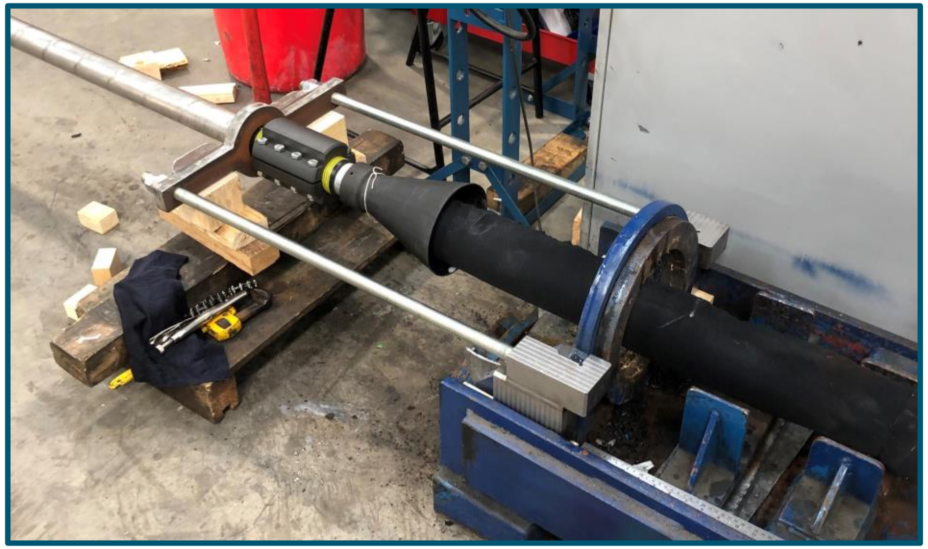
Filtrex – Sand Control

Agenda

- Filtrex Application Overview
- The Filtrex Media OCMP
- Stacking
- Deployment Overview
- AICDs
- Challenges in Multi Zone Well
- Proposed Solutions
- Principles
- Results

Filtrex – Application Overview

- Filtrex is a remedial sand control system to address the issue of sand production in existing perforated wells.
- Filtrex can be installed on drill-pipe, tubing, coiled tubing or slickline providing operational flexibility and be tailored to specific applications.
- Requires no further intervention but can be easily retrieved, if required, in future.



GIANT OIL TOOLS FREE ZONE

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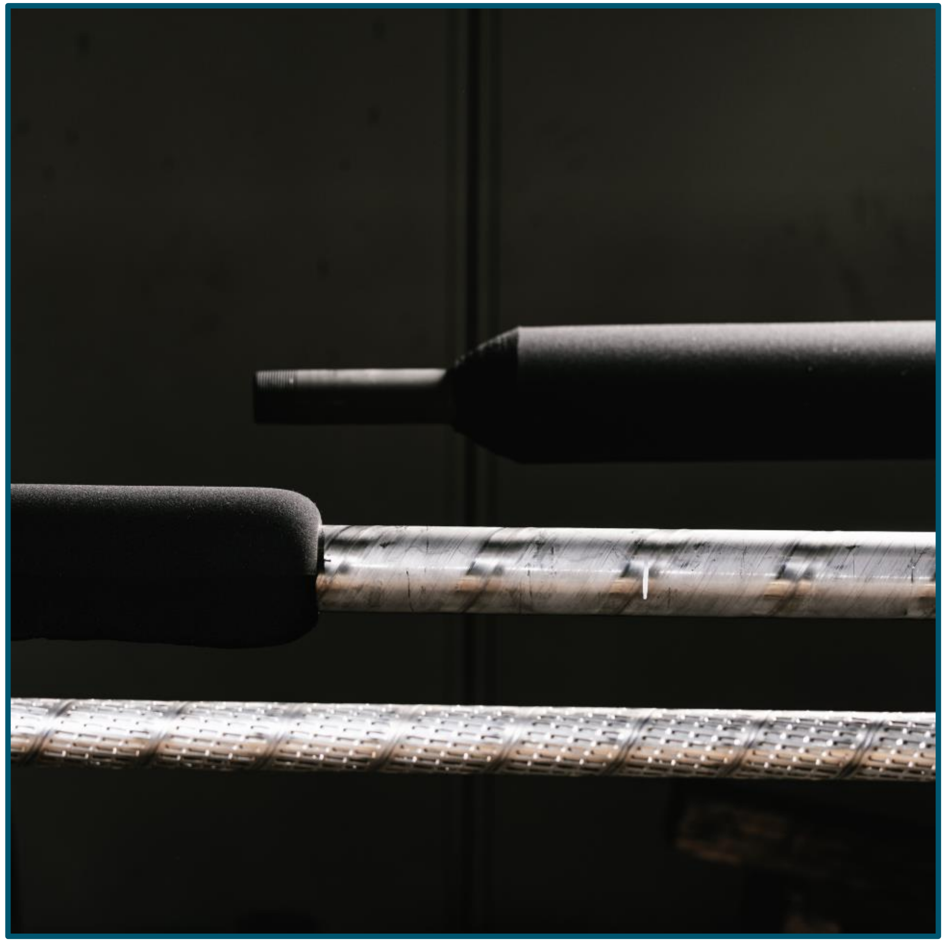
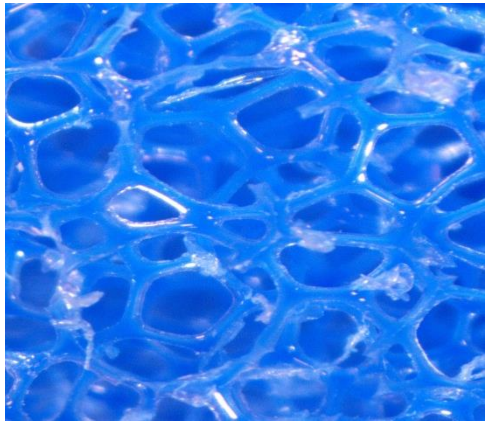
Filtrex – Application Overview



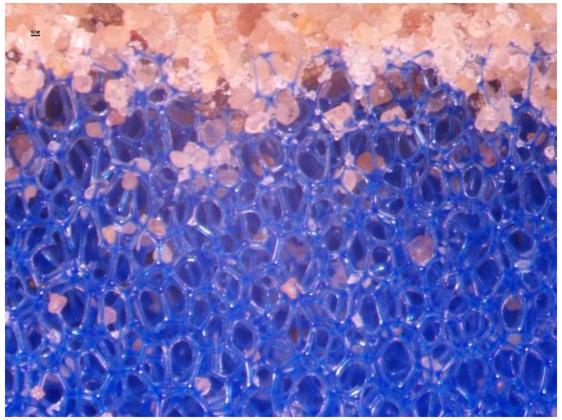
- Filtrex OCMP Media
- Filtrex Shroud
- Filtrex Base Pipe

Filtrex – Application Overview

- A simple intervention based system utilising a filter media of multi-layer **open cell matrix polymer (OCMP)** which is designed to retain sand whilst allowing fluid flow through it.
- Once set, the filter media expands to conform to the wellbore ID.



OCMP



OCMP RETAINING SAND

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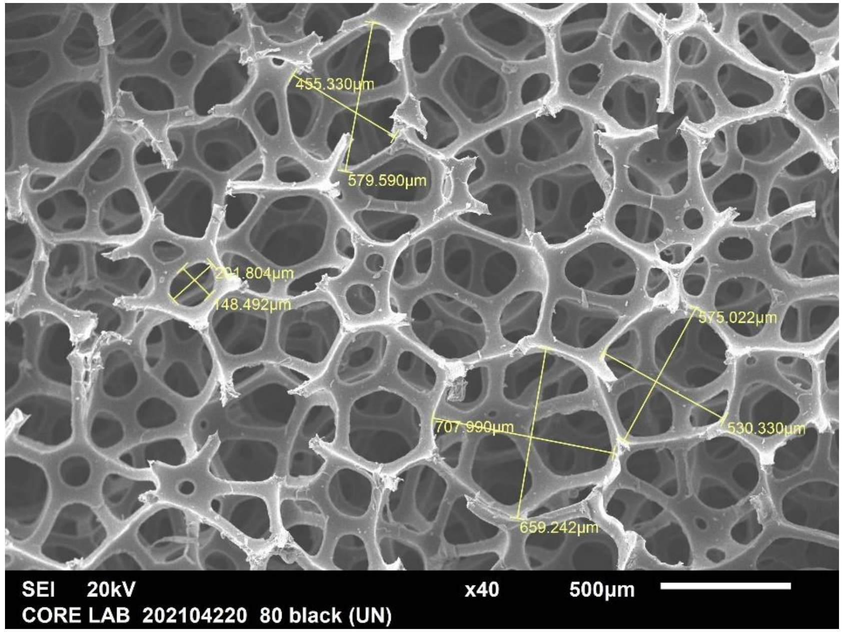
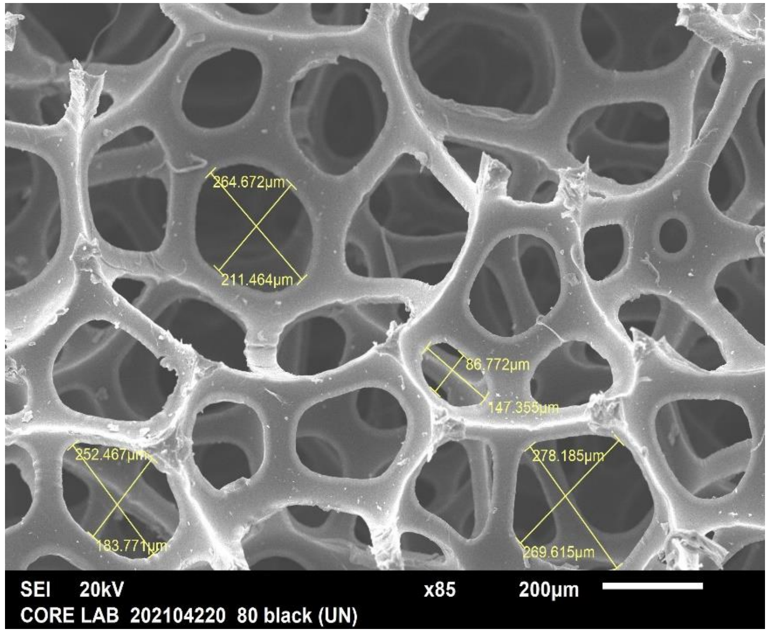
SEM Imagery – 80ppi retention layer





Key Specifications of OCMP

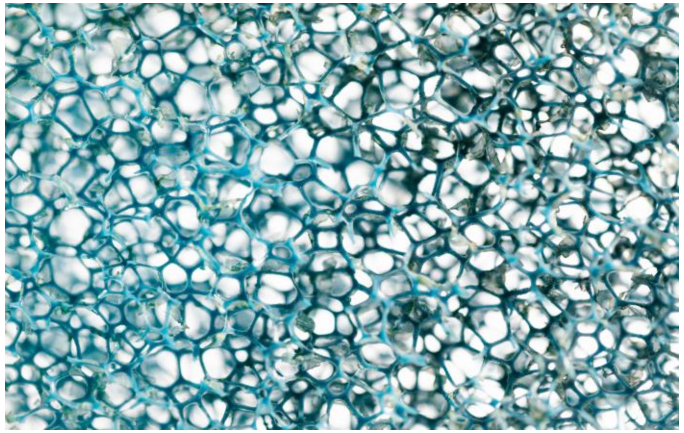
Porosity of the media is **77%-85%**

Permeability of the media is **43.7 Darcies**

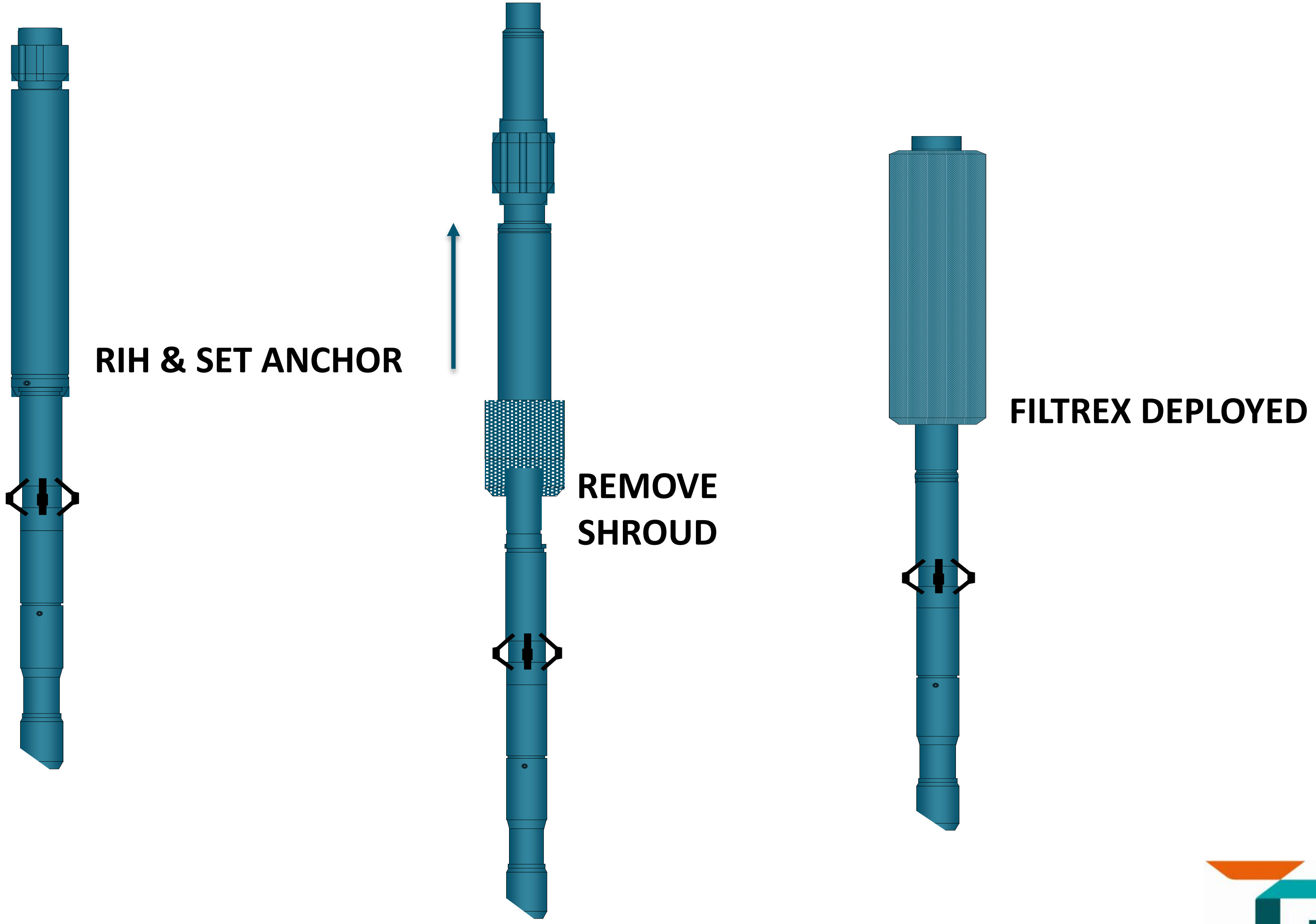
Multiple layer design to provide a **more tortuous path for sand** and acting as a convergence layer to homogenous flow

The OCMP works as depth filter with the outermost convergence layer filling up with **sand and naturally bridging off**. Sized on the **D50 100µm and above.**

Erosion tests showed no erosion of the *OCMP at 6ft/sec flow rates as the polymeric nature of the filter deflects the energy from sand grain* impingement and minimise erosion.



Filtrex – Deployment Overview



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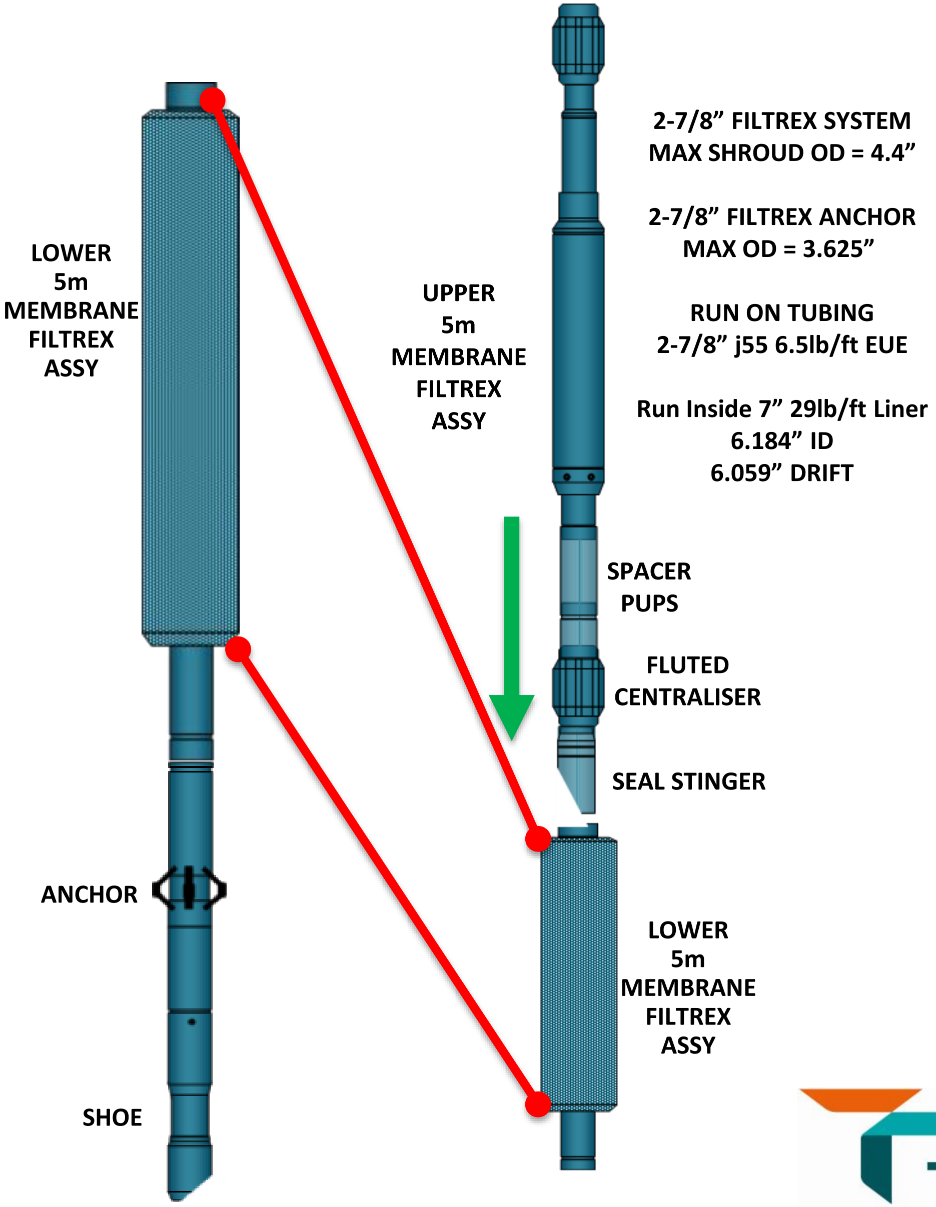
Filtrex – Application Overview - Stacking



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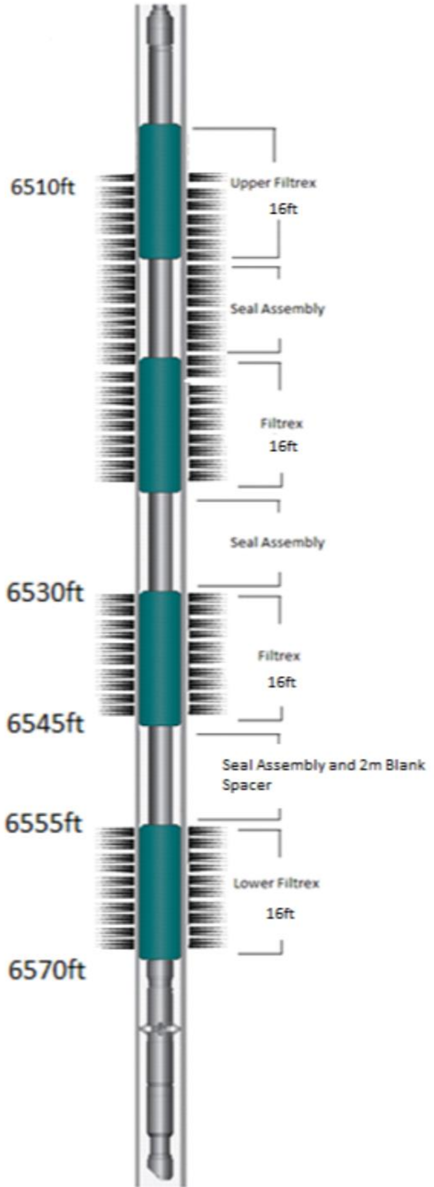
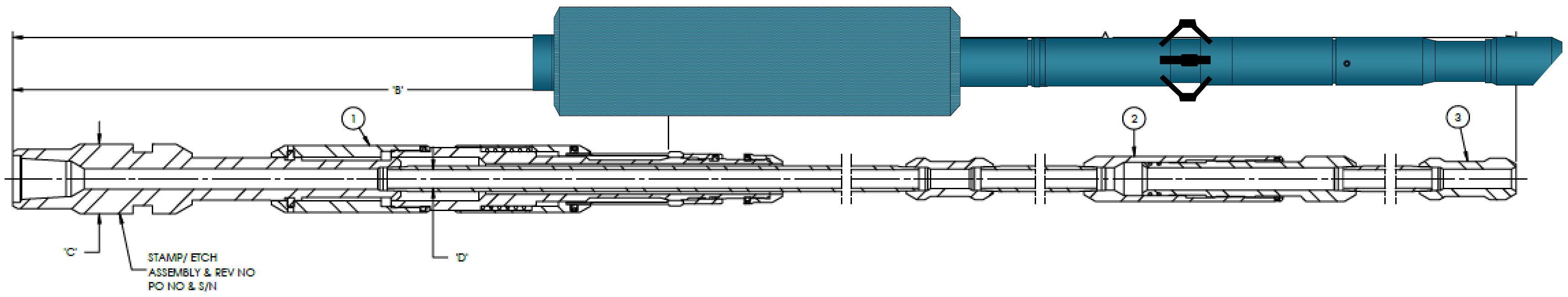
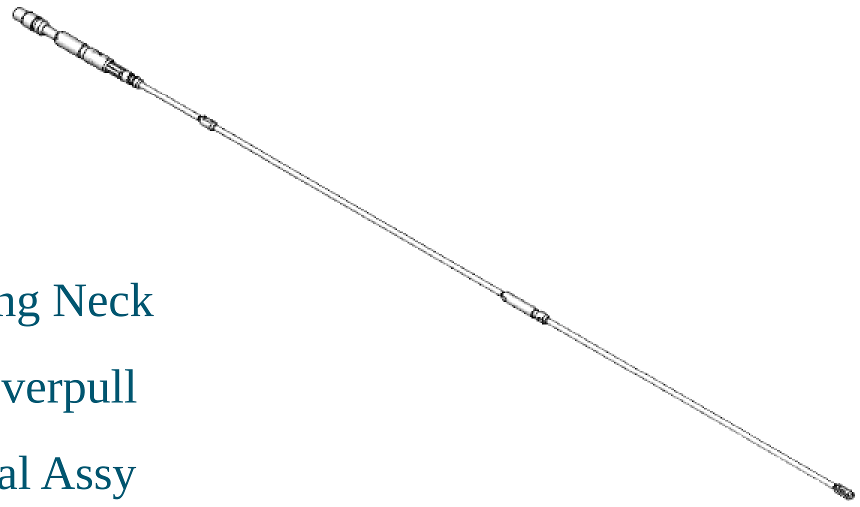
Filtrex – Application Overview - Stacking



- Filtrex can be stacked
- Maximum of 5x Filtrex Units
- Governed by Shear Ratings on the Seal Stinger below each Filtrex Unit.
- Max Length of Filtrex Media
  - 5m for DP/Tubing/CT

Filtrex – Retrieval - Anchor





- RIH with Running and Retrieving Tool
- Retrieving Tool Collet Enters the Fishing Neck
- With Retrieving Tool Engaged apply Overpull
- Continue Overpull To Shear Latch / Seal Assy
- Recover to Surface

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Filtrex – Deployment Options

Anchor Deployment :

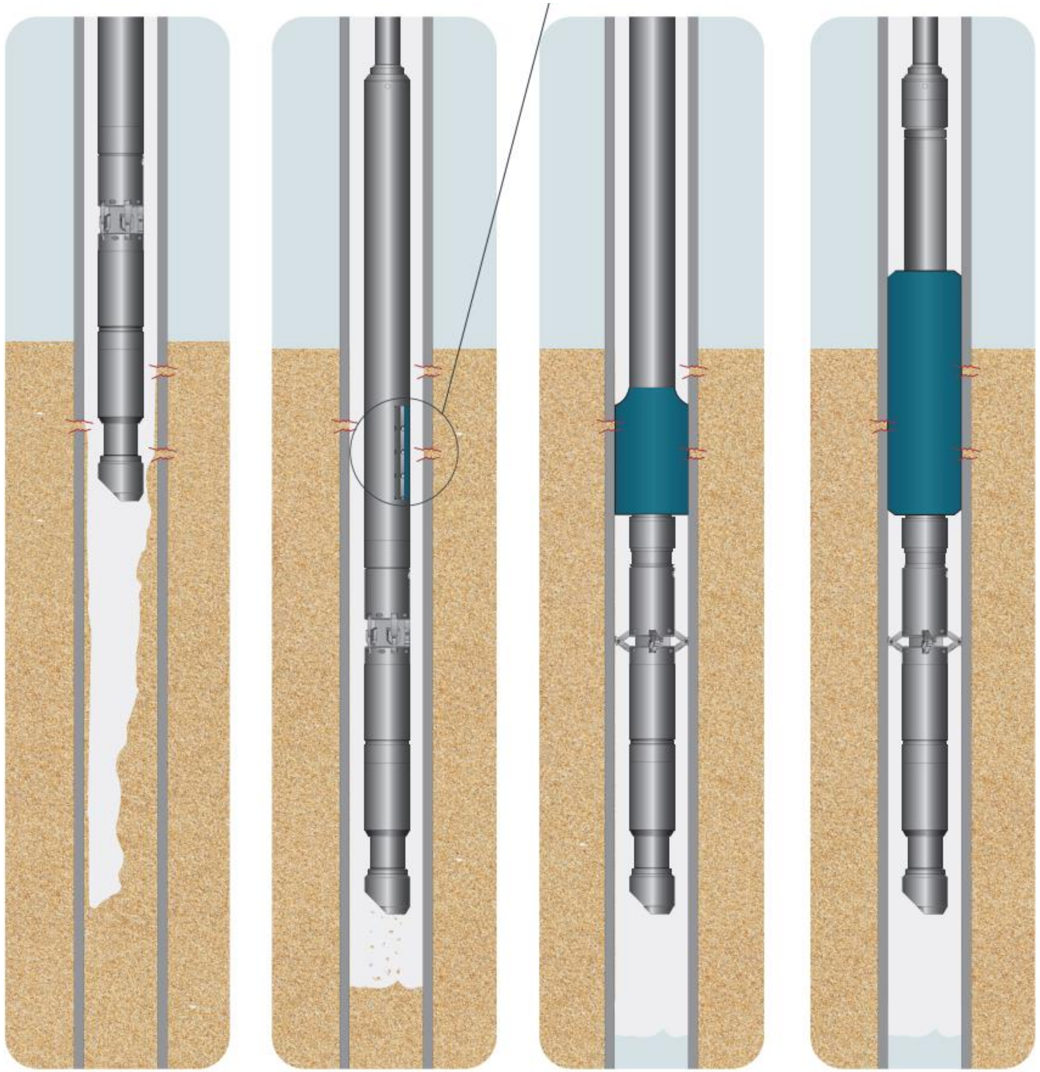
- One Trip System*
- DP/Tubing/CT ONLY – Circulation Required
    - Drop a ball to hydraulically set the anchor & for primary release from the running tool
    - Can use a captured ball seat

Packer & Latch:

- Two Trip System*
- Slickline & Optional DP/Tubing/CT
    - Install 3rd Party Packer
    - RIH with Filtrex assy c/w 3rd Party Latch matched to Packer

*For a single Filtrex Assy installation

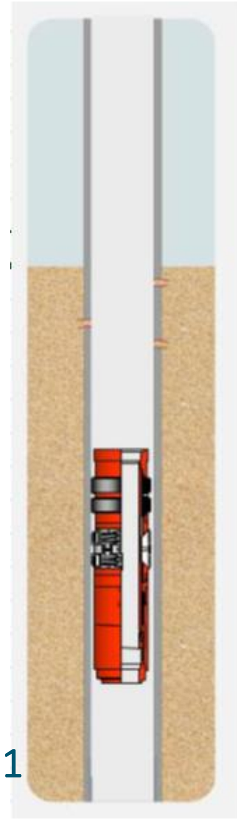
Filtrex – Anchor Deployment



Filtrex – Packer & Latch Deployment

Stage 1 : Install Packer accurate space out, ensuring Filtrex Mid Point is middle of Production Zone

Stage 2 : RIH Anchor Latch which pre made up to Filtrex Assembly and latch into Packer



Stage 1

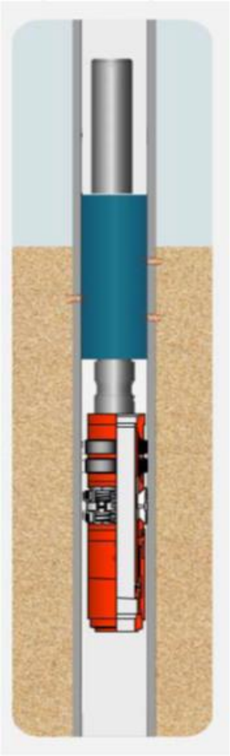
Stage 2

Filtrex – Case History

Stage 3 : Latch Anchor Latch to Packer and Overpull Test for confirmation

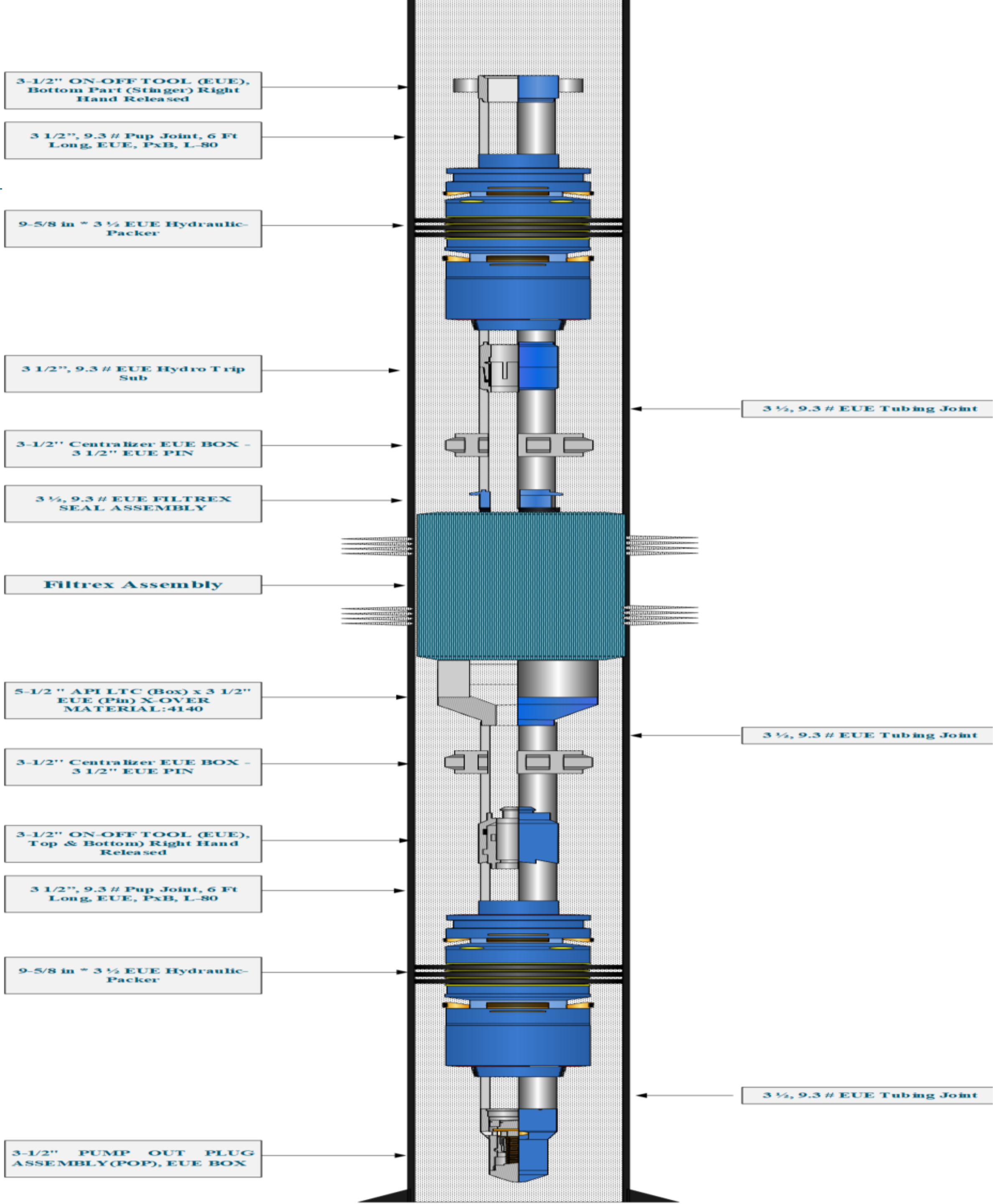
Stage 4 : Begin Release the Filtrex Running Tool by Jar Down and apply Overpull to 1600 lbs to remove the Filtrex Sleeve, Weight drop indicates Sleeve is fully removed, and POOH to surface retrieving Running Tool and Sleeve

Stage 3



Stage 4

Filtrex – Case History

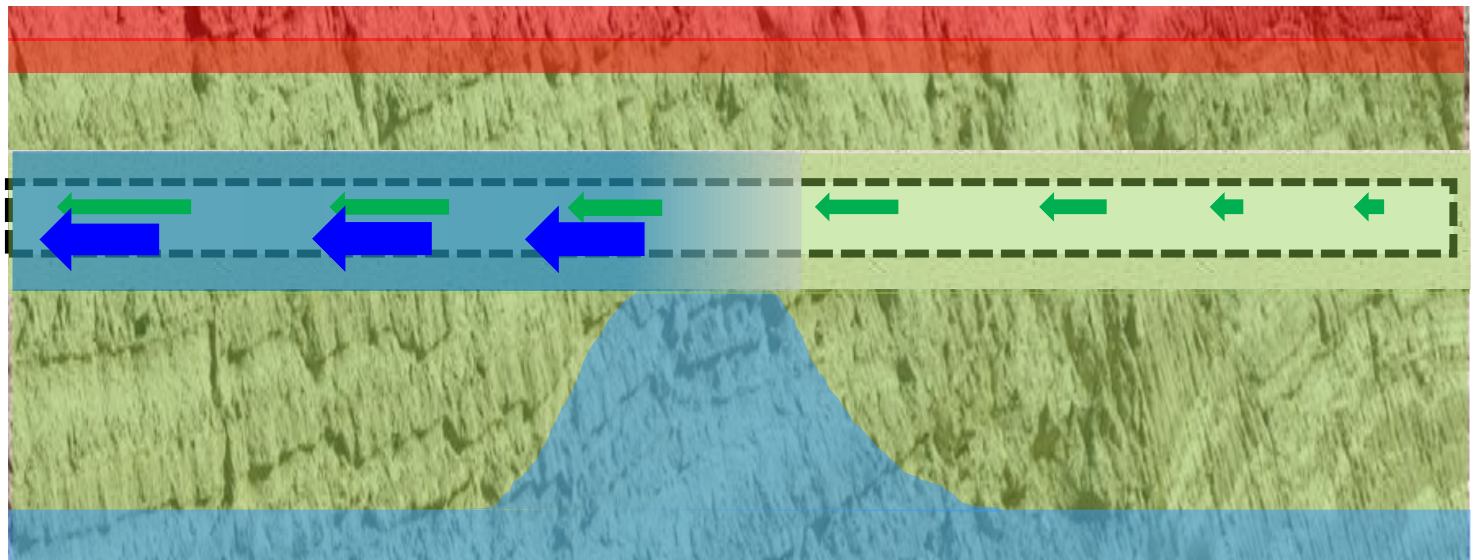


Flow Control Technology – AICD

The Challenge – Requirement for Flow Control

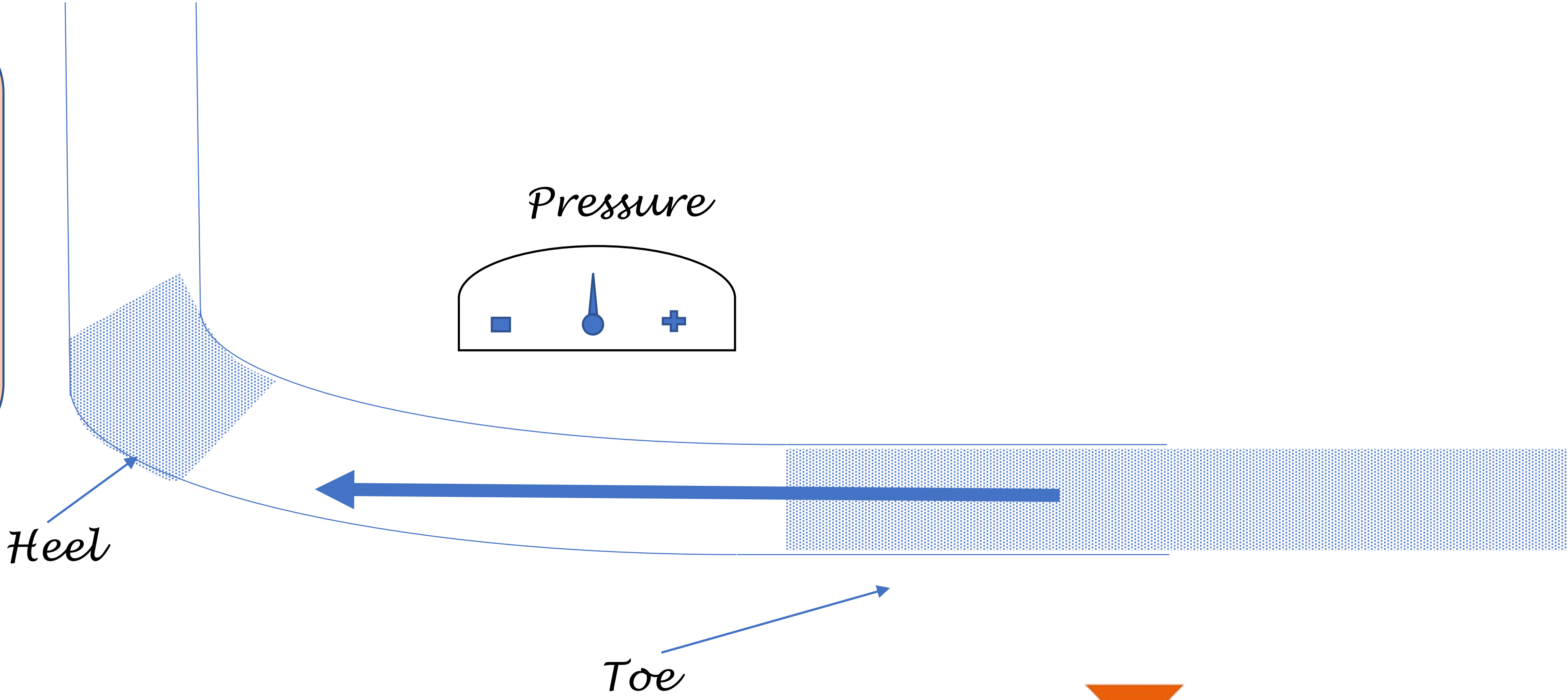
Mult-Zone Horizontal Well Challenges:

- Thin Oil Rim
- Different Permeable formations and Fractures
- Cross Flows
- Early Water / Gas Coning
- Unfavorable Fluid Mobility



The Challenge, Heel to Toe Effect in Horizontal Wells

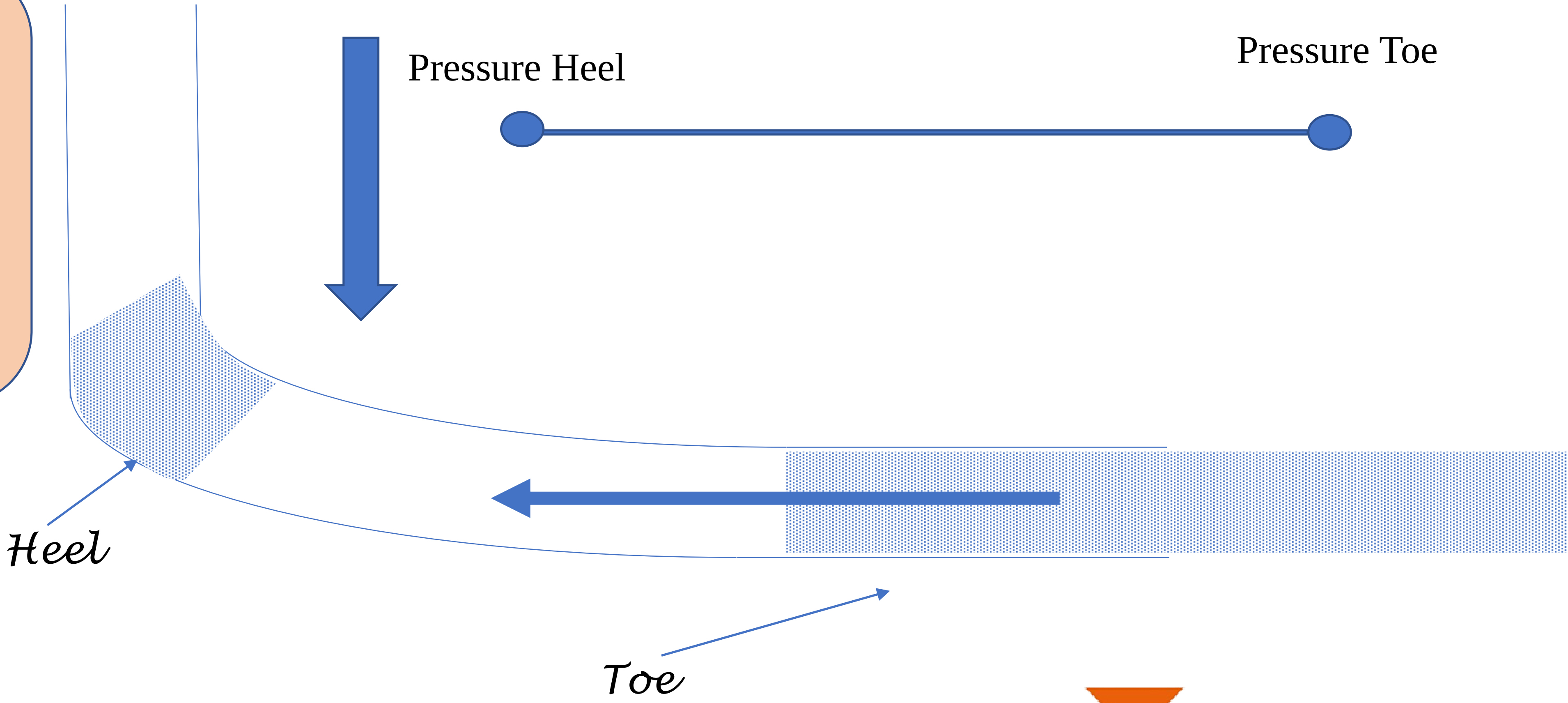
Pressure drops as fluids goes from *Toe* to *Heel* due to **friction losses** between the **wall pipe** and **fluid**



The Challenge, Heel to Toe Effect in Horizontal Wells

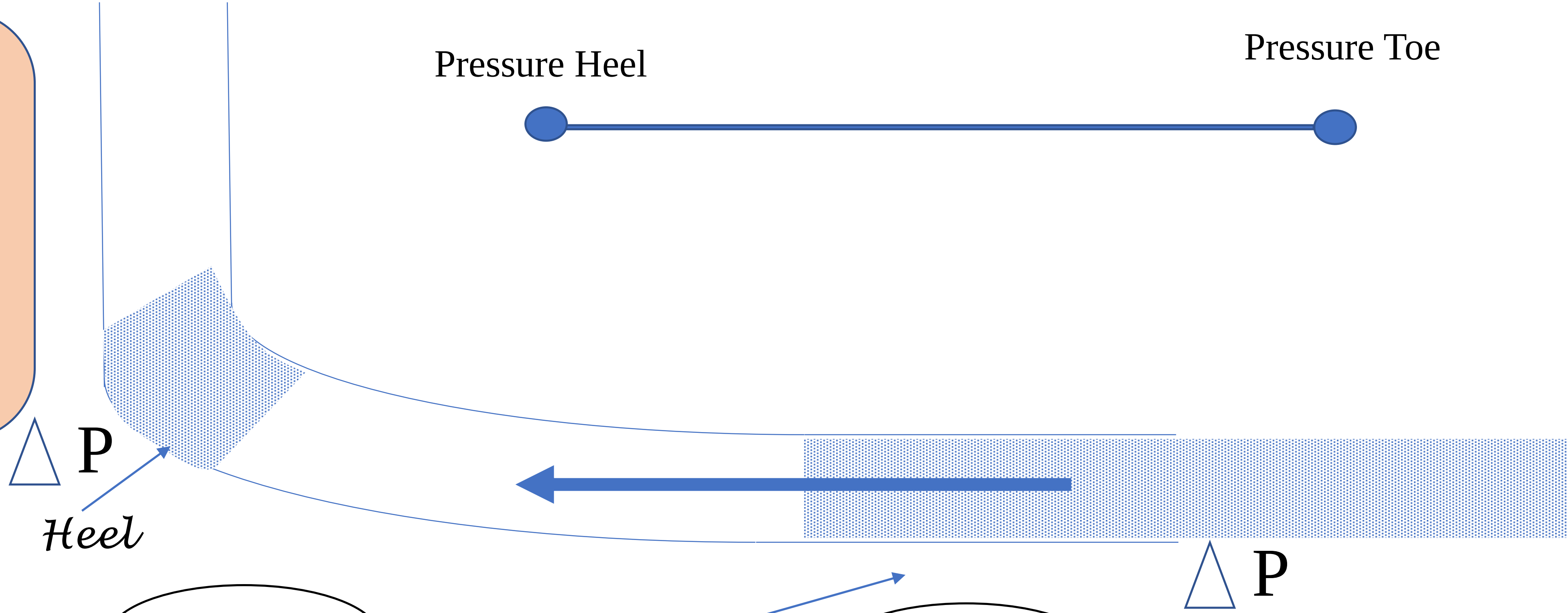
The result of **pressure losses** due to **friction** losses, leads to:

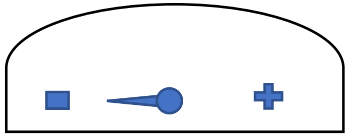
- **Lower pressure** at the *Heel* inside the pipe than the toe



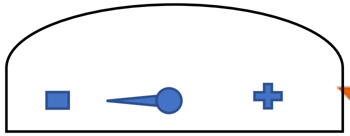
The Challenge, Heel to Toe Effect in Horizontal Wells

This results that **<u>ΔP</u>** at the **<u>Heel</u>** is larger than **<u>ΔP</u>** at the **<u>Toe</u>**





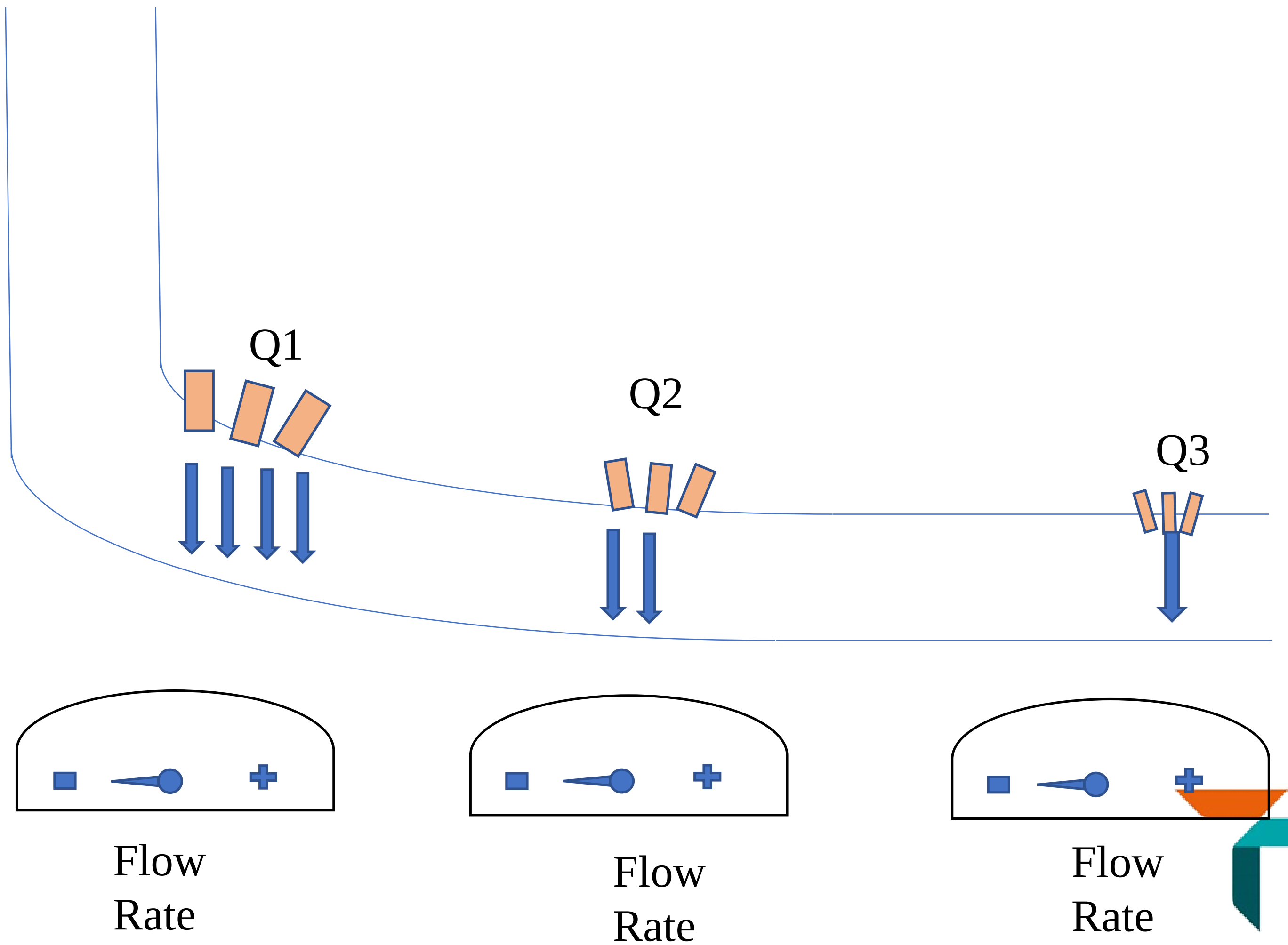
Delta P at Heel



Delta P at Toe

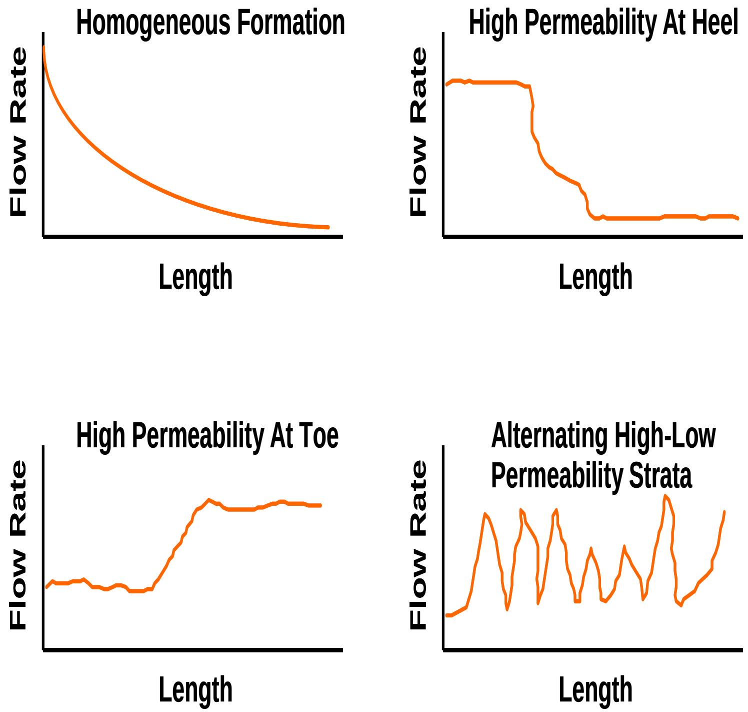
The Challenge, Heel to Toe Effect in Horizontal Wells

Consequently with the different **ΔP** along the Heel to Toe, with the Heel having the largest **ΔP** it will also have the highest Flow rate

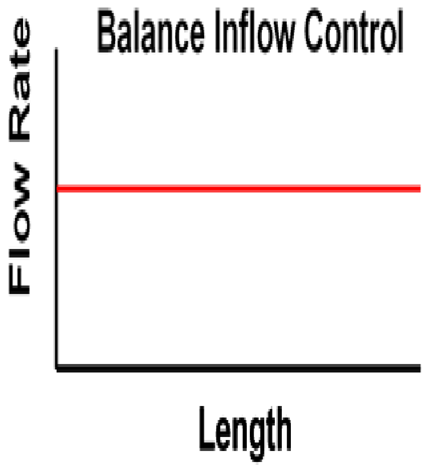


The Challenges

Without Inflow Control



With Inflow Control devices



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Autonomous Inflow Control Devices

It is a device that regulates flow of fluids, used in ***horizontal, multi-lateral*** or ***other advanced well architectures***

It is capable of modifying its flow control characteristics automatically in response to fluid properties to ***exclude unwanted effluents: water, gas***

Demonstrates different response in **pressure drop vs flow rate performance** as a function of **fluid type**

RCP AICD
SPE 159634

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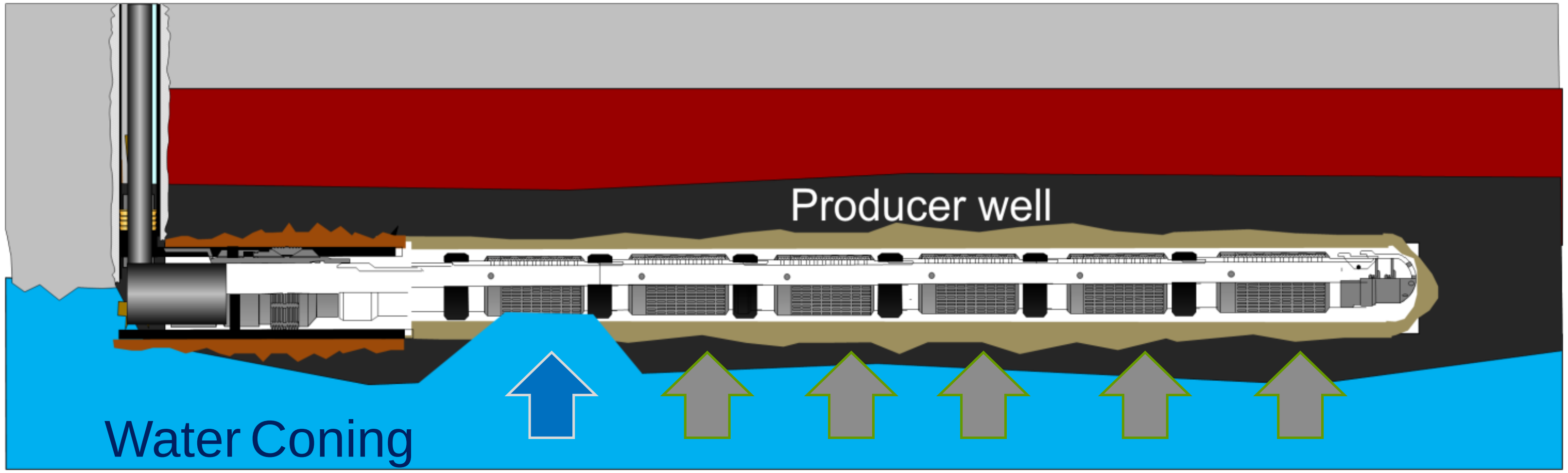
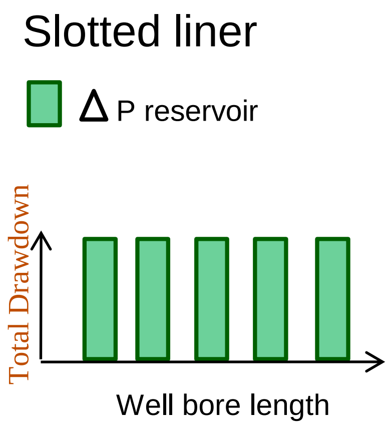
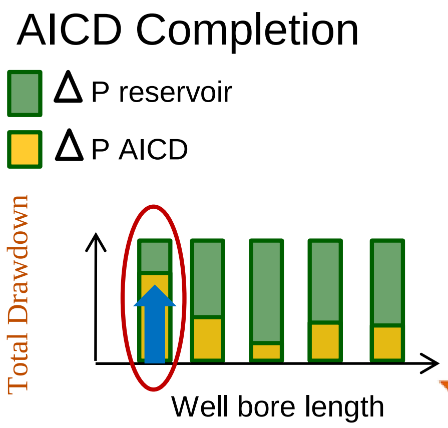
AICD inflow Pressure drop







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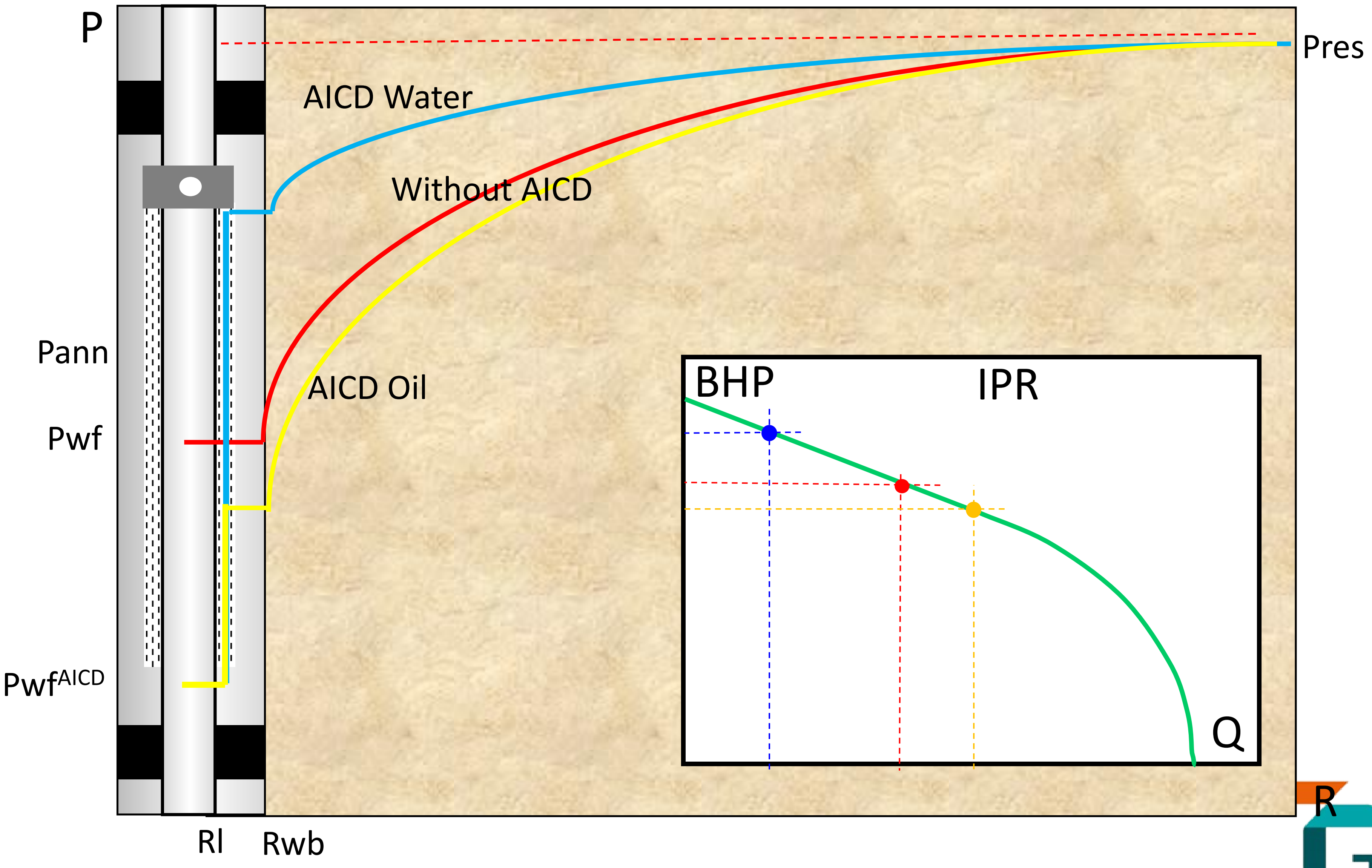
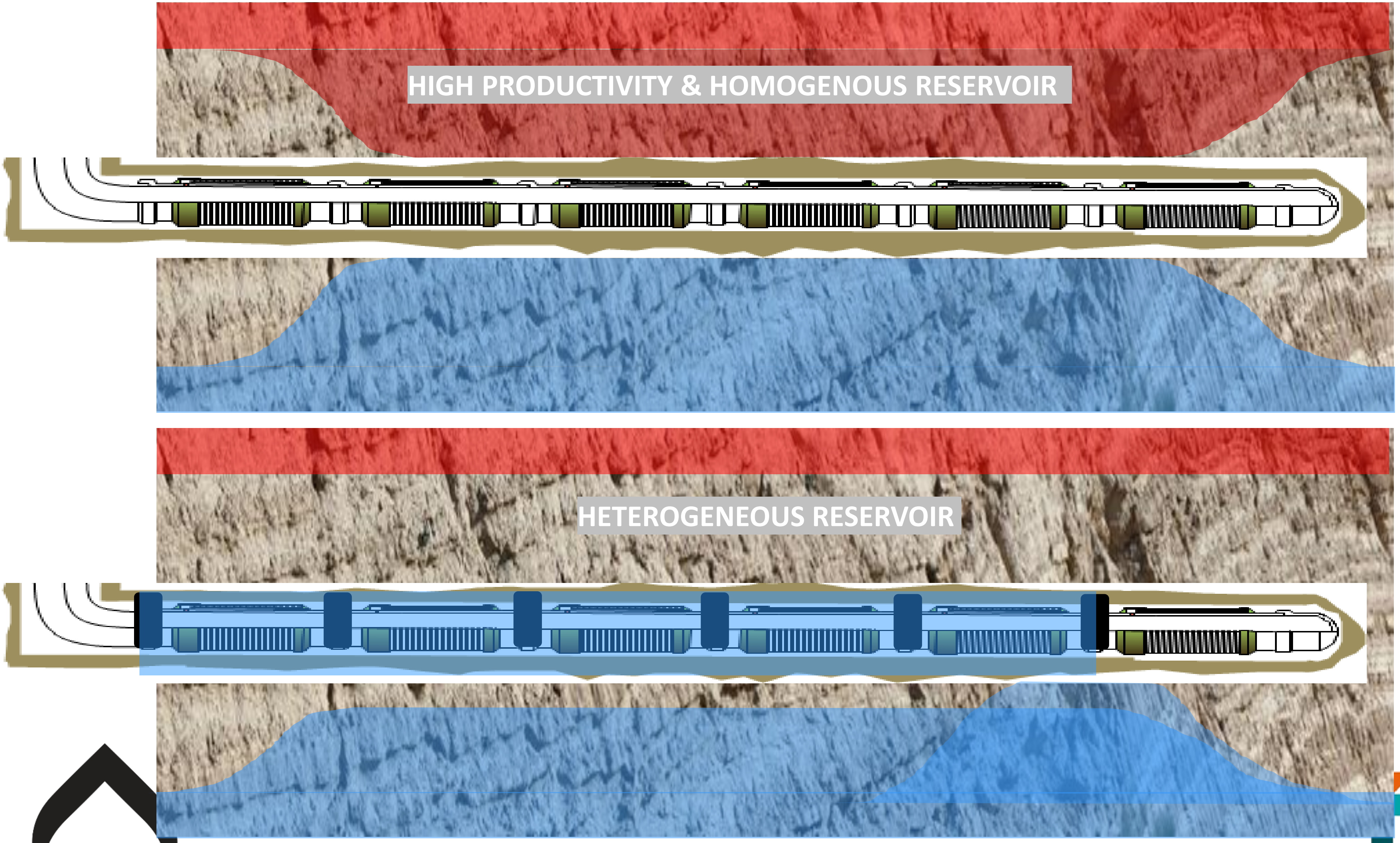
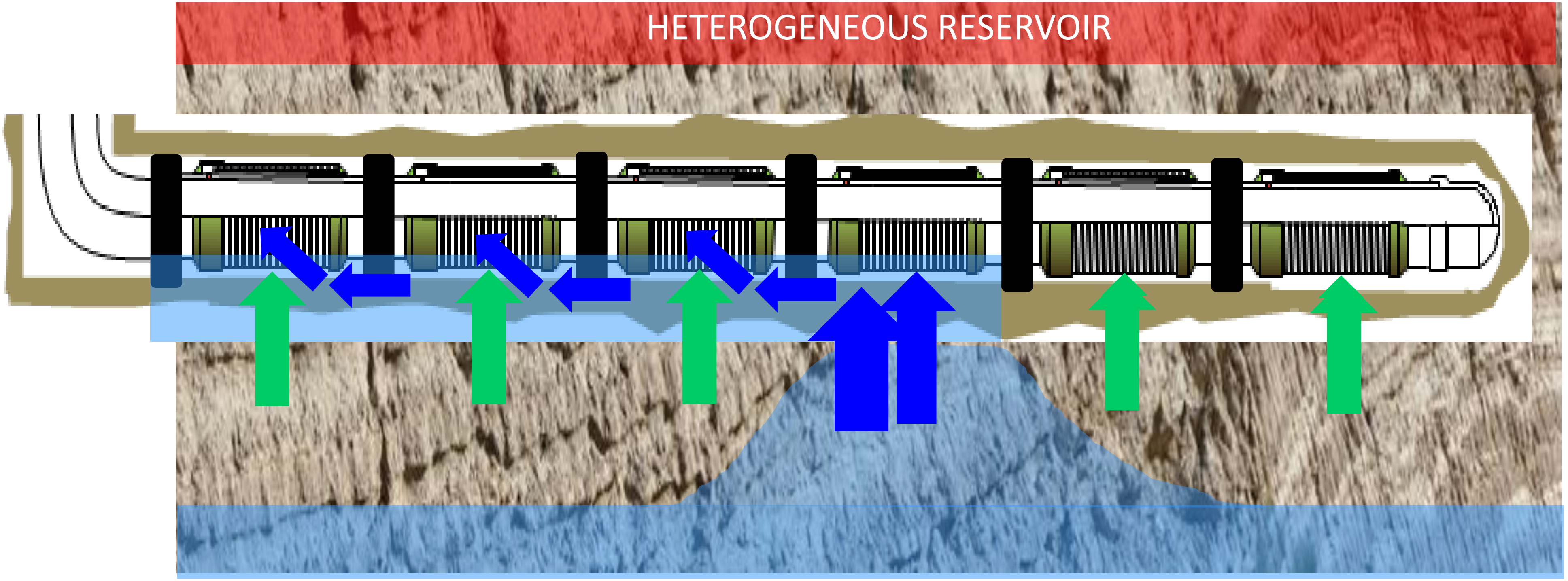
AICD Inflow Pressure drop



The Solution

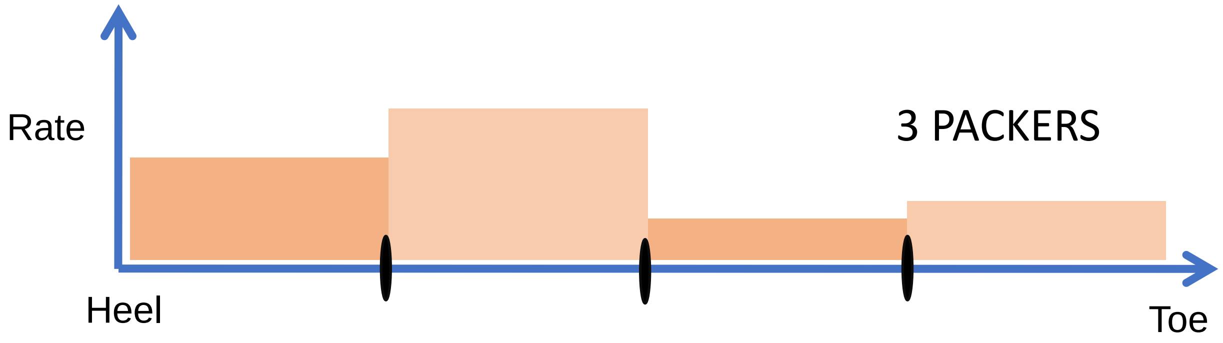


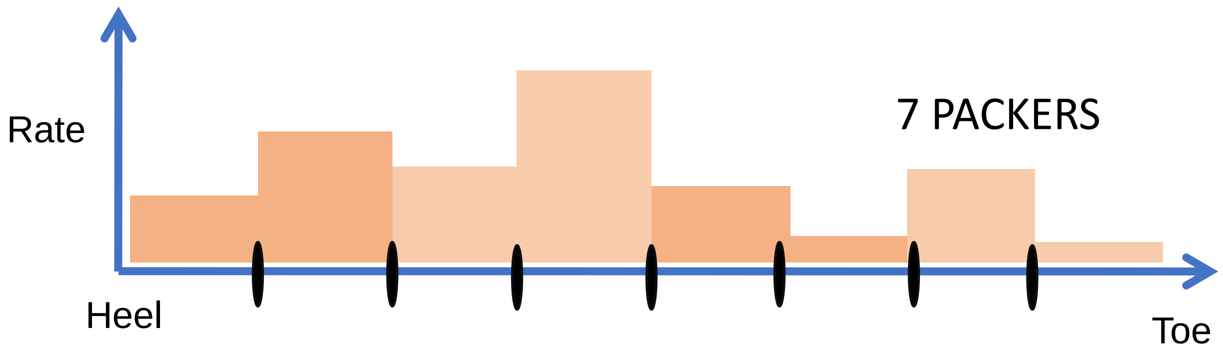
Importance of Packer Placement-After Coning

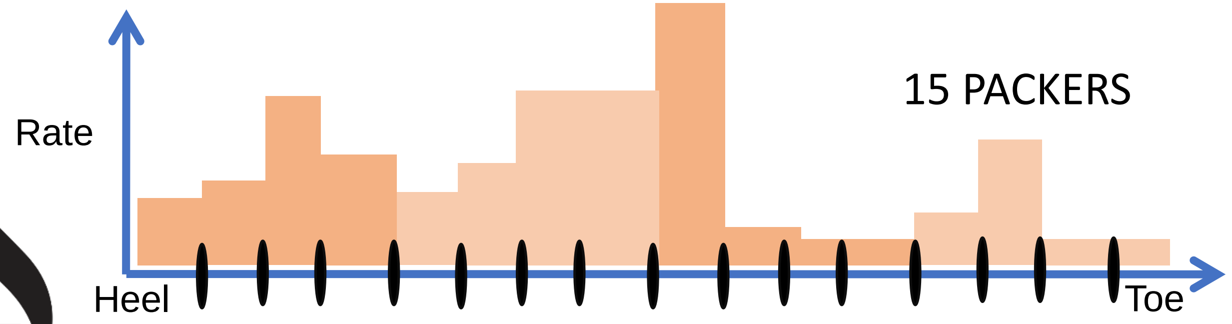


Compartments through zonal isolation enables zonal control

Importance of Packer Placement







Inflow control technology

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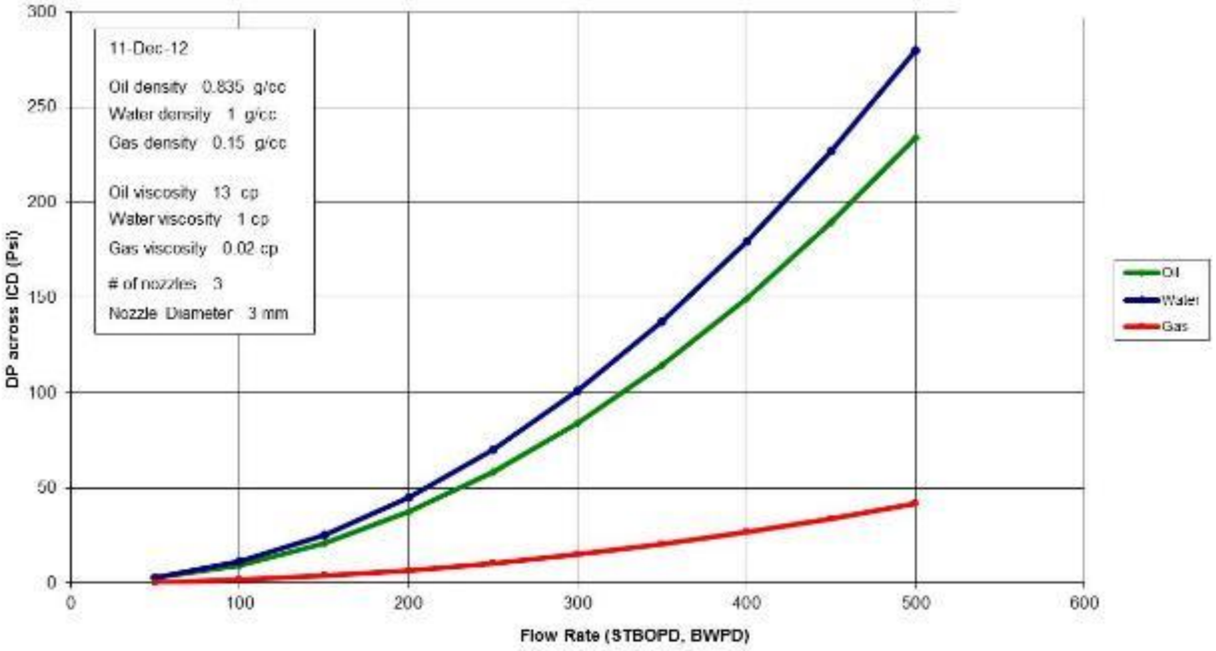
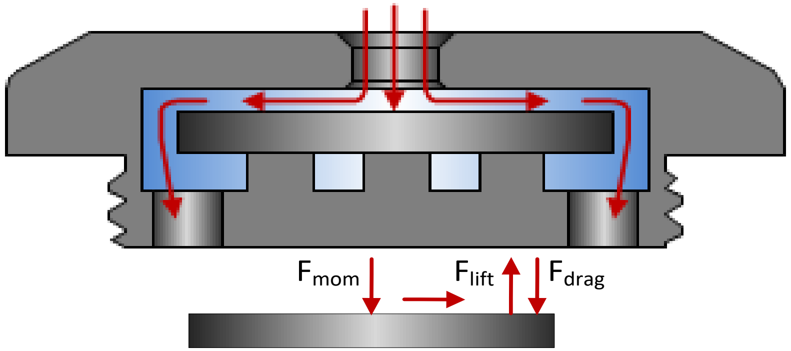
Principle: Nozzle ICD

Pressure drop is a function of density and rate squared

$$\partial P = \left(\frac{1}{2}\right)\left(\frac{\rho}{Cd^2A^2}\right) Q^2$$



Principle of Operation

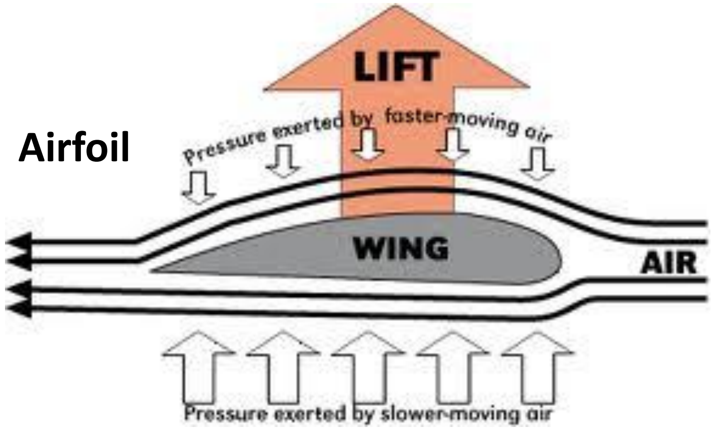


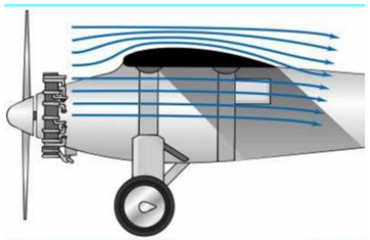
$F_{mom} + F_{lift} + F_{drag} = 0$

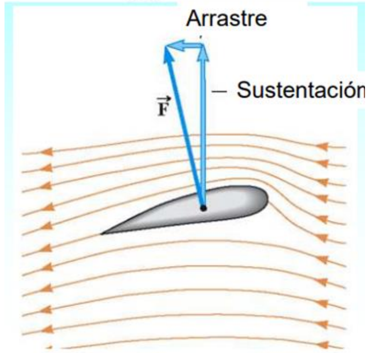
$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

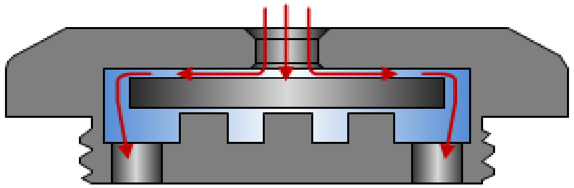
ρ = fluid density
g = acceleration due to gravity
P_1 = pressure at elevation 1
v_1 = velocity at elevation 1
h_1 = height of elevation 1
P_2 = pressure at elevation 2
v_2 = velocity at elevation 2
h_2 = height at elevation 2

Airfoil

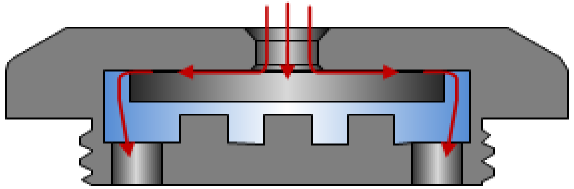






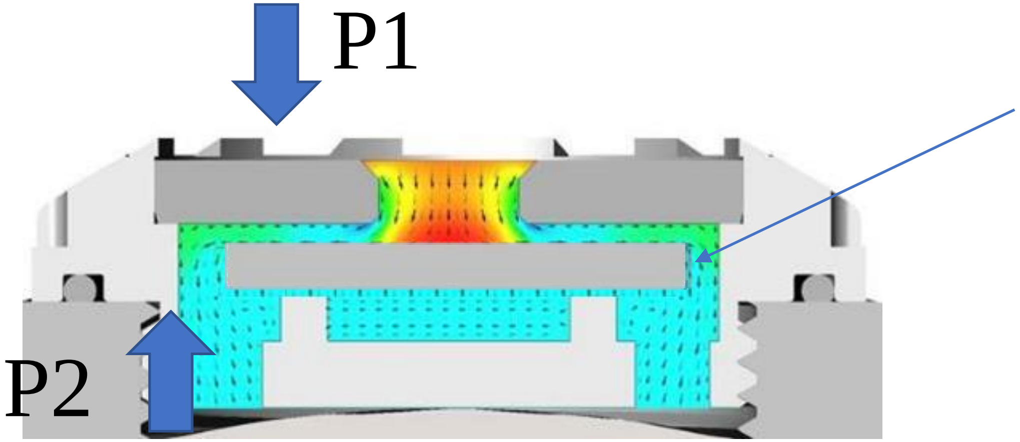


Water



Gas

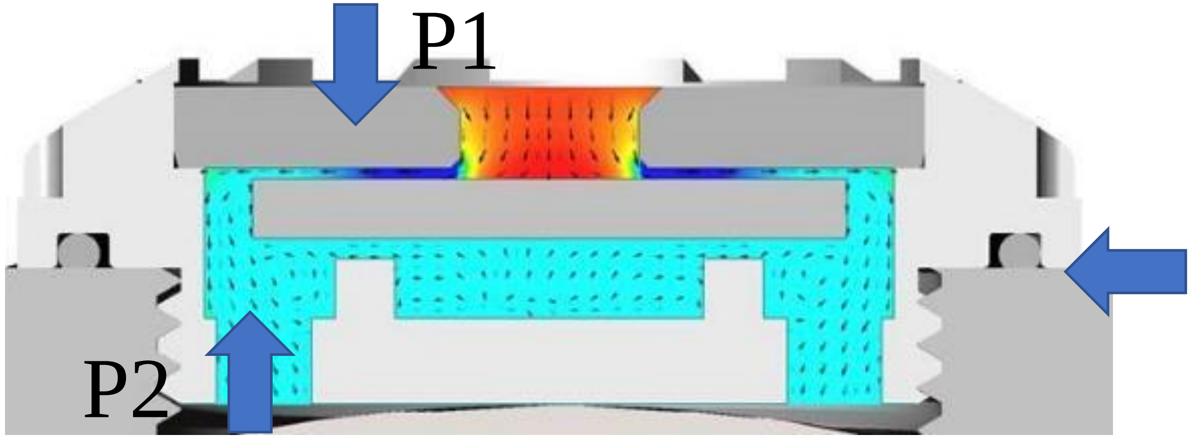
Principle: Autonomous ICD levitating disk



LEVITATING DISC

OIL

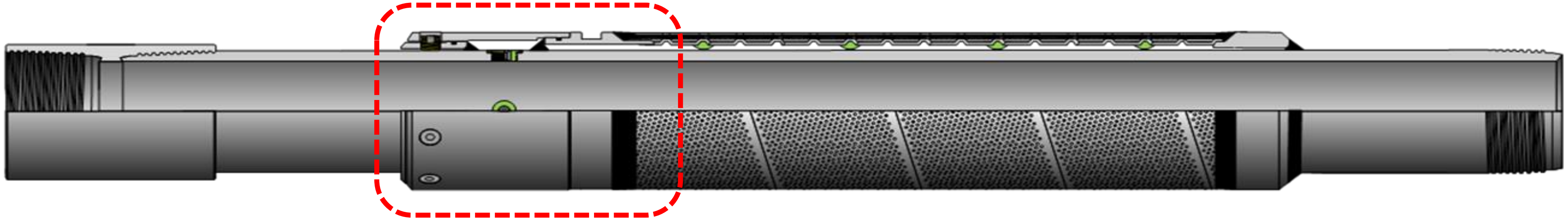
Disc low levitate,
restrict at inlet
P1>P2



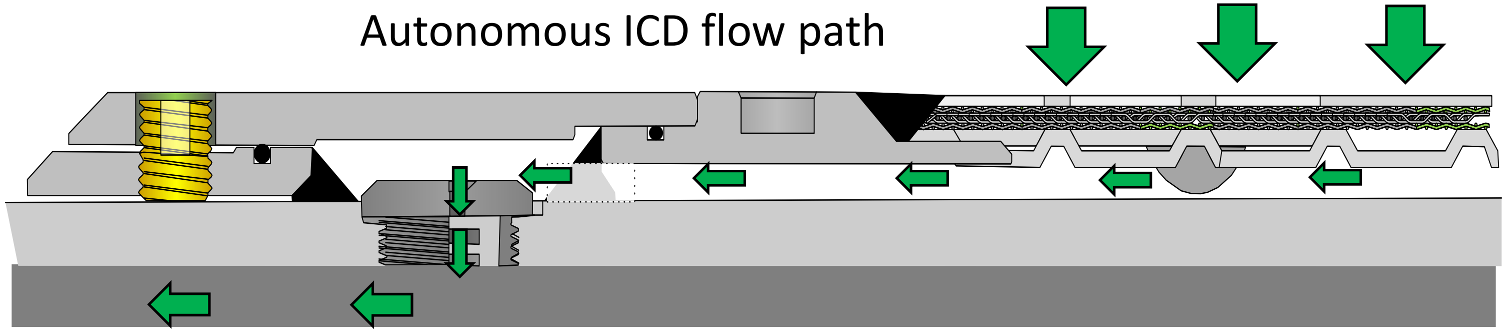
GAS AND WATER

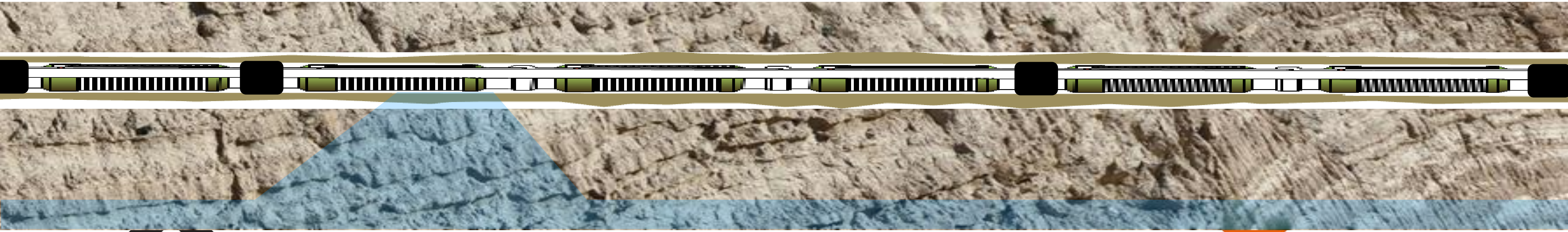
Disc levitate,
restrict between disc
P1<P2

FloSure AICD deployment – Screens and Swell packers



Autonomous ICD flow path





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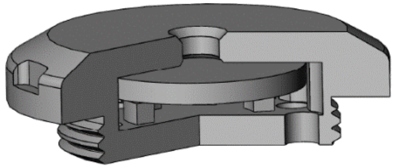
AICD Important Principles

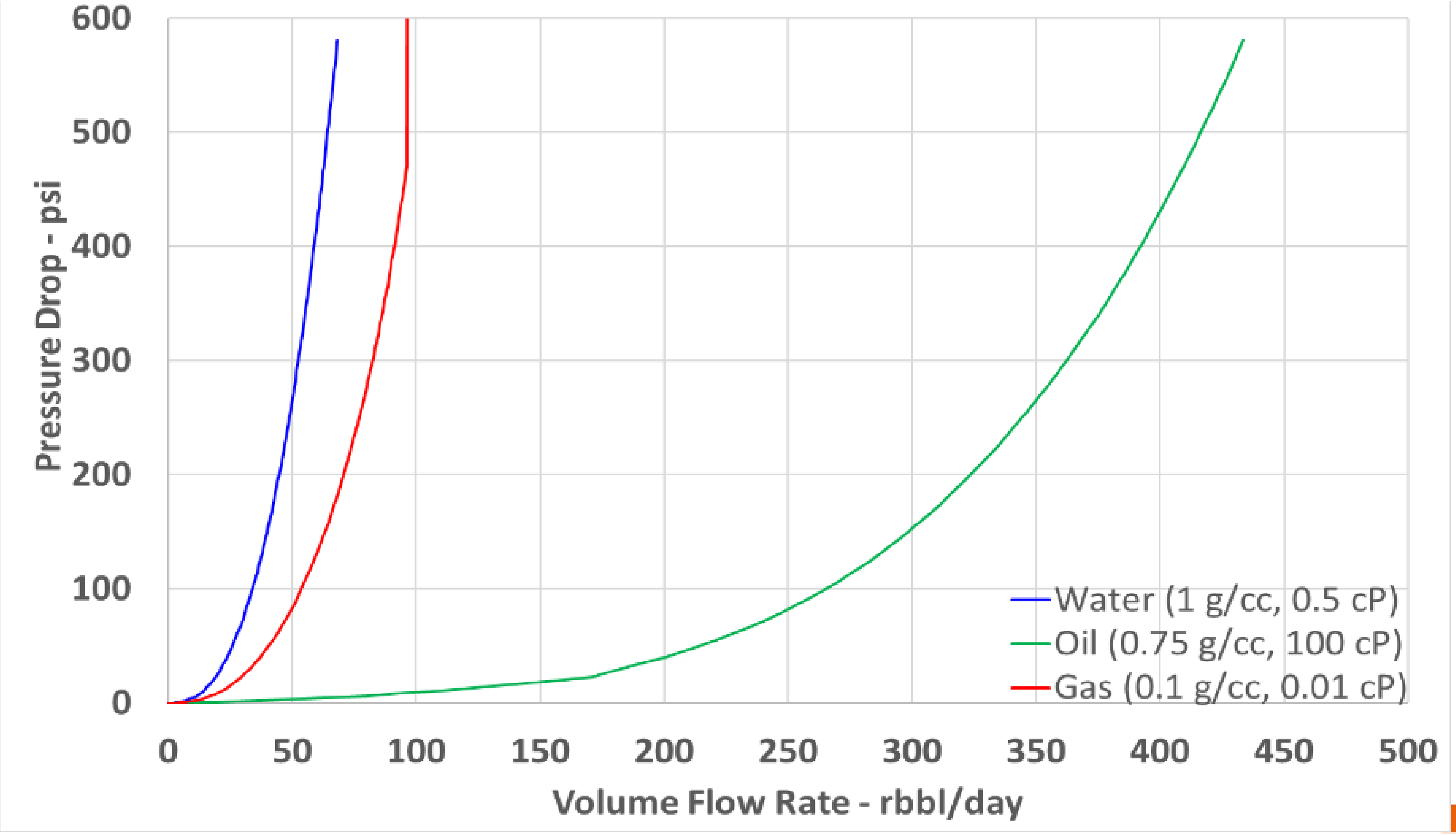
- AICDs are not downhole separators

- High water cut zones will see higher pressure drop across the AICD and thus lower drawdown and lower production rate
- Low water cut zones will see lower pressure drop across the AICD and thus higher drawdown and higher production rate

It never fully shut-off flow from a zone



AICD Performance



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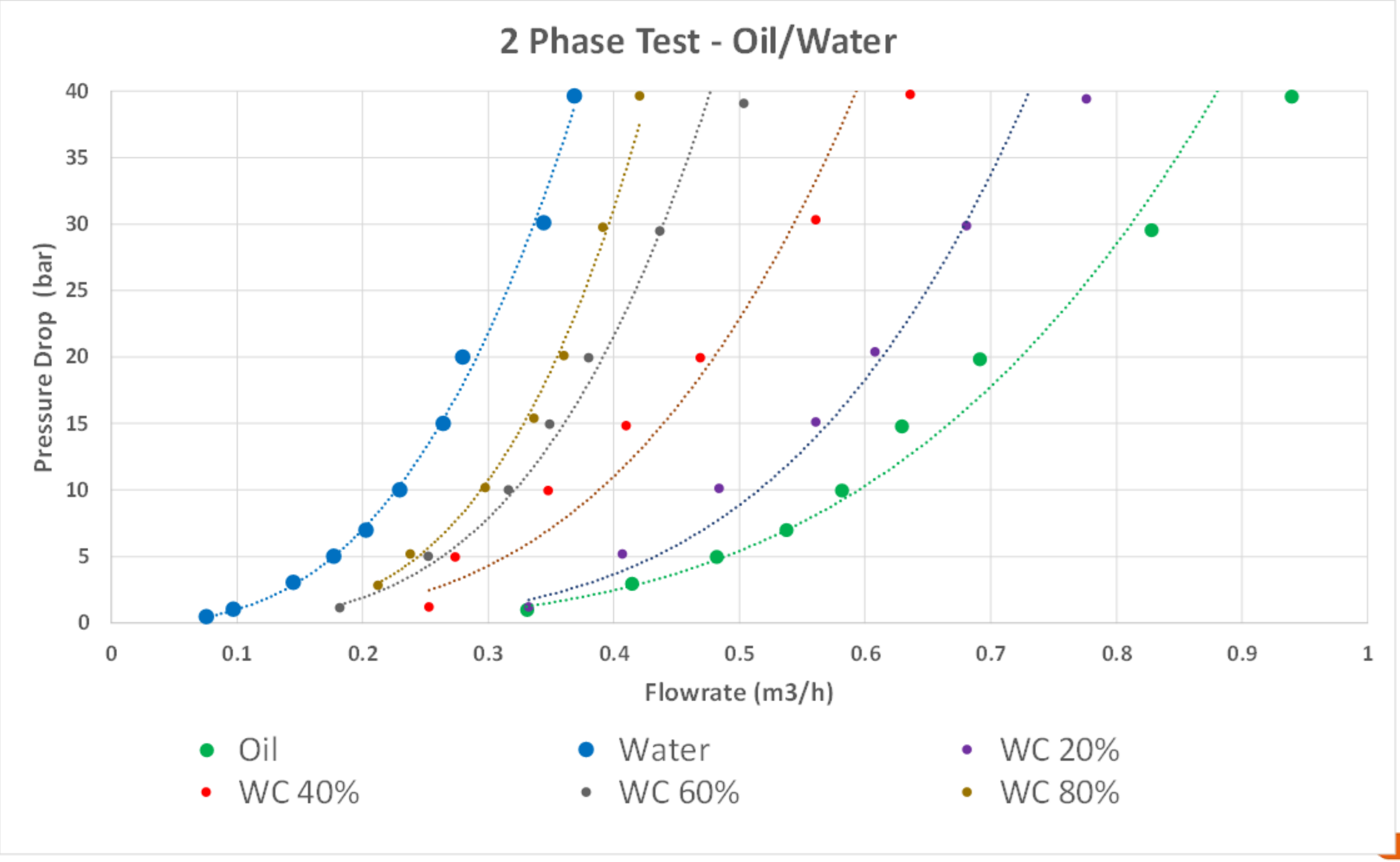
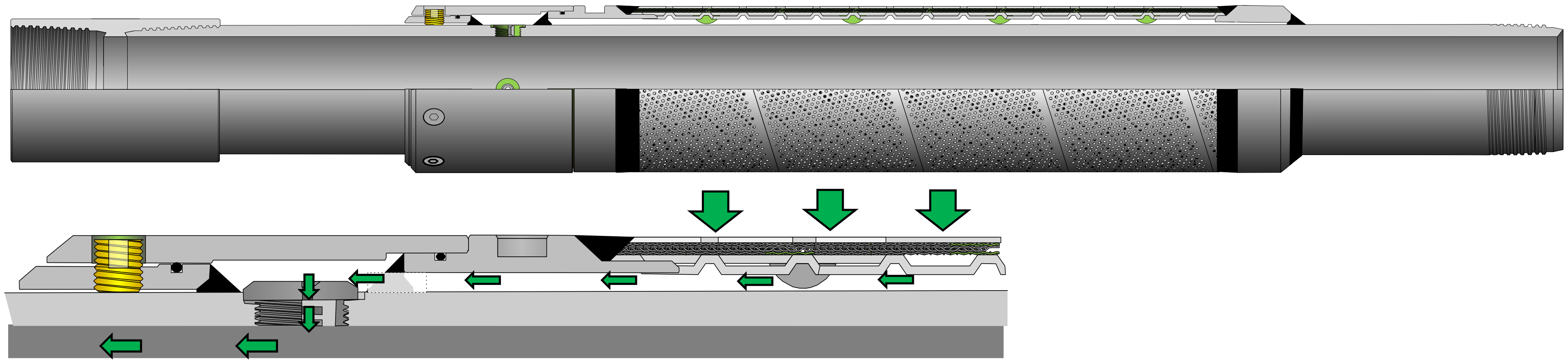
AICD Performance

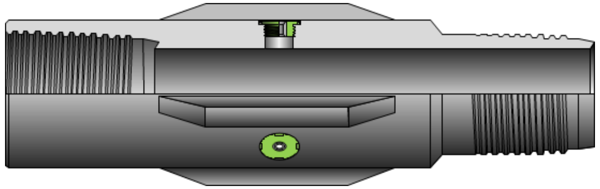


AICD Deployment



Sandstone reservoirs : FloSure metal mesh or direct wrap screens – field adjustable ICD units

Carbonate reservoirs : FloSure debris filters – field adjustable ICD units



Retrofit Completions: FloSure subs – field adjustable fluted subs

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Discussion

Thank You

Principle: Autonomous ICD

A viscosity and density dependent empirical equation

- Implemented in most reservoir simulators:

$$\partial P = \left(\frac{\rho_{mix}^2}{\rho_{cal}}\right)\left(\frac{\mu_{cal}}{\mu_{mix}}\right)^y * a_{AICD} * q^x$$

(SPE145737)

$$\rho_{mix} = \alpha_{oil}\rho_{oil} + \alpha_{water}\rho_{water} + \alpha_{gas}\rho_{gas}$$

$$\mu_{mix} = \alpha_{oil}\mu_{oil} + \alpha_{water}\mu_{water} + \alpha_{gas}\mu_{gas}$$

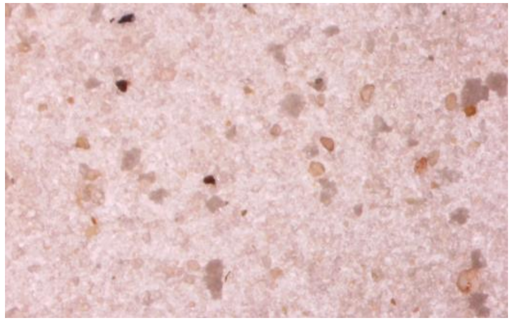
$$\partial P = \left(\frac{1}{2}\right)\left(\frac{\rho}{Cd^2A^2}\right)^{\cdot} Q^2$$

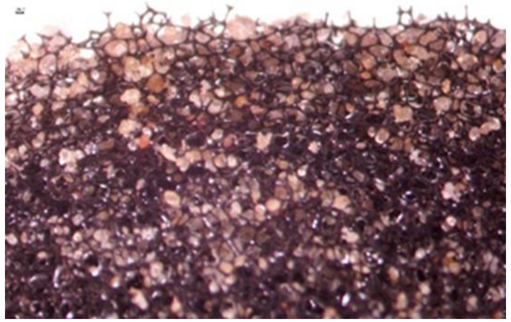
Filtrex – Commission and Qualification.

- Multiple rounds of sand retention testing have now been completed on the OCMP to be used when manufacturing Filtrex – reservoir and outcrop sands.
- Numerous suppliers and their materials have been carefully selected, reviewed, and assessed in both the fluids and sand laboratory to determine the quality, longevity, and suitability for the final product.

Testing completed:

- ✓ Multiple OCMP pore sizes
- ✓ Layering
- ✓ Different % compression
- ✓ With and without convergence layer
- ✓ OCMP thickness
- ✓ Porosity
- ✓ Retained permeability
- ✓ SEM





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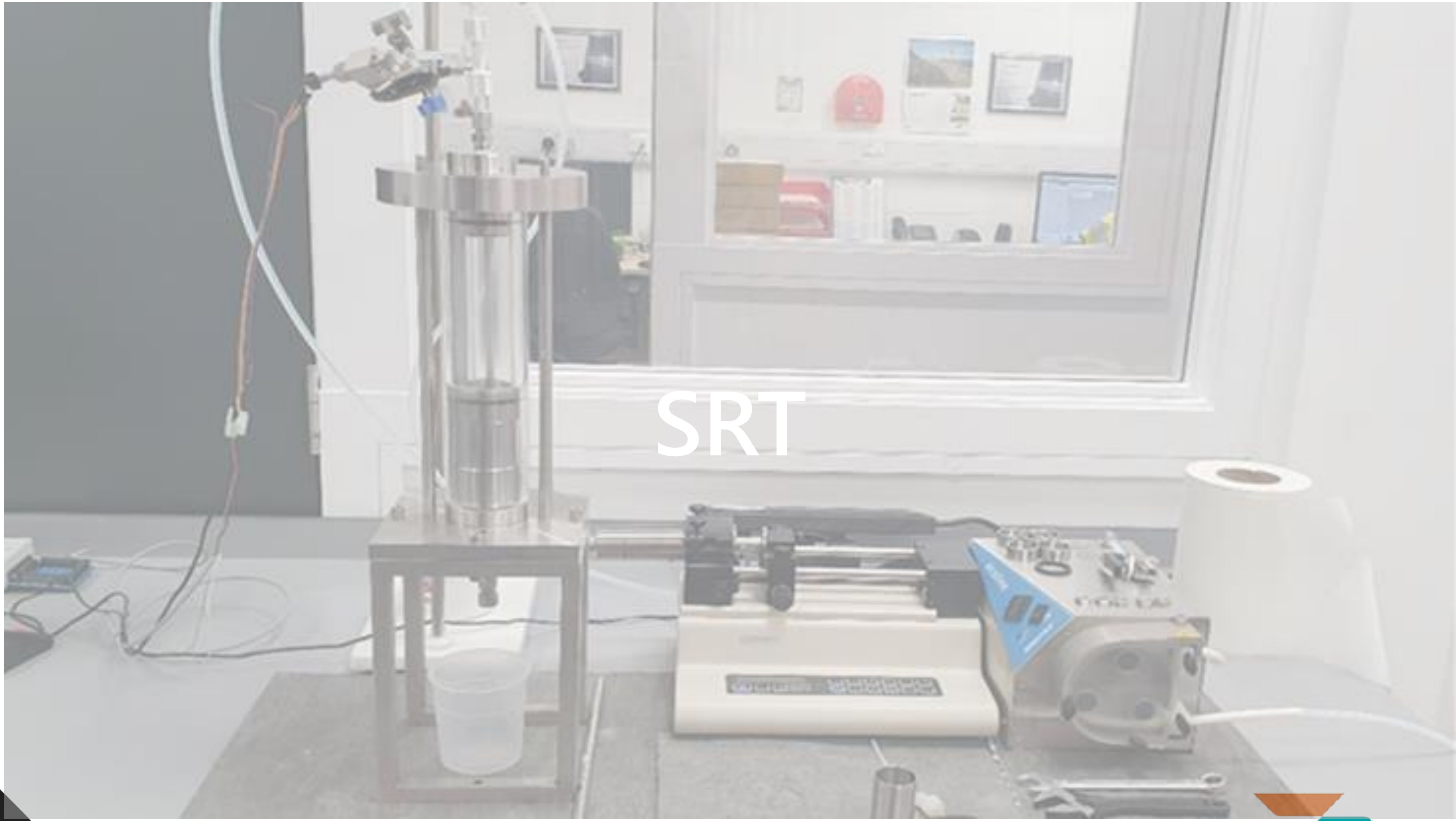
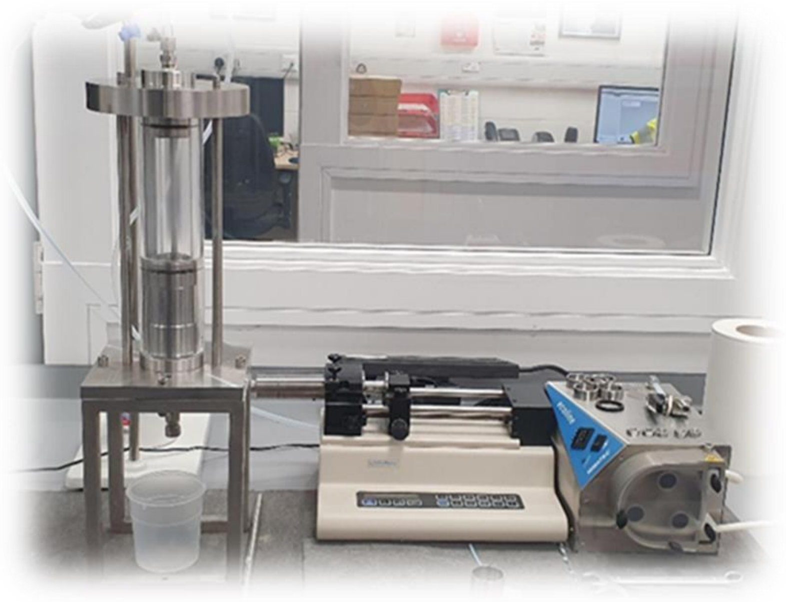


Test Method

- Particle size distributions are measured by industry standard dry sieve analysis
- The sand sample is then suspended in water viscosified with xanthan polymer to generate a stable slurry suspension.
- During the slurry tests, the prepared formation sand slurry is pumped and diluted with water before being flowed through the open cell matrix polymer filter.
- Pressures are recorded over time to monitor the pressure build up during the test, which then indicates if the OCMP filter tested is providing adequate retention and/or liable to plugging.
- The effluent samples collected during the test are filtered through pre-weighed 1.2µm filter membranes, which are dried and then reweighed.
- The pressure data and sandthrough data results are collated and represented graphically for interpretation.



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Filtering

- 250ml effluent samples collected from the slurry tests
- Filtered to accurately capture the sand passing through the Filtrex OCMP.
- Samples are filtered through a 1.2-micron filter paper and allowed to dry.
- Cumulative weight of sand through calculated.
- More info on test set up can be found in SPE-202300

Filtrex SRT Example

- Monobore 3.5” cased and perforated completion
- Historically used sand consolidation resin, thru tubing gravel packs, and ceramic screens but with very poor results.
- Each zone lasts 3-6 months before watering out, short timeframe for production
- Customer wanted a one size fits all screen to remove sand issues caused by PSD dependencies.

Well Data

Location: Tunu & Handil, Indonesia

Well Type: Gas & Oil Producers

Installation Date: April/May 2022

Tubing Size: 3½”

Deviation: From 13 to 58 degrees

No	Well	Fluid	Stakes	Perfo interval (m)	P Res (psi)	Permeability (mD)	Porosity (%)	Vshale (%)	D10 Approach
1	AX-1	Oil	21 kkbl	1.5	1529	385.9	26	15	300 micron
2	AX-2	Gas	0.04 bcf	2	1066	1594	28.4	21.6	250 micron
3	AX-3	Gas	0.05 bcf	1	1286	39	26.3	56.7	175 micron

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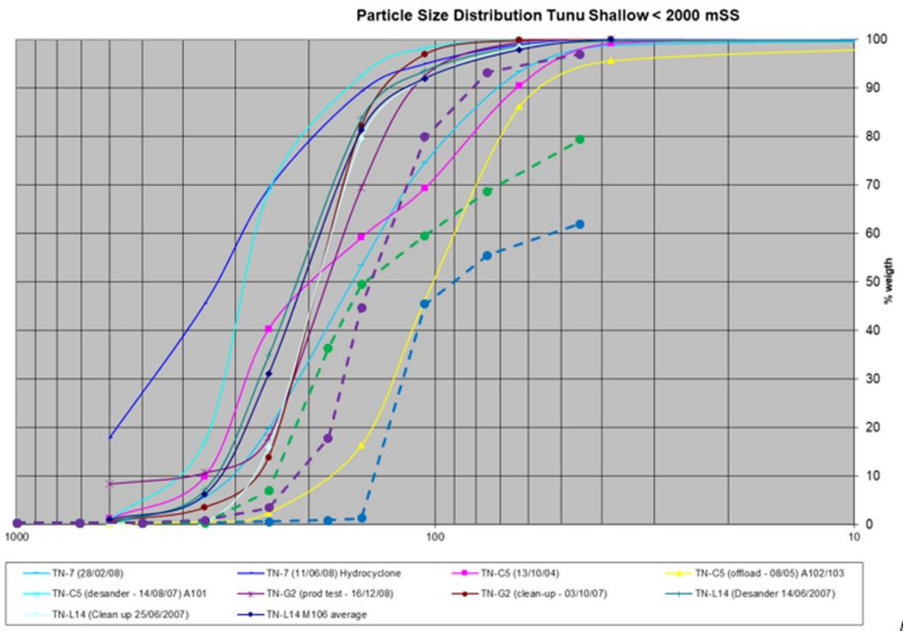
Particle Size Review

- PSD Review
- Sand Retention Testing
- Suitability Review



Suitable representative test sands for retention testing were overlaid on the client provided PSD in the absence of reservoir samples.

d50 range: 100-350 microns, less than 10% fines (<45 microns)

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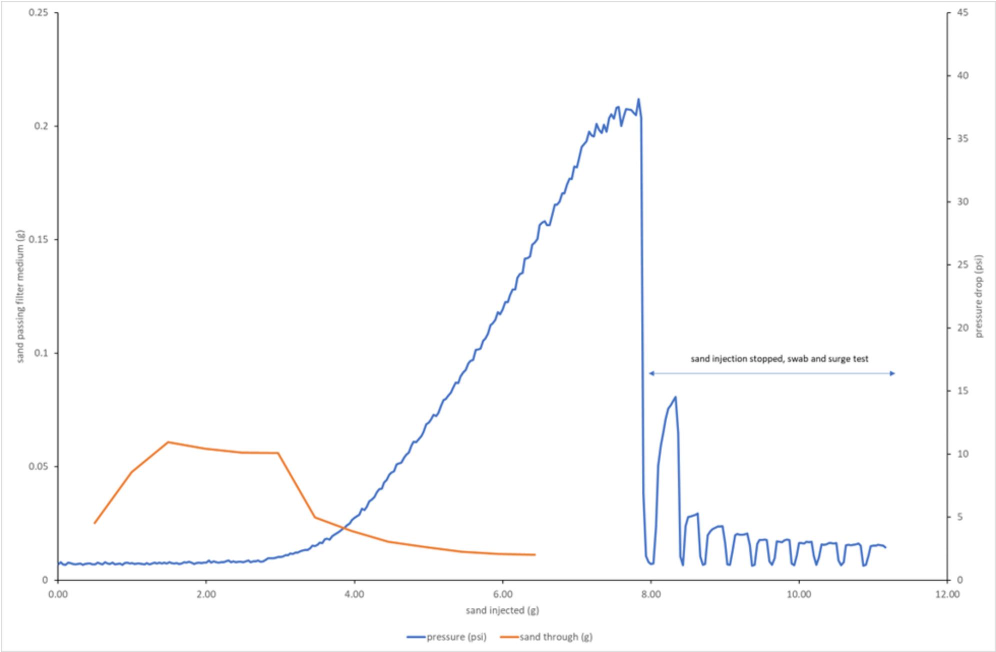
Sand Retention Testing

- PSD Review
- Sand Retention Testing
- Suitability Review



- The pressure drop observed will be a combination of the sand permeability and any plugging of the OCMP filter.
- The filters themselves are too permeable to generate any significant pressure drop. Therefore, the pressure profiles for a particular sand should be similar on each polymer filter tested given good retention and no plugging.

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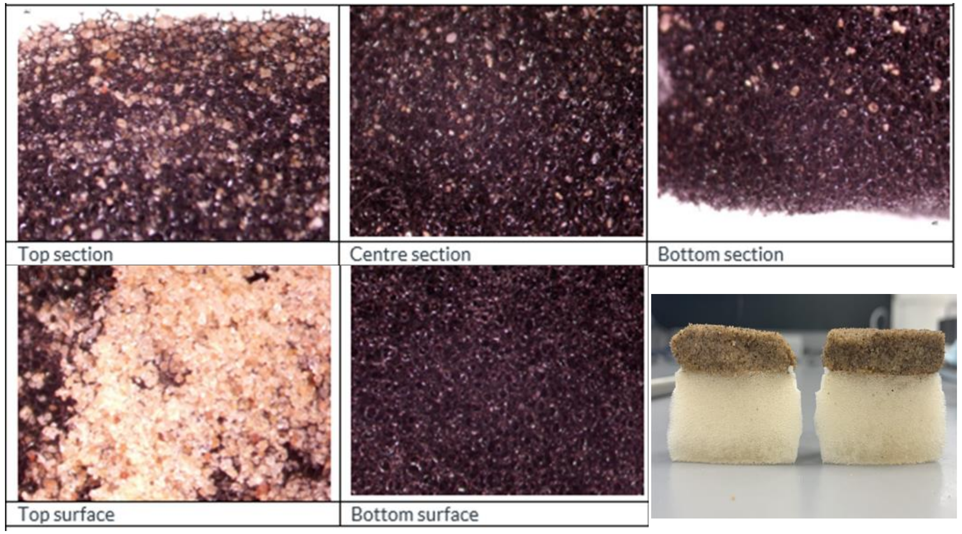
Sand Retention Testing

- PSD Review
- Sand Retention Testing
- Design Review

- Detailed analysis of particle size and grain shape can be performed using our high magnification stereo-microscope.
- The integral camera allows photographs of the sand distribution through the Filtrex OCMP to be examined after slurry testing as well as filter papers from the test.



Sand Invades the Filtrex media in the uppermost layer and starts to create an internal gravel pack

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Suitability Review

- If both the data provided by the customer and the sands tested by TAQA are representative of the formation material to be retained thru tubing within the well, then these test results conclude that the OCMP filter will have a positive effect on sand retention and will provide improved well performance.
- No anticipated issues with the OCMP retaining these sands. No evidence of plugging.
- As with sizing sand screens, if smaller sands can be retained by the OCMP material, the assumption is generally made that the larger sands in the distribution will not encounter any significant issues with retention either.
- TAQA can make a suitability recommendation using only customer particle size data or by performing SRT.
- The more information, the better the understanding!

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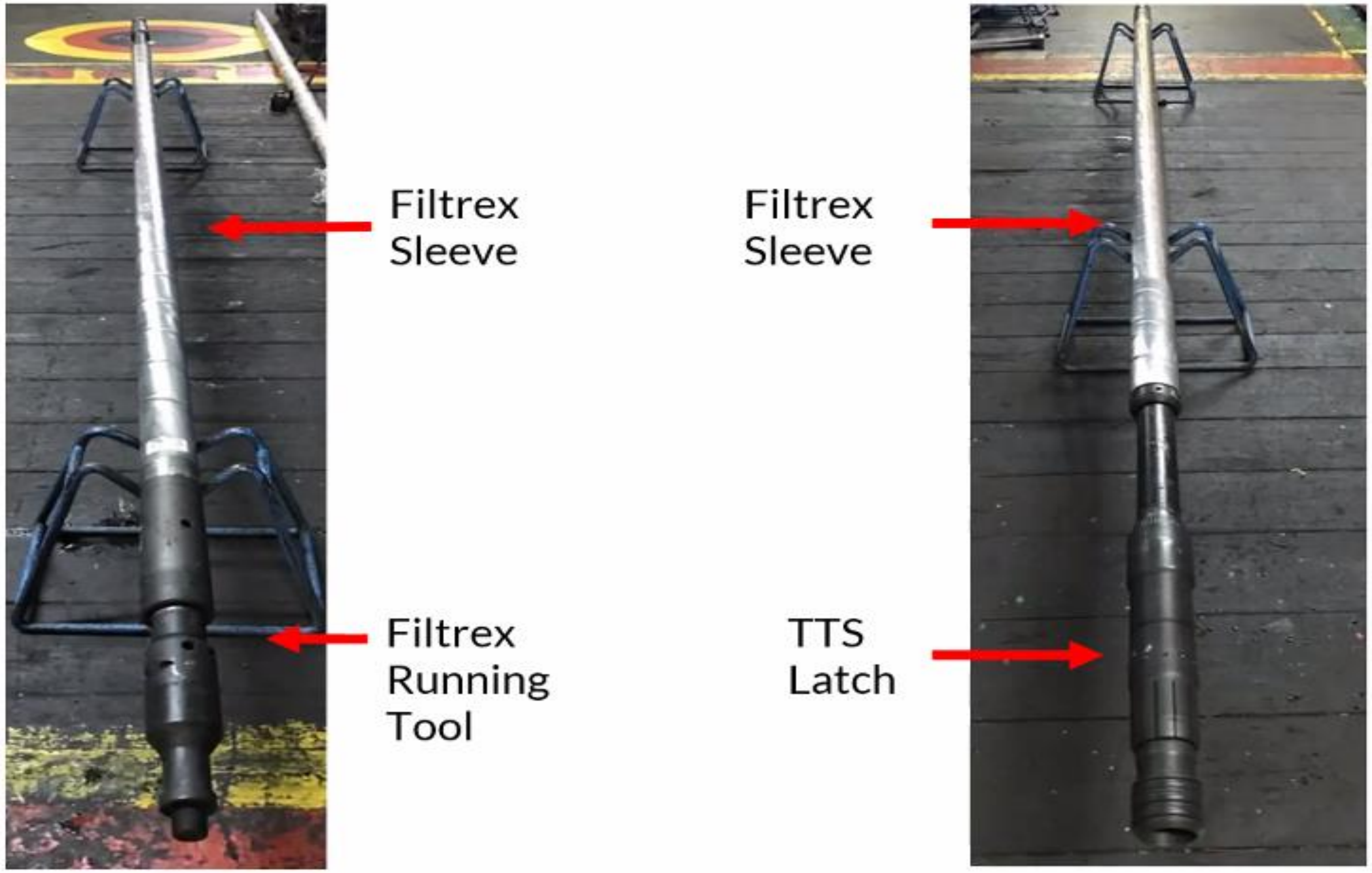
Filtrex – Pertamina Application

- Filtrex Assembly with Installed Running Tool and Anchor Latch



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