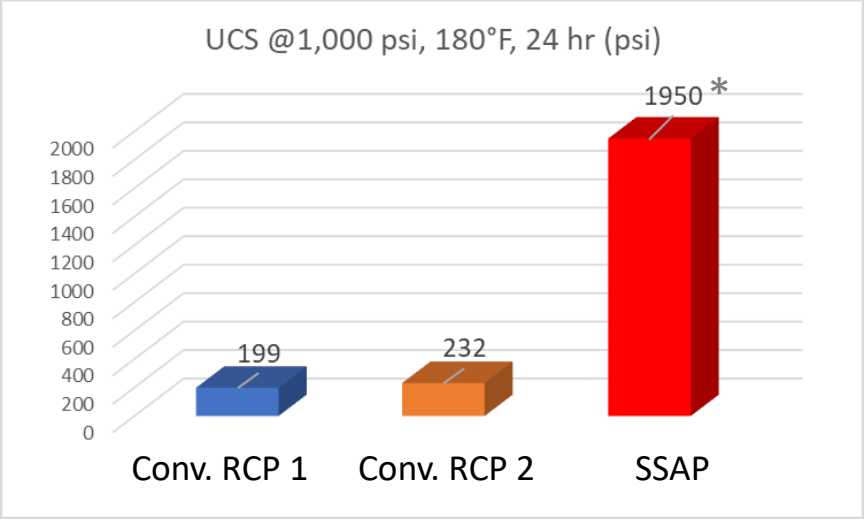
- North Sea example, BHST 70°C



SSAP vs. Conventional systems

- Conventional RCPs vs. SSAP for screenless completion applications offshore Malaysia
- SSAP provides effective bonding at low or no stress
- SSAP provides 10x UCS at 1,000 psi effective stress and test conditions





* UCS lower bound due to hydraulic press limitation

Screenless Sand Control Completions

- Screenless Sand Control Completions
  - Formation sand is held back by a proppant self-supported
  - Provides Sand Control and Stimulation
  - No jewelry: minimum intervention, reduced cost , full wellbore access
- Self supported proppant
  - Forms a consolidated pack in-situ filter
  - Zero to any stress, ambient to any temperature
- Successful application in Colombia
  - Recovered wells
  - Increased sand-free production, maintained water cut