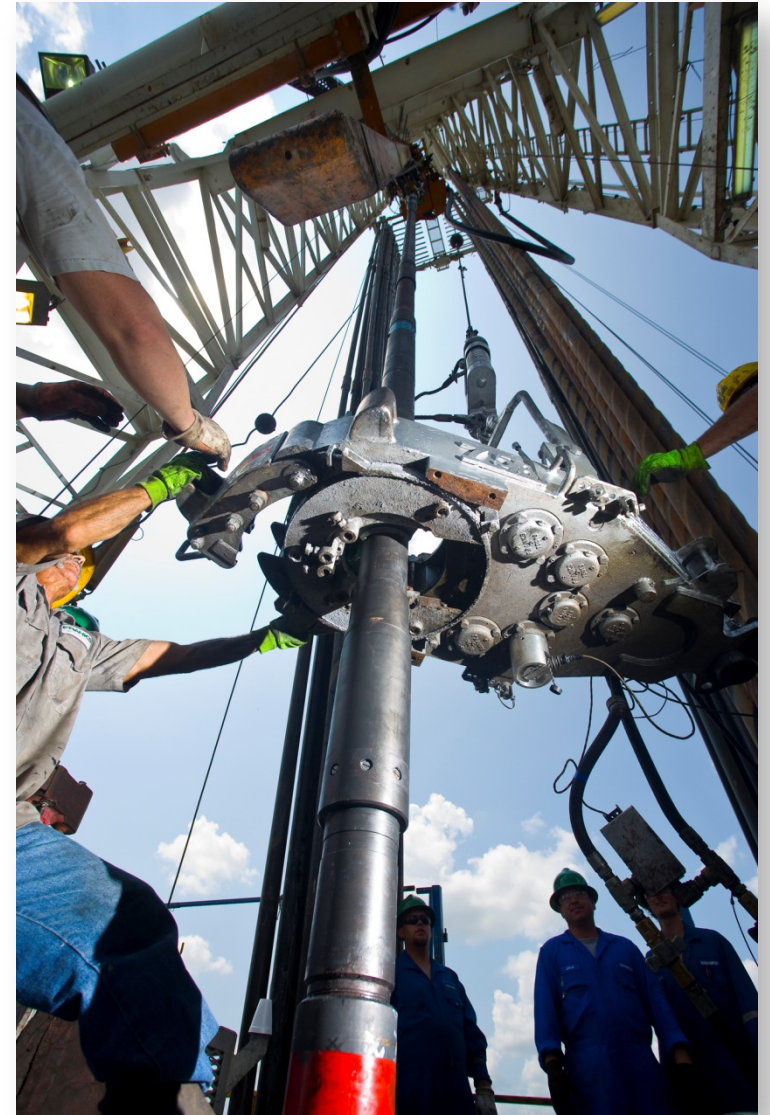




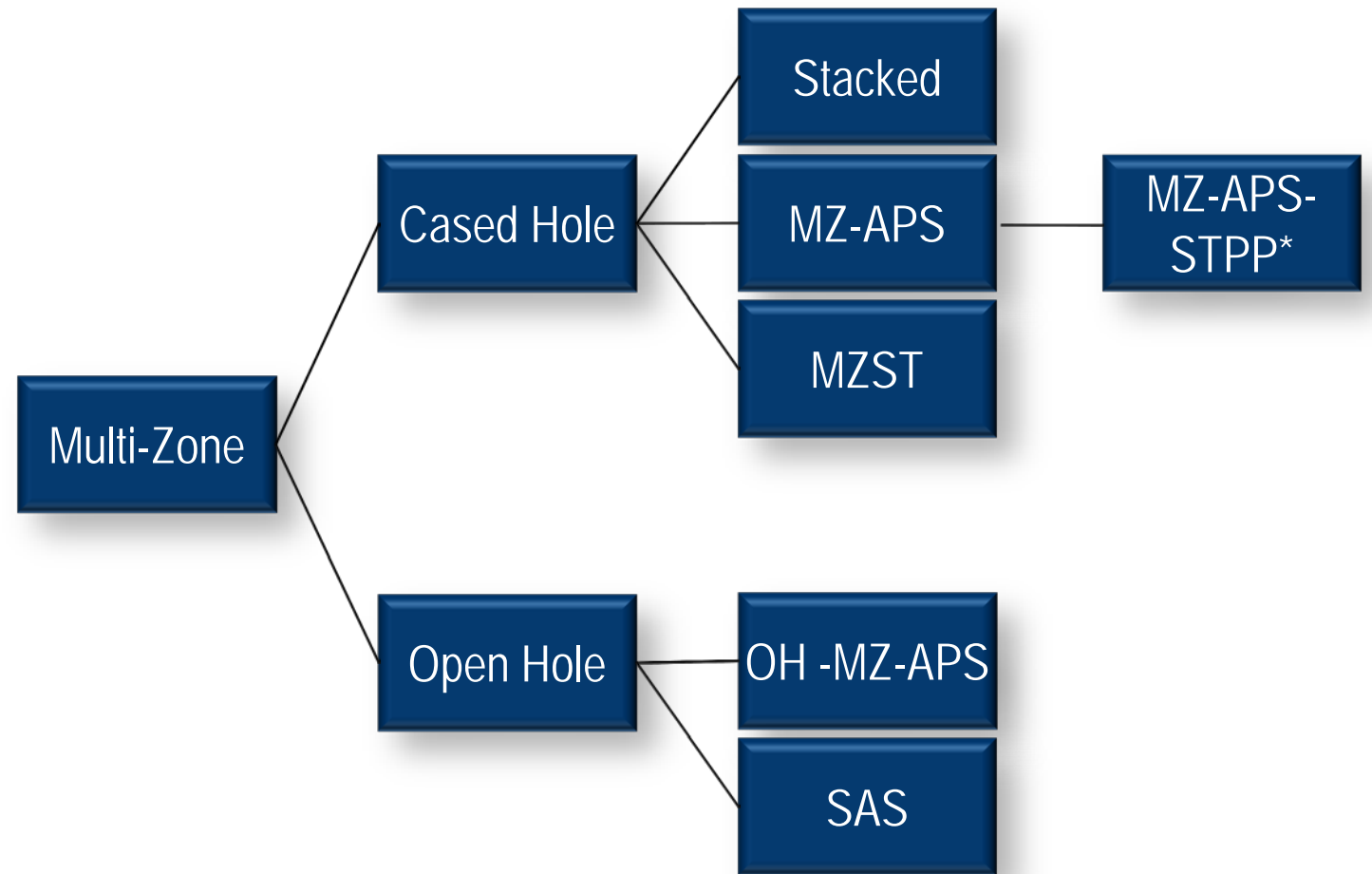
# Agenda

- Cased Hole and Open Hole
- Techniques & Architectures
- Case Studies

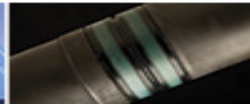


# Multi-Zone Solutions

- Completion challenges
  - Long/laminated intervals
  - Multiple zones
- Portfolio of solutions
- Drivers
  - Reservoir properties
  - Production objectives
  - Risk profile

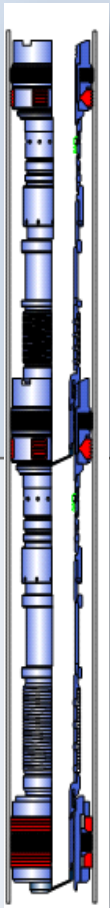
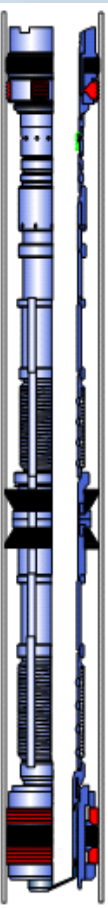
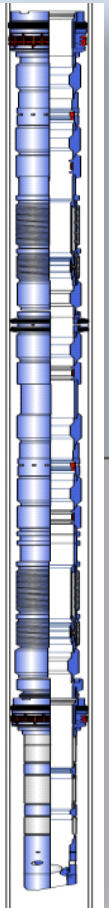


\*STPP = Single Trip Perforating and Packing



# Cased Hole Multi-Zone Solutions

- Wide range of options
  - Conventional
  - Proven
  - Efficient
- Reservoir specific
  - Long intervals
  - Zone spacing
- Tailored Solutions

| Stacked Frac Pack  | Alternate Path Technology  | MZST  |
|--|--|---|
|  <ul style="list-style-type: none"> <li>■ Well established</li> <li>■ Selectivity and isolation</li> <li>■ No limit on zones</li> </ul> |  <ul style="list-style-type: none"> <li>■ Simple Hardware</li> <li>■ One perforation operation</li> <li>■ One pumping operation</li> <li>■ Low risk</li> </ul> |  <ul style="list-style-type: none"> <li>■ Significant rig time savings vs stacked frac pack</li> <li>■ One perforation operation</li> </ul> |
| <ul style="list-style-type: none"> <li>■ Stimulation</li> <li>■ Track record</li> </ul>  | <ul style="list-style-type: none"> <li>■ Least amount of rig time</li> <li>■ Minimal distance required between zones</li> </ul>  | <ul style="list-style-type: none"> <li>■ Selectivity and isolation</li> </ul>   |

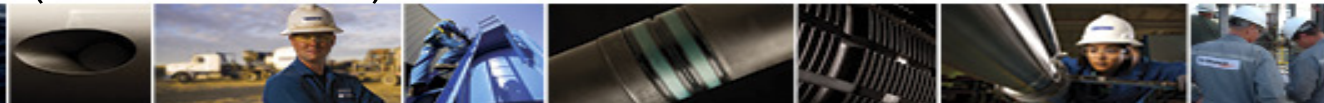


# Techniques & Architectures

|            |         | Architectures |           |           |           |                  |           |
|------------|---------|---------------|-----------|-----------|-----------|------------------|-----------|
| Strategy   |         | Comingle      |           | Selective |           | Intelligent DHFC |           |
| # of Zones |         | 2 Zones       | 2 + Zones | 2 Zones   | 2 + Zones | 2 Zones          | 2 + Zones |
| Techniques | Stacked |               |           |           |           |                  |           |
|            | MZ-APS  |               | GP FRAC   |           | GP FRAC   |                  |           |
|            | MZST    |               |           |           |           |                  | >4 Zones  |

## Criteria

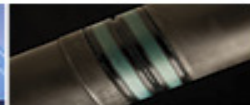
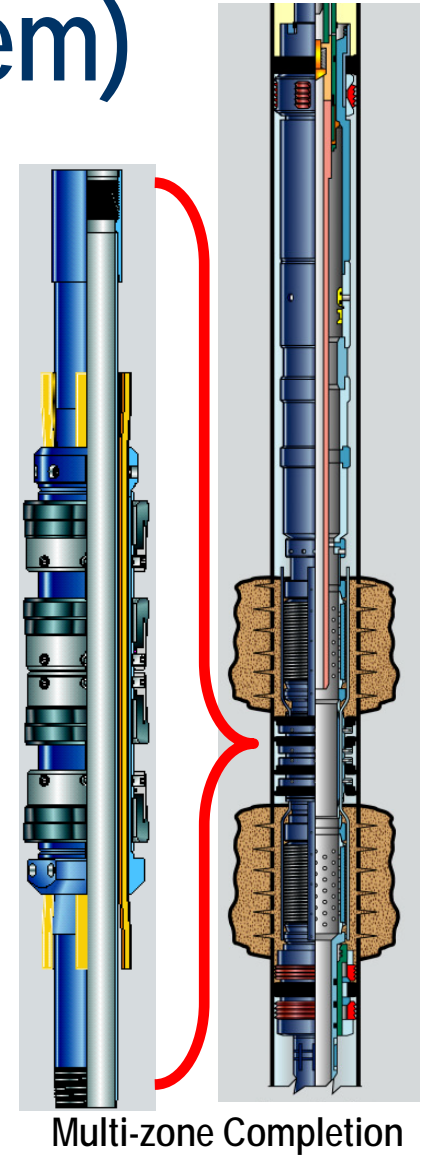
- Hydrostatic vs Fracturing gradient (drilling program)
- Overbalance (<1000 psi for Single trip systems)
- Deviation (APS if > 70deg)
- Perforating Height / Interval Length (APS if > 250ft)
- Zone Spacing (MZST min 63ft)
- Overall Completion Length (MZST max 2500ft)



# MZ-APS (Multi Zone-Alternate Path System)

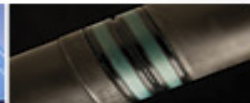
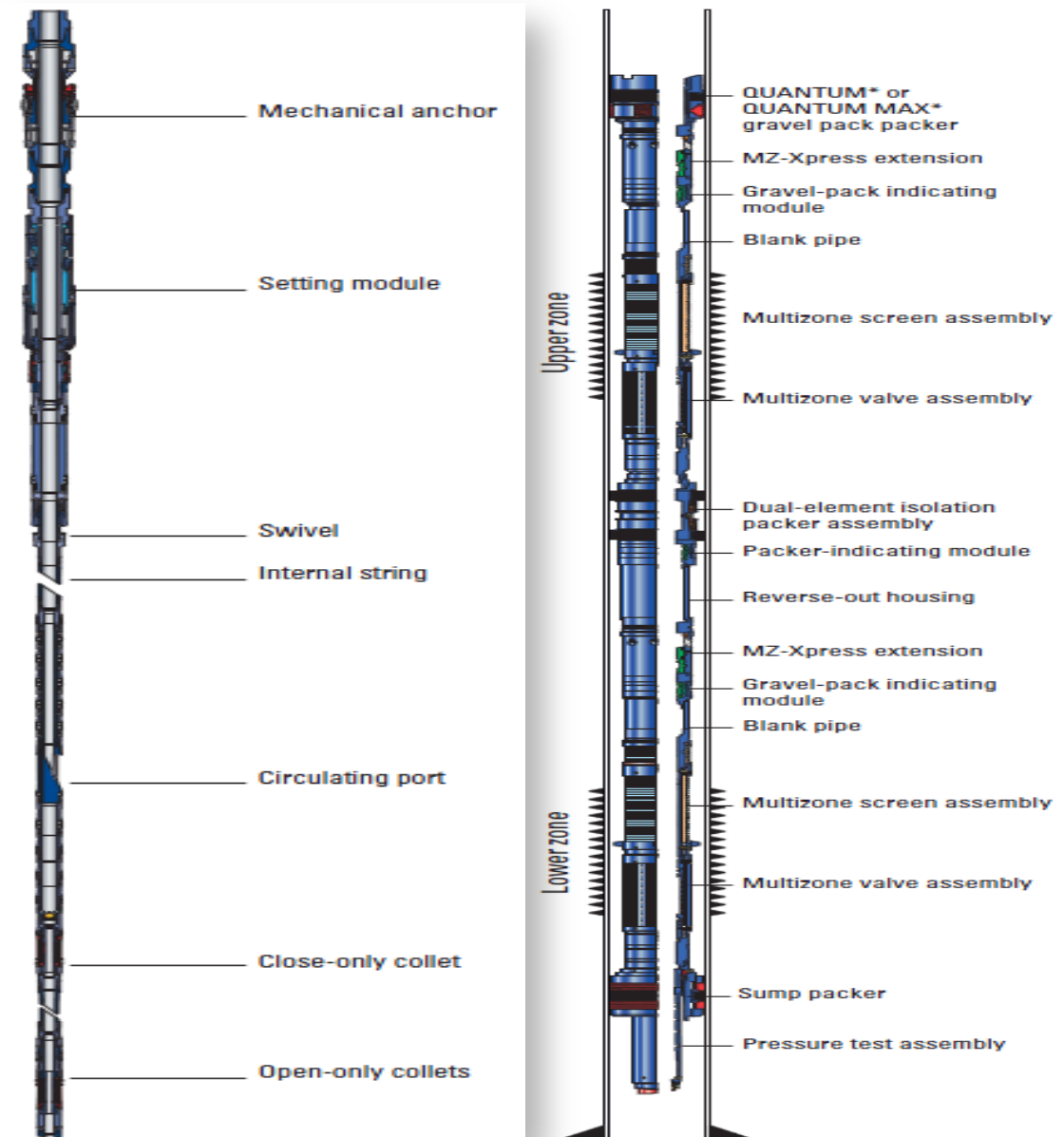
- Providing isolation of closely spaced reservoirs
- Single mobilization of pumping equipment for multiple zones
- Multi-zone completion in single tool run
  - Seal bore IDs/Nipple profiles
  - Shunt tube isolation
- > 100 completions
- Can be combined with PERFPAC technology for even greater efficiency

MZ-Packer

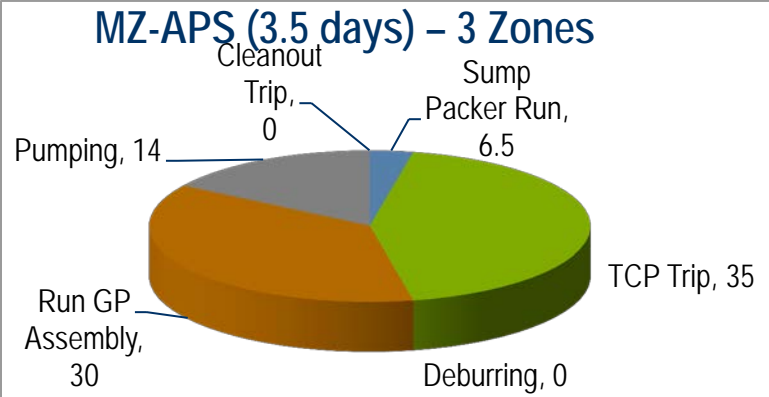
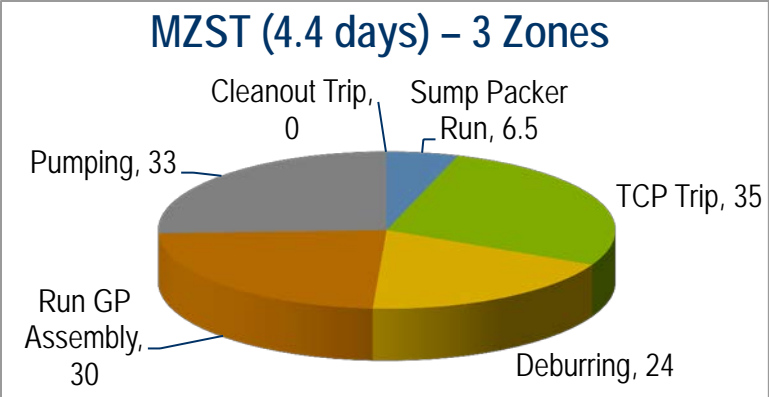
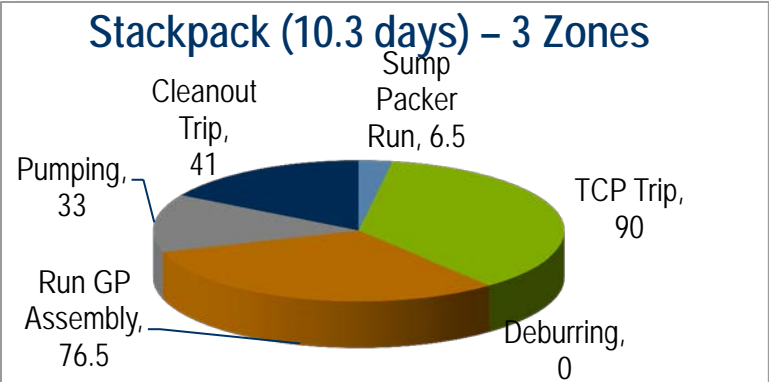
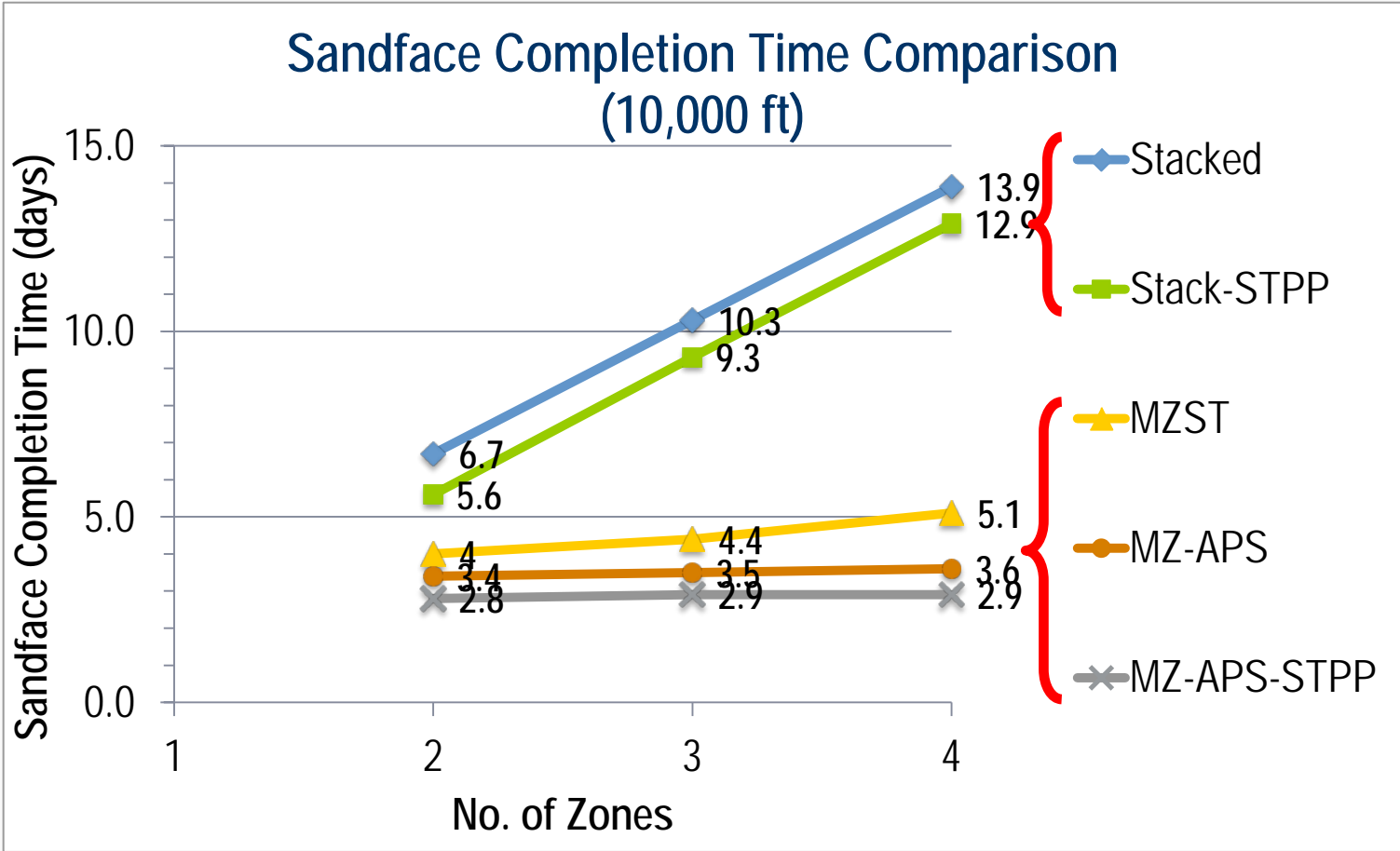


# MZST System

- Multi Zones Single Trip System w Integrated Fluid Loss
  - 7", 7-5/8" = 2.813", 9-5/8" = 4.562
- Applications
  - Multiple Zones with GP / Medium to High Rate FP (6 to 12Kpsi)
  - Selective / Commingle Completion
  - Over balance < 1,000psi
- Features
  - Mechanical Anchor (set down positioning)
  - Dump / Reverse out Housing
  - Solid Base Pipe Screens + Valve (fluid loss)
  - Collets (shifters)
- APS compatible



# Multi-Zone Time Comparison



# Case Study: Nigeria (SPE 133080)

## Challenges:

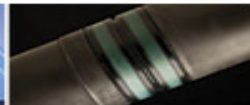
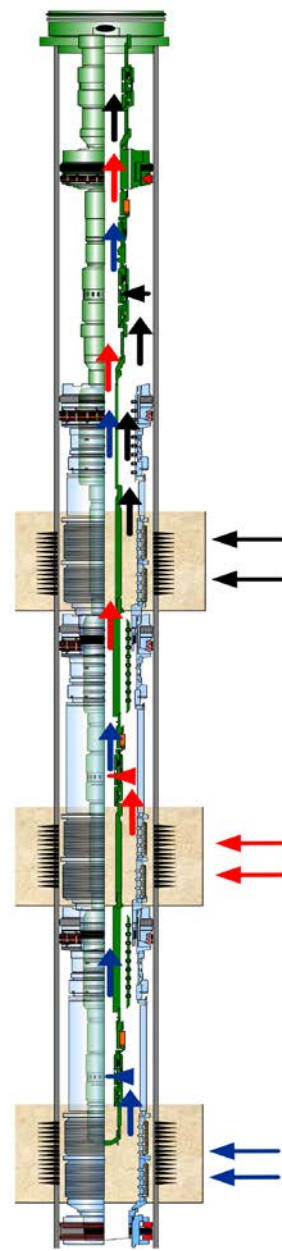
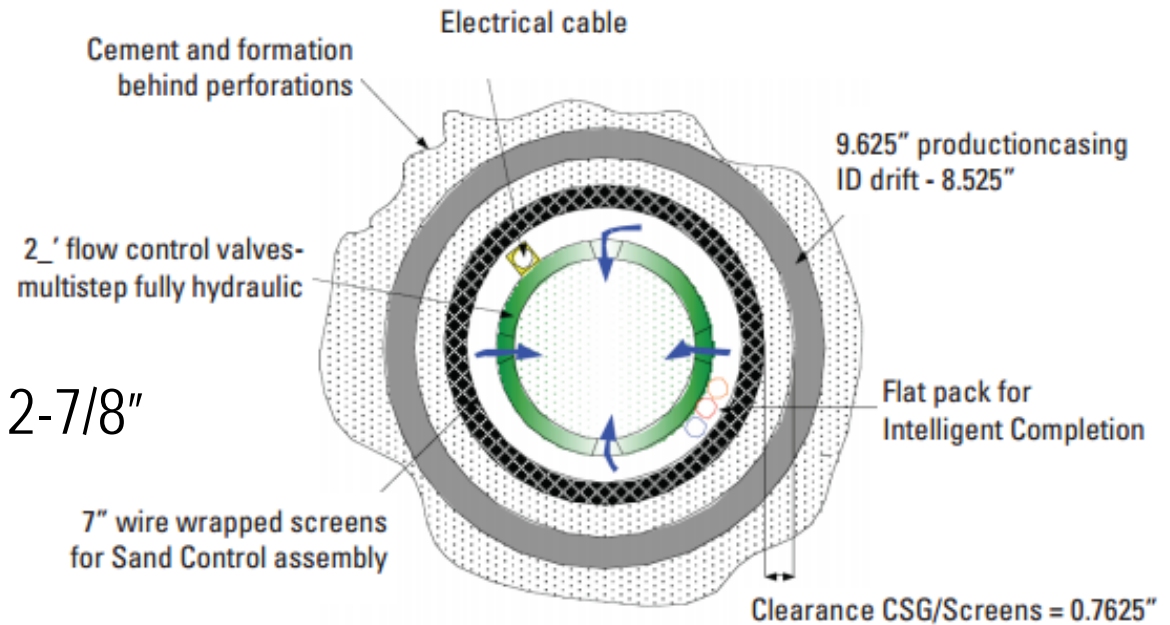
- Water depth 640m / 2100ft
- Screen Clearance
- Zonal Isolation

## Solution:

- 3 Zone Stacked FP with 7" screen w/ 2-7/8" FCVs
  - <40 ft intervals

## Result:

- Under AFE budget / NPV increment 15%
- Completion time 22 days no NPT



# Case Study: West Indonesia I

## Challenges:

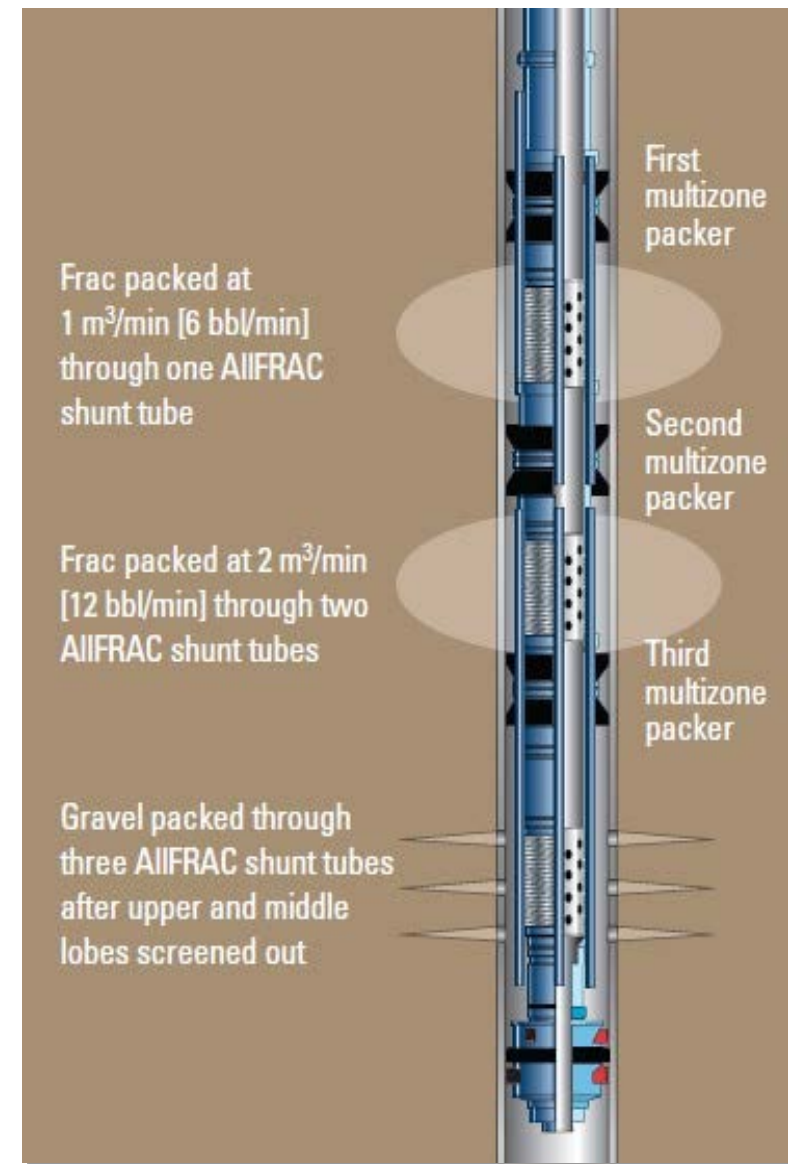
- 3 widely separated gas bearing zones (195-m (640-ft) interval))
- Separated by thick shale
- High Deviation > 60°

## Solution:

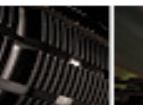
- MZ-APS & Single Trip Perforating and Packing (STPP)

## Result:

- Under AFE budget / added \$20M in projected revenue
- Additional recoverable reserves
- 3.25 days



Multi-zone STPP Completion



# Case Study: East Indonesia

## Challenges:

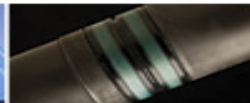
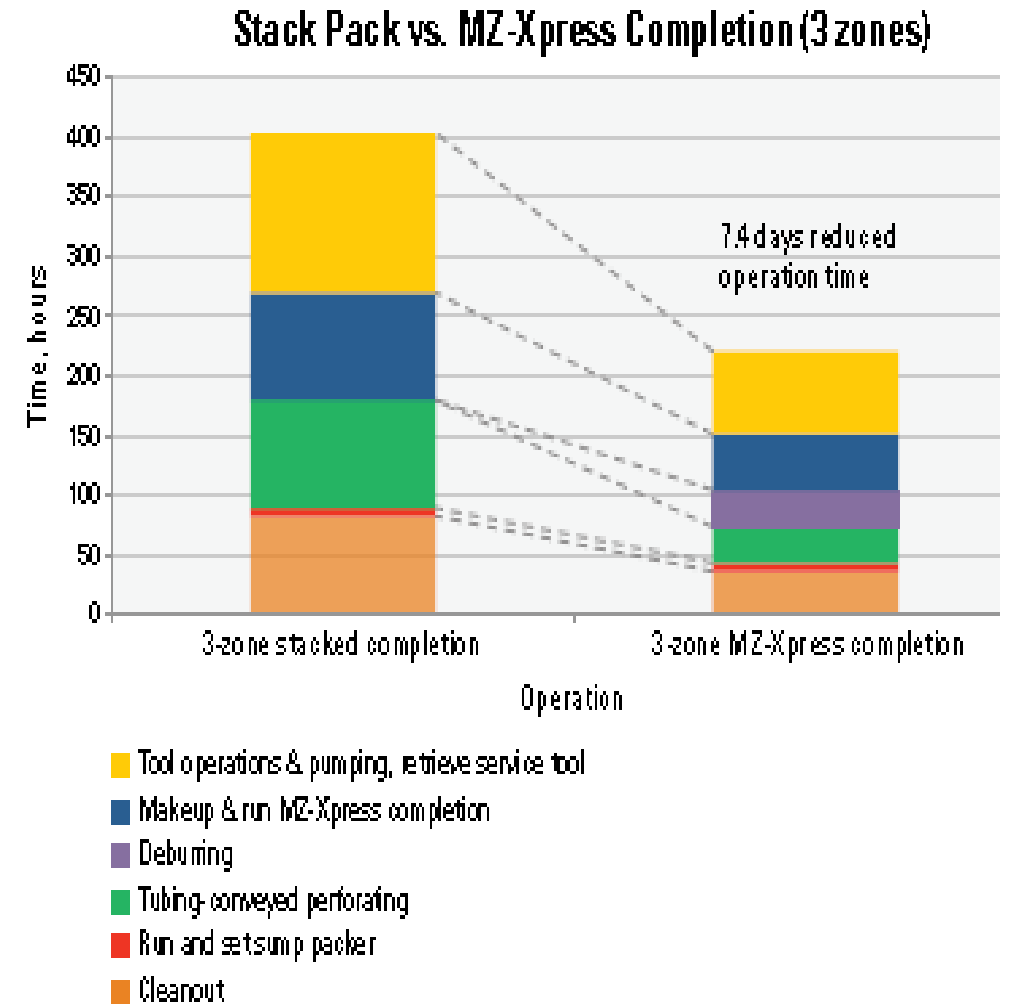
- Improve efficiency
- Depleted unconsolidated & Laminated reservoir

## Solution:

- 7" X 2.813" MZST
- HRGP with VES

## Result:

- Increased production 2.5 times initial estimation
- 7 days rig time savings (\$1.6M)



# Case Study: West Indonesia II

## Challenges:

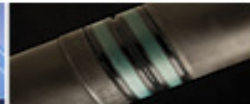
- 1685ft 5 zones completion
- Reservoir Gradient difference 4.49 to 8.44pg
- 4-1/2" Production tubing

## Solution:

- 9-5/8" X 4.562" MZST
- FPs and GPs, with FPs up to 35BPM with VES

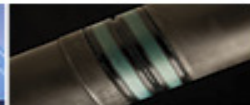
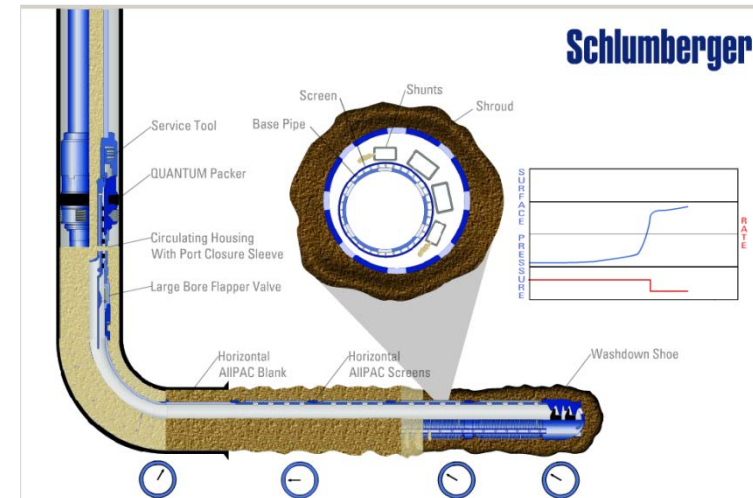
## Result:

- Production above expectation
- 11 days rig time savings



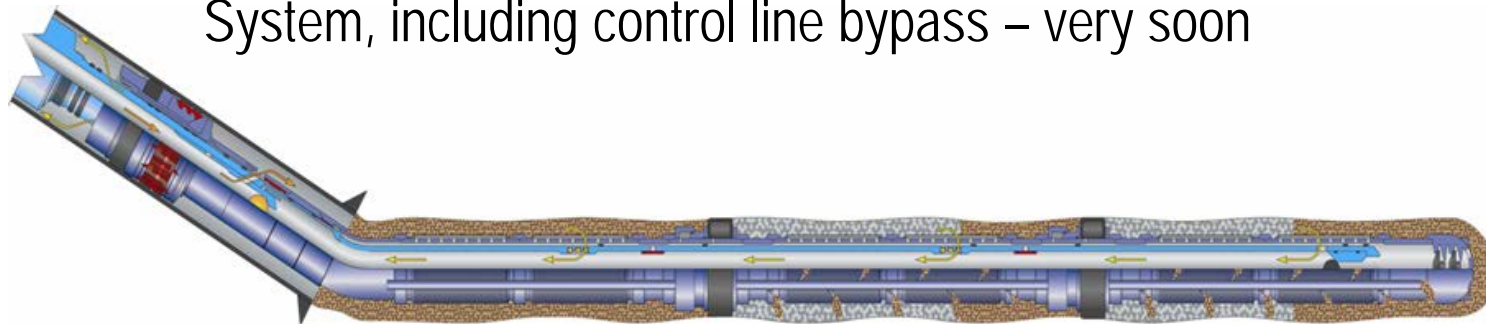
# Open Hole Multi-Zone Solutions

- Wide range of options for SAS and ICDs
  - Swell packers
  - Mechanical packers
- Emerging Technologies for OHGP
  - OH-APS packers
    - Swell (2X2 conventional shunt system)
    - Mechanical (2X2 conventional shunt and 6X3 internal shunt systems)



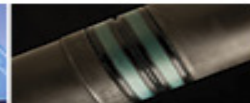
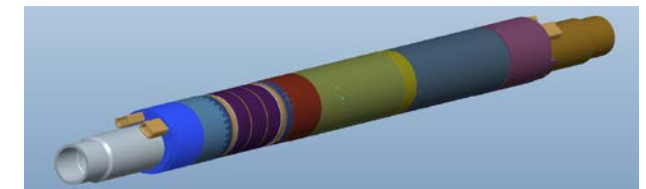
# Open Hole APS Packers

- Set prior to pumping the gravel pack
  - Complete isolation
  - Gravel placed below the packers, through the shunt tubes
  - Multiple options commercially available
    - Fast Oil Swell for conventional 2X2 Shunt System
    - Mechanical hydrostatic set for Internal 6X3 Shunt System
    - Mechanical hydrostatic set for conventional 2X2 Shunt System, including control line bypass – very soon



## Isolation

- ✓ Initial water / gas isolation
- ✓ Shale isolation
- ✓ Future water / gas shut off
- ✓ Internal string with SSDs, DHFC, or ICDs
- ✓ 2 zone IC, with DHFC above packer



# Case Study: Brunei (SPE 146803)

## Challenges:

- Uphill gravel packs (>120 deg)
- Zonal isolation , in order to deploy internal string of DHFC valves

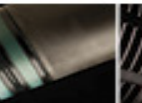
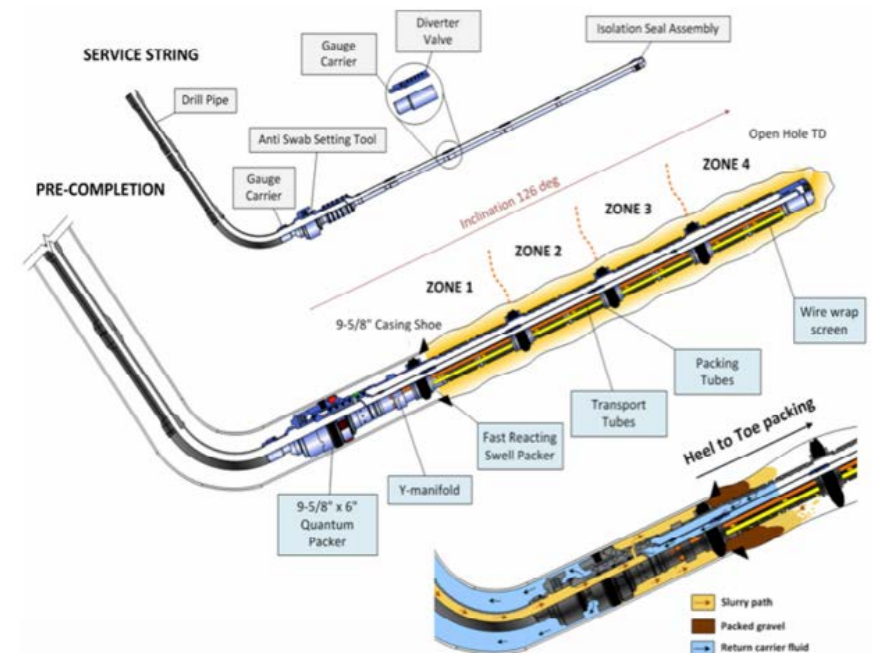


## Solution:

- OHGPs with OH-APS Fast Swell Packers (oil swell)
  - Conventional 2X2 system
  - WB DIF , OB packer setting fluid, 16 hrs swell time

## Result:

- Complete packing
- 4+ zones



# Case Study: Colombia (SPE 170900)

## Challenges:

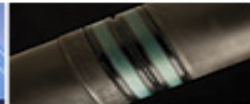
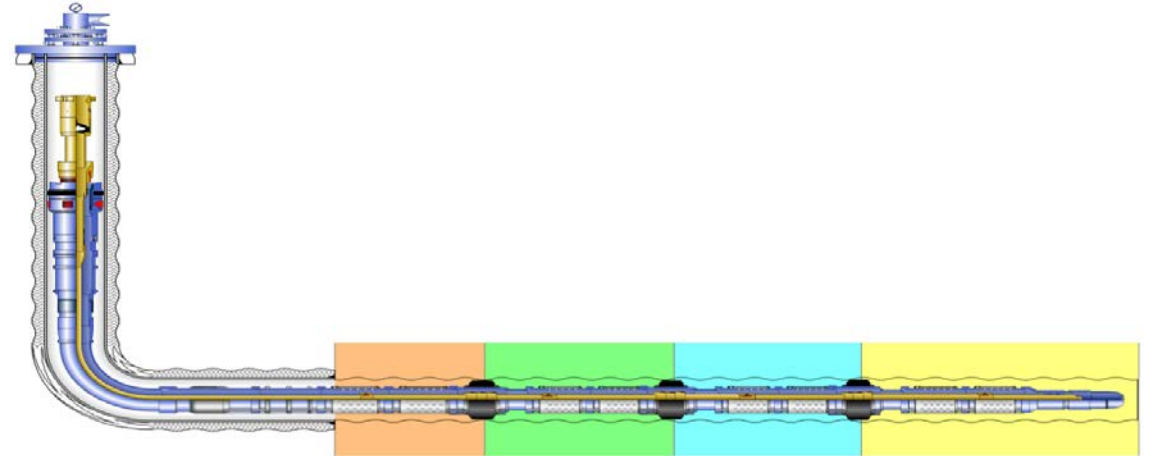
- Field requires OHGPs
- Heavy oil, with early water breakthrough

## Solution:

- OHGPs with OH-APS Fast Swell Packers (oil swell)
  - Internal string with ICDs and SSDs

## Result:

- 30% increase in recoverable reserves



# Case Study: Angola (SPE 151171)

## Challenges:

- Extended reach OHGPs
- Zonal Isolation

## Solution:

- OHGPs with Internal Shunt 6X3 Systems
  - Open hole hydrostatic set mechanical packer

## Result:

- Complete packing
- Full zonal isolation

