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Sustainable Sand Management Control and Solutions - Balancing Performance, Costs, and Environment

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Smart Fracturing System for Screenless Sand Control Strategy in Cemented Monobore Completions

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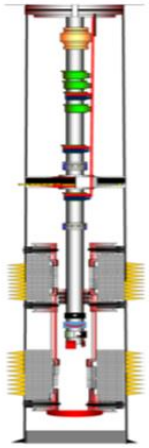
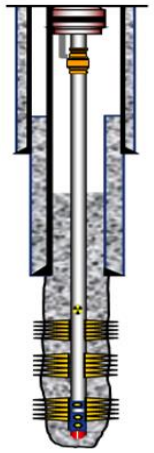
Smart Fracturing System Background and Challenges

- Downhole sand exclusion is increasingly crucial in Malaysia's oil fields as declining reservoir pressure and weakening formation sands become more common.
- Multi-stack reservoirs demand effective zonal isolation to prevent cross-flow.

- Cased Hole Gravel Pack (CHGP) is the preferred technique in many Malaysian fields.
- The high cost of CHGP renders many marginal fields uneconomical.



CHGP Fracpack



Cemented Monobore Fracpack

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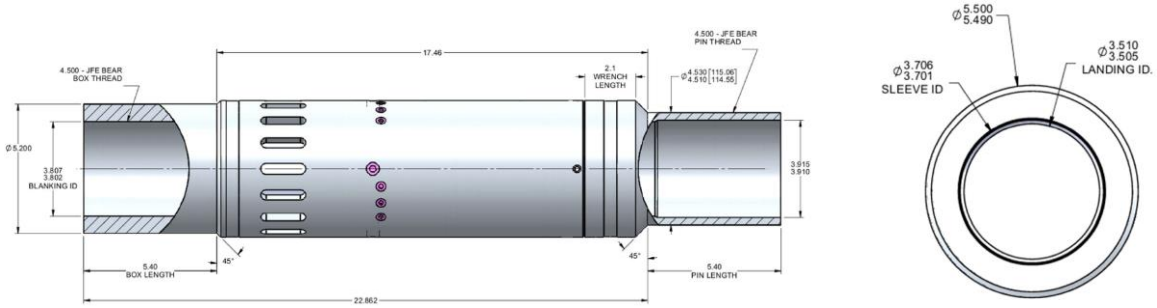
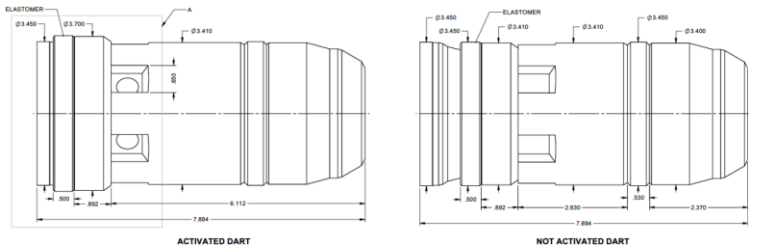
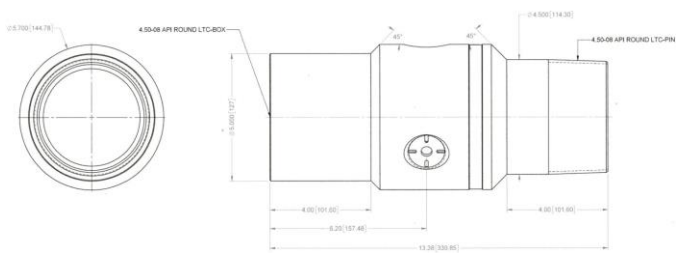
Smart Fracturing System Schematic



Single Point Frac Sleeve



Intelligent Dart



Fracture Initiation Sub

TRSV

PDG

MEP

Zone 5

Zone 4

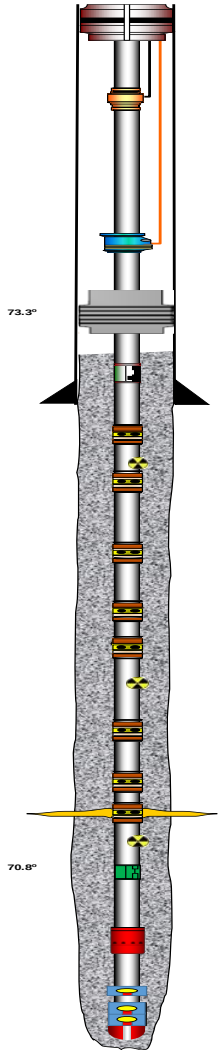
Zone 3

Zone 2

Zone 1

Float Collar

Float Shoe



Contingency / Dummy Sleeve

Single Point Closable Sleeve

Single Point Closable Sleeve

Contingency Sleeve

Single Point Closable Sleeve

Single Point Closable Sleeve

Contingency Sleeve

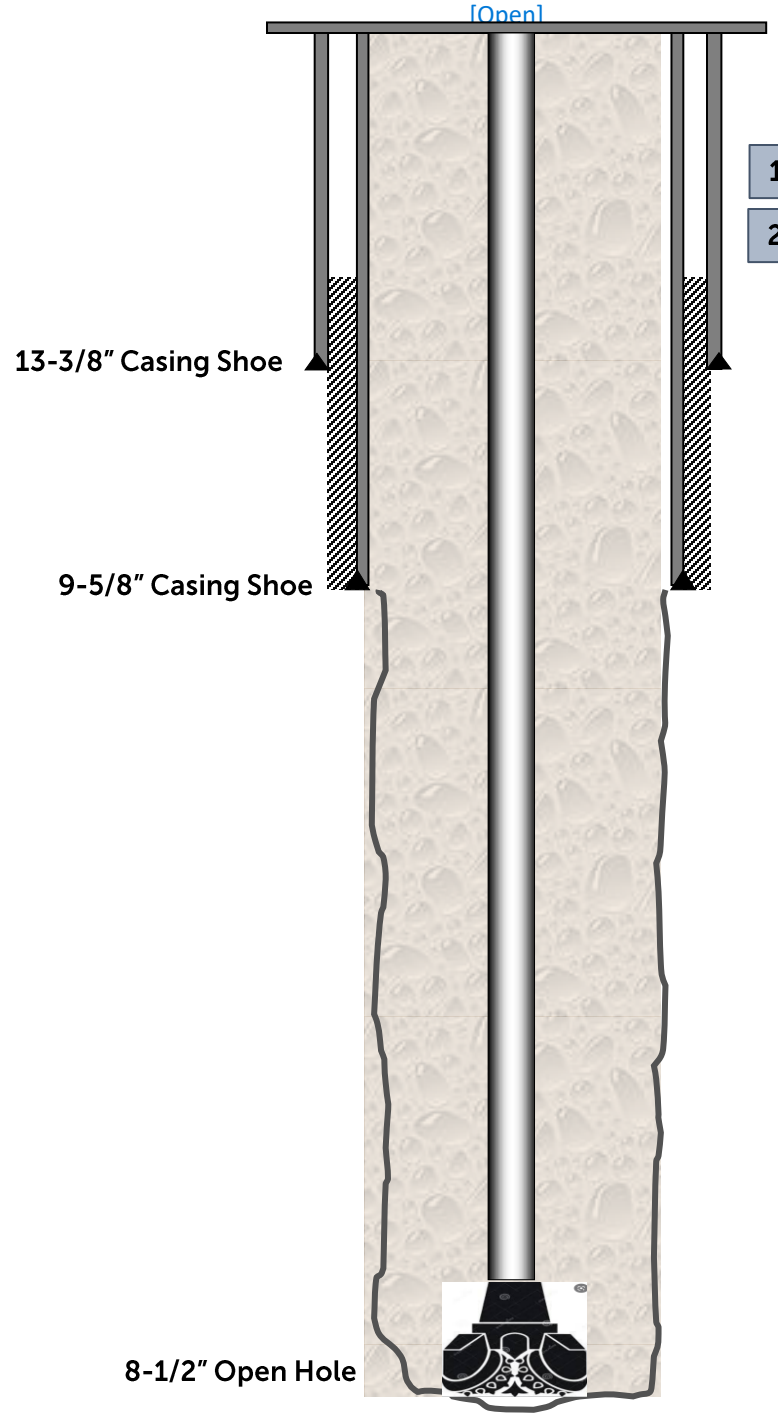
Single Point Closable Sleeve

Nippleless Plug

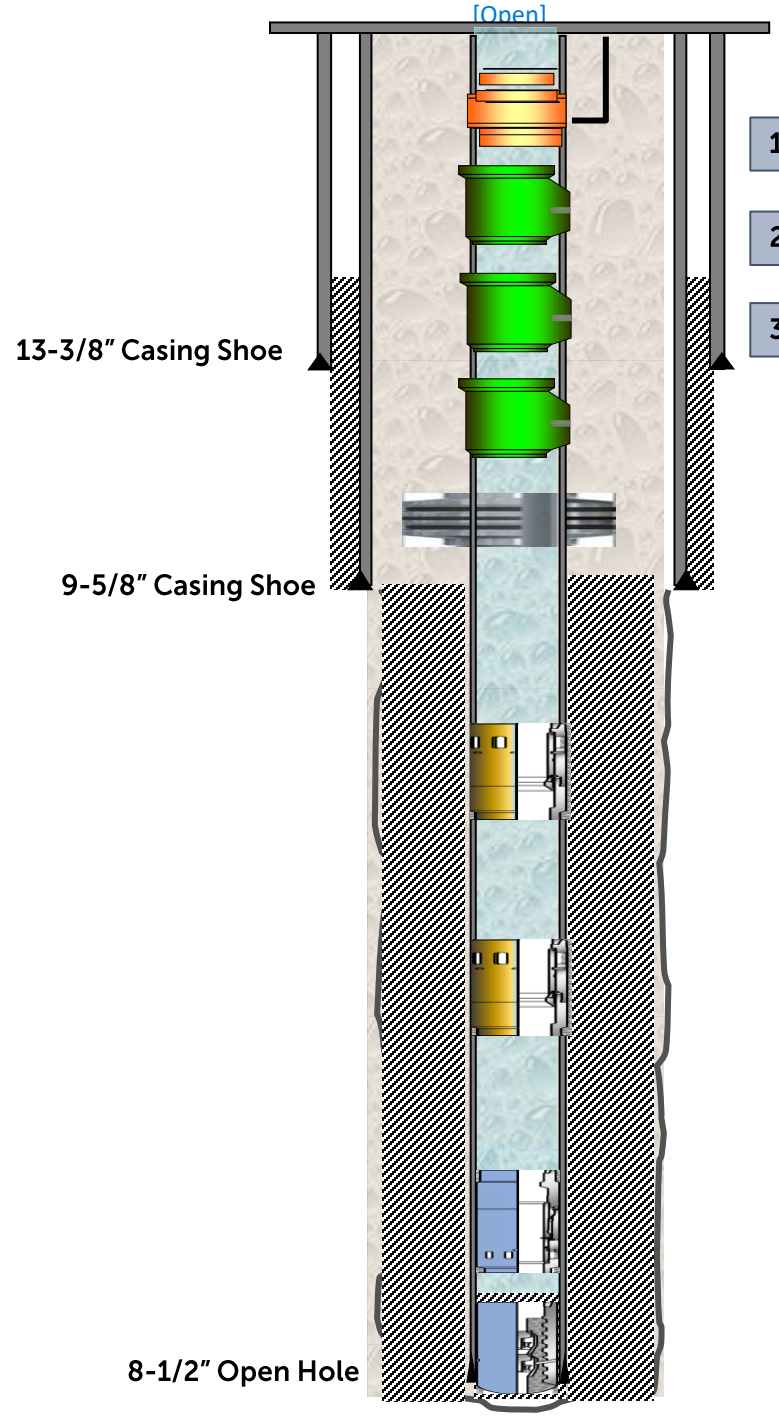
Fracture Initiation Sub

[Open]

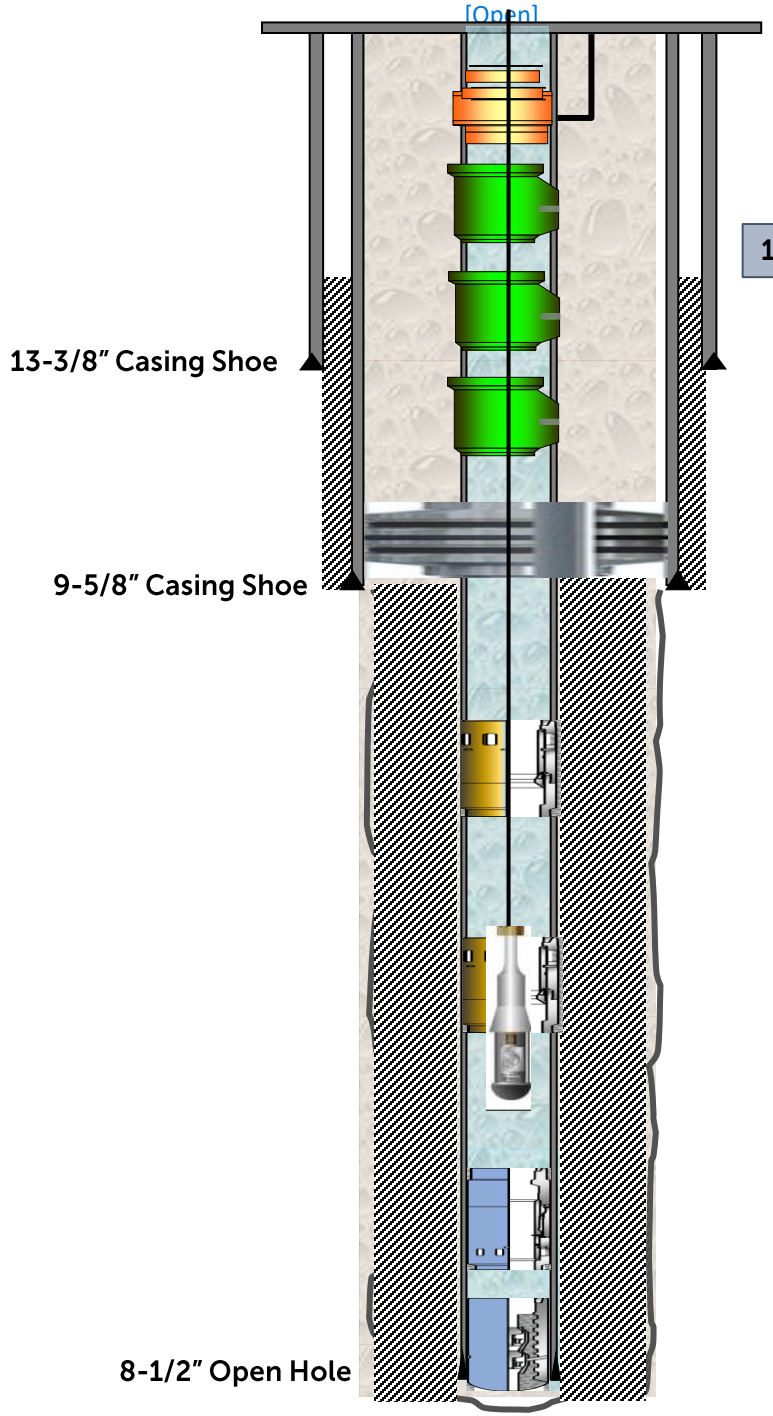
Smart Fracturing System Operational Procedure



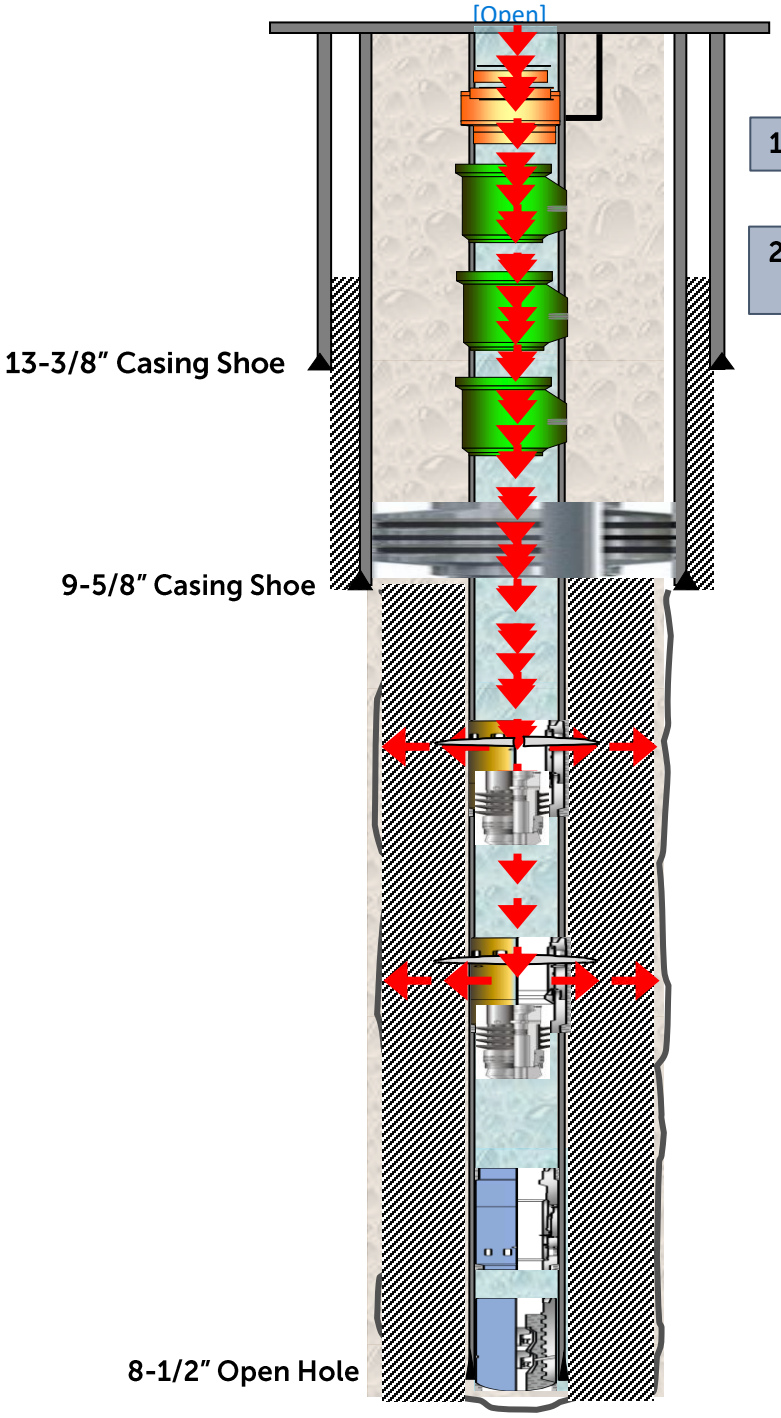
1. Condition Mud
2. POOH Drilling Assy



1. RIH 4-1/2" Completions
2. Perform Cement Job
3. Set Metal Expendable Packer



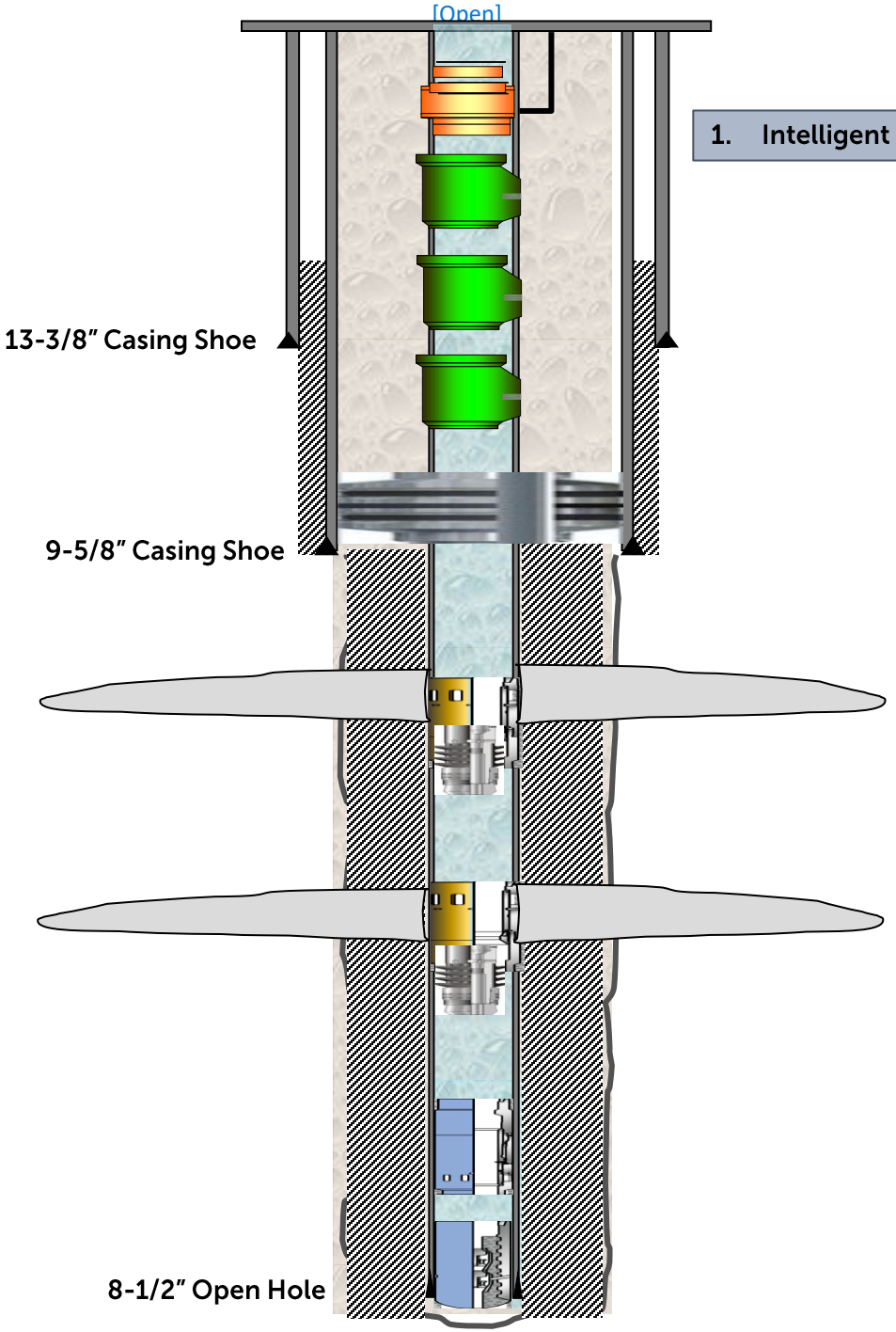
1. RIH USIT CBL Log



1. Activate Fracture Initiation Sub

2. Drop intelligent darts to open the frac sleeves and perform fracturing job

1. Intelligent darts self dissolve



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Smart Fracturing System Design Considerations

Equipment	Considerations
Christmas Tree	▪ Tree saver must be used but will reduce the ID.
Wellhead	▪ Able to sustain high pressure with a minimum of 7,500 psi.
Subsurface Safety Valve	▪ Cement-through type and able to withstand erosion from frac job.
Permanent Downhole Gauge	▪ Cement-through type and able to withstand erosion from frac job.
Metal Expendable Packer	▪ The MEP setting pressure must be low as possible.
Frac Sleeves	▪ Has the smallest ID in the well which is 3.505”.
Intelligent dart	▪ Dissolution test needs to be done with the required completion brine.
Fracture Initiation Sub	▪ Highest setting pressure in the completion string (6,400 psi).
Cement Wiper Plug	▪ Able to pass through the frac sleeve with maximum pressure of 1,800 psi.
Landing Joint & Frac Cross	▪ Have a common connection or xover to slickline, e-line, CT and frac cross.

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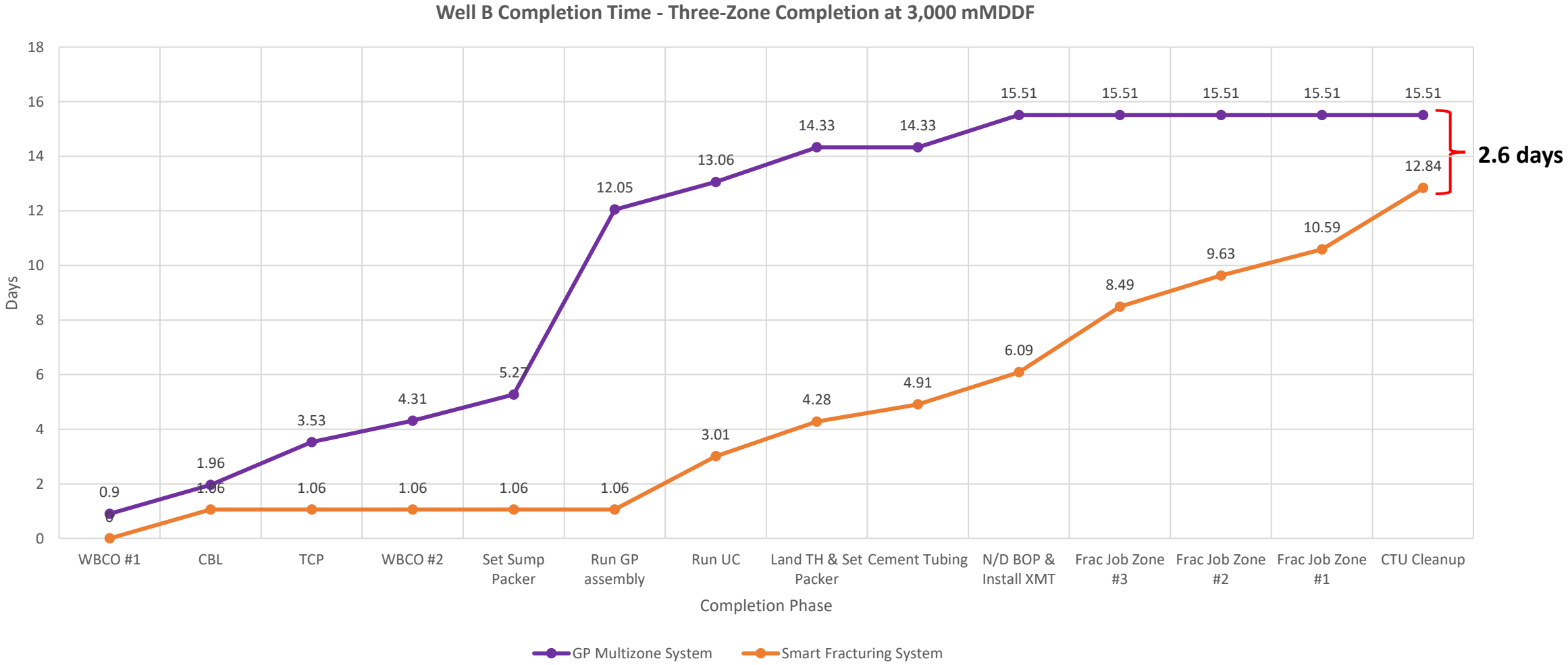
Smart Fracturing System Operation Time

Comparison Between GP Multizone System and Smart Fracturing System



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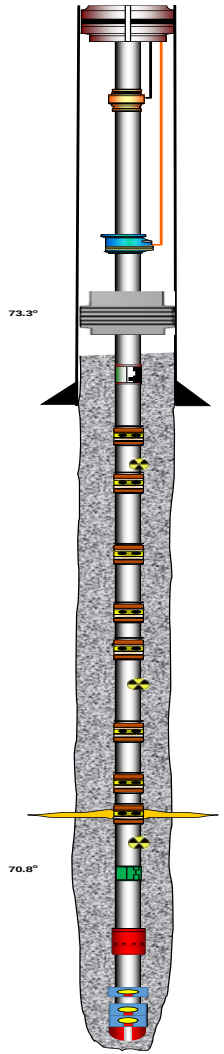
Smart Fracturing System Successful Installation in Well B



- Well B's depth is 2,783 m MDDF at 73 degree inclination.
- Only 1 zone was completed out of 5 zones.
- Fracturing 1 zone only took 17 hrs including breakdown test, Step Rate Test and mini frac.
- Smart Fracturing System in comparison to GP Multizone System saved 2.0 days.
- Low sand count of 2.8 g/d with 32/64" choke size (MSFR).
- Achieved 43.2% of targeted production rate from 1 zone only.

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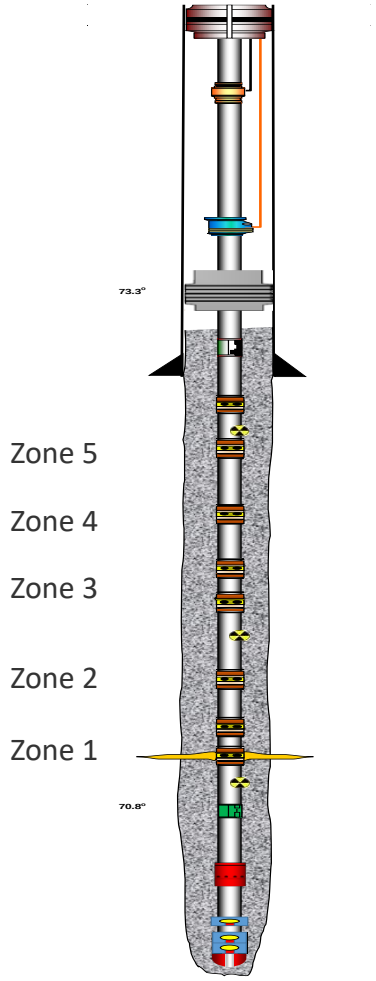
Smart Fracturing System Lesson Learnt in Malaysia

Failure of the intelligent dart to open the Zone 2 frac sleeve



Frac : Drop Dart to Open Zone 1

Frac : Frac Pack Operation Zone 1

TCC

Successful Zone 1

Frac : Drop Dart to Open Zone 2

Observed Zone 3 sleeve opened

CT Milling

TCC #2

TCC #1

Frac : Frac Pack Operation Zone 2

Shift close Zone 3 Frac Sleeve

Frac : Convey Dart to Open Zone 3

Decision to drop Smart Fracturing System & change to plug and perf

Set bridge plug

Decision to temporary suspend Well B and skid to next well.

Set Sand plug for Zone 2 unsuccessful

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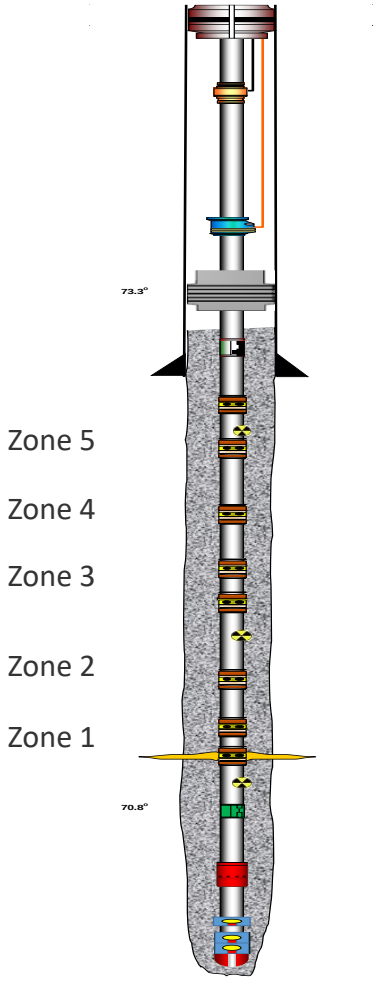
Smart Fracturing System Lesson Learnt in Malaysia

Failure of the intelligent dart to open the Zone 2 frac sleeve



What happened?

- The dart unexpectedly opened the Zone 3 sleeve (2nd treatment).
- Dart was prematurely stuck at the Zone 5 secondary frac sleeves (3rd treatment) when pushing the dart with CT.

What was performed to regain Well B?

- Milled the dart using CT, closing the Zone 3 sleeve, and re-running the Zone 2 dart with CT assistance.
- Drop Smart Fracturing System and change to plug and perf method.
- The CT tagged the top of the sand plug higher than anticipated.
- All the sand plugs had been overflushed into the Zone 1 formation.

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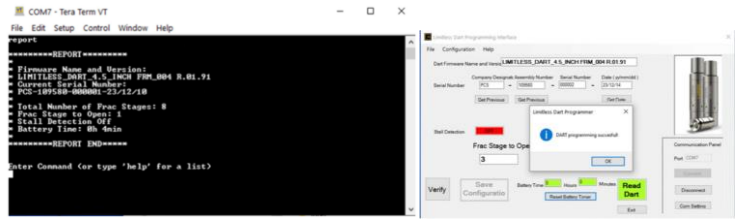
Smart Fracturing System Lesson Learnt in Malaysia

Possible Root Cause

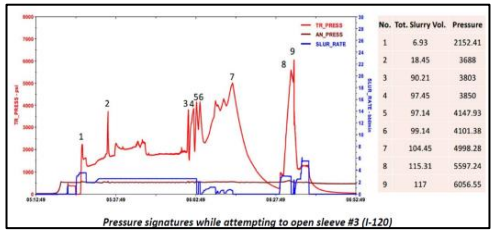
Programming/launch order errors

Correct programming based on confirmation report from dart PCB & internal memory.



Excessive Pressure

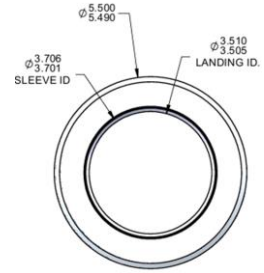
None of the darts were exposed to maximum operating pressure of the dart (13,000psi).



Pressure signatures while attempting to open sleeve #3 (I-120)

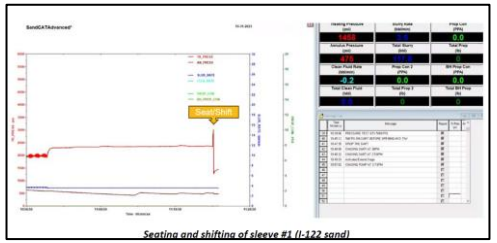
Electro-magnetic Interference

Video file taken prior to dart cap installation doesn't show any ghost counts on the circuit board (red light).

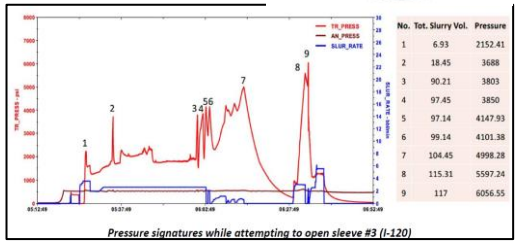


Dart Clearance

Sleeve ID 3.505", Dart OD 3.450",
-circumferential clearance of **0.0275"**.
"Signature of dart pushing slug of proppant"



Seating and shifting of sleeve #1 (I-122 sand)



Pressure signatures while attempting to open sleeve #3 (I-120)

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Smart Fracturing System Lesson Learnt in Malaysia

Conclusions

Future improvement for Smart Fracturing System:

- Utilize cross-linked gel as the carrier fluid for proppants.
- Perform a slickline run before the pumping job.
- Implement a continuous pumping method.
- Include more sleeves in a zone for lower skin value.
- Ensure feasibility in offline mode to avoid consuming rig time.

Acknowledgement

The team would like to extend their heartfelt appreciation to PETRONAS Carigali Sdn. Bhd. for allowing all the information to be used in this SPE Workshop. All the members who actively participated and made valuable contributions to the successful execution of this project, despite the challenging and high-risk nature of the operations. Their unwavering commitment to ensuring safety and compliance is commendable.

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