Dynamic Underbalance (DUB) Perforating

Cam Le
Perforating Product Champion

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Agenda

- Overview
  - DUB Software
  - Tools
- Case histories

Dynamic Underbalance Software

- Dynamic pressure and fluid flow predictions
  - Accurately modeling the effects of pressure transients during the perforating event
    - Packer differentials, reservoir reaction
  - Service provide precise management of dynamic perforating pressures
    - Enhancement, mediation
  - Main purpose is to provide optimal cleanup

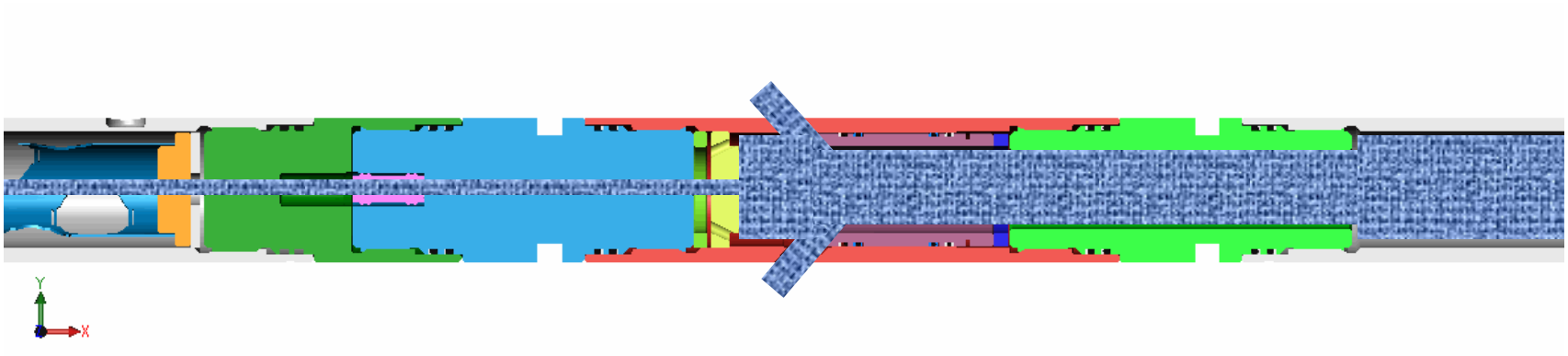
Applications

- Assess the natural surge potential of conventional gun systems
- Evaluate the effectiveness of underbalance perforating and back-surging techniques
- Customization of BHA to generate the desired DUB
  - Vents, chambers, partial loading
- Evaluate tools that are use to mediate DUB
  - Charge Selection, PIDs, Propellants
- Monitor the effects of operational procedures on the perforating process
  - Applied pressures, opening/shutting of valve, pumping, etc.

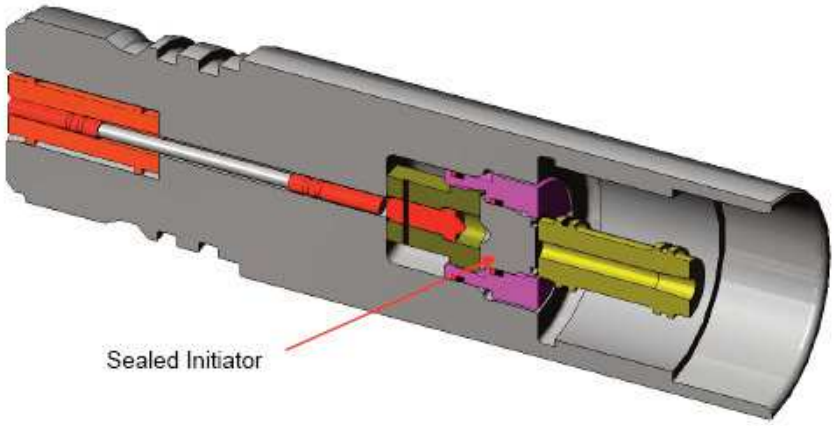
Surge Vent

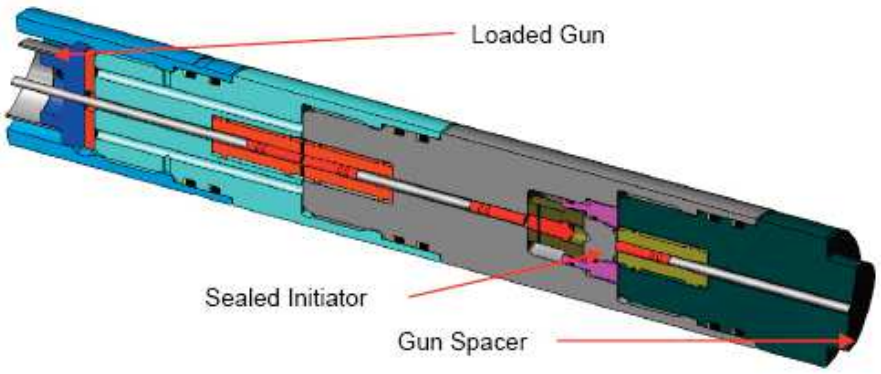
Loaded Gun

Blank Gun



Pressure Isolation Device (PID)



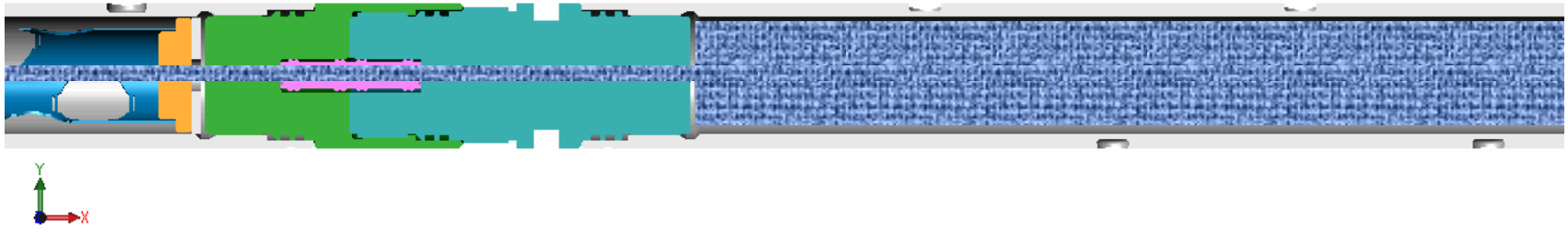


- Provides the capability to isolate wellbore pressure when deploying and/or retrieving perforating guns under pressure.
- Providing a means for isolating gun spacer chambers, the PID helps manage DUB surges during perforating.

Pressure Isolation Device (PID) Effects

Loaded Gun

Blank Gun



Case History - DUB Orientated Perforating in Horizontal

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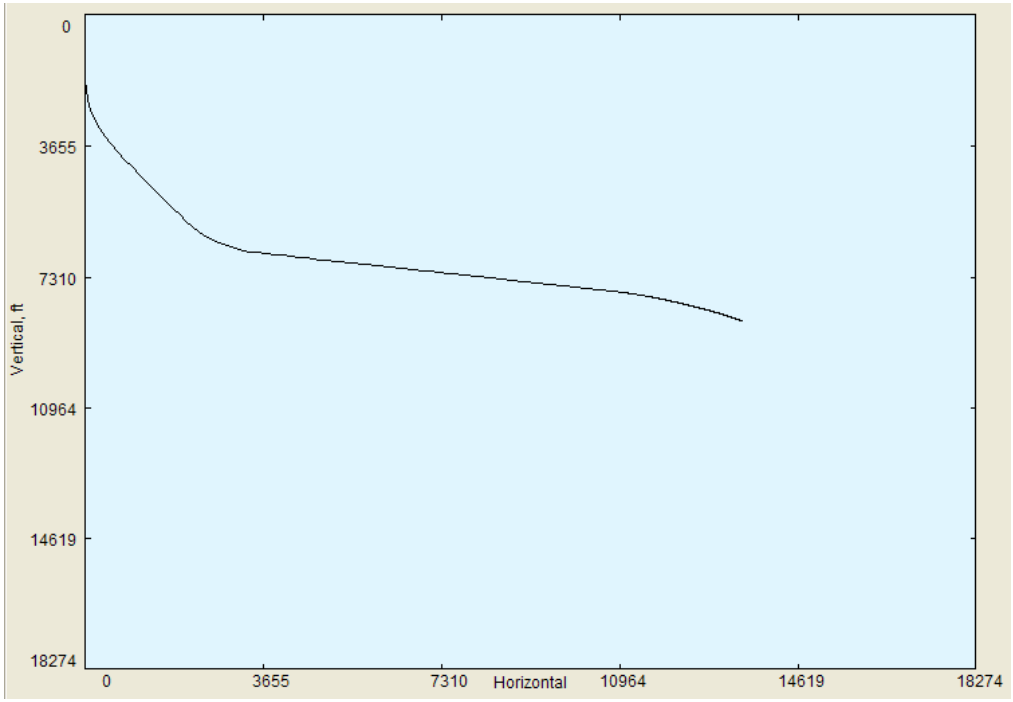
DUB Orientated Perforating in Horizontal

- Norwegian North Sea
- Sandstone
- Oil
- 5570mMD / 2602mTVD



- Automated gun handling subs
- 4 5/8” ultra low debris internal oriented perforating system, 10-350 , 4spf

Automated Gun Handling Subs-The Automated Solution

- Fully Automated Gun Handling
- Safety - No personnel required on rig floor
- Rig Time/Cost Savings up to 40% reduction in deployment and recovery

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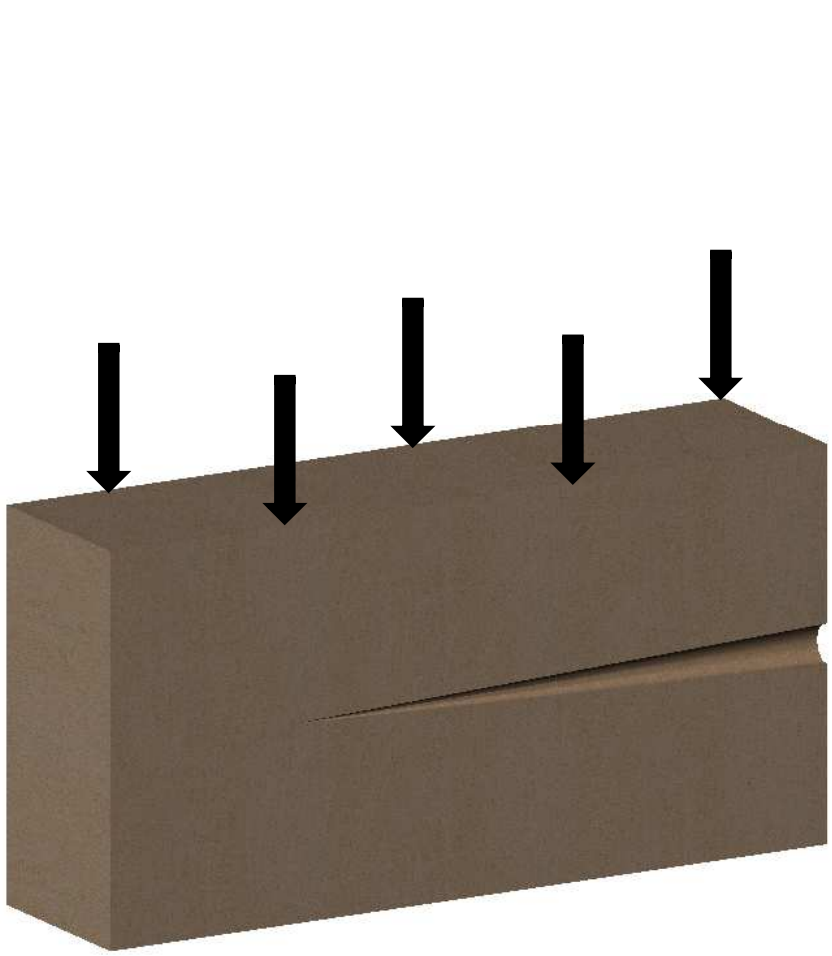
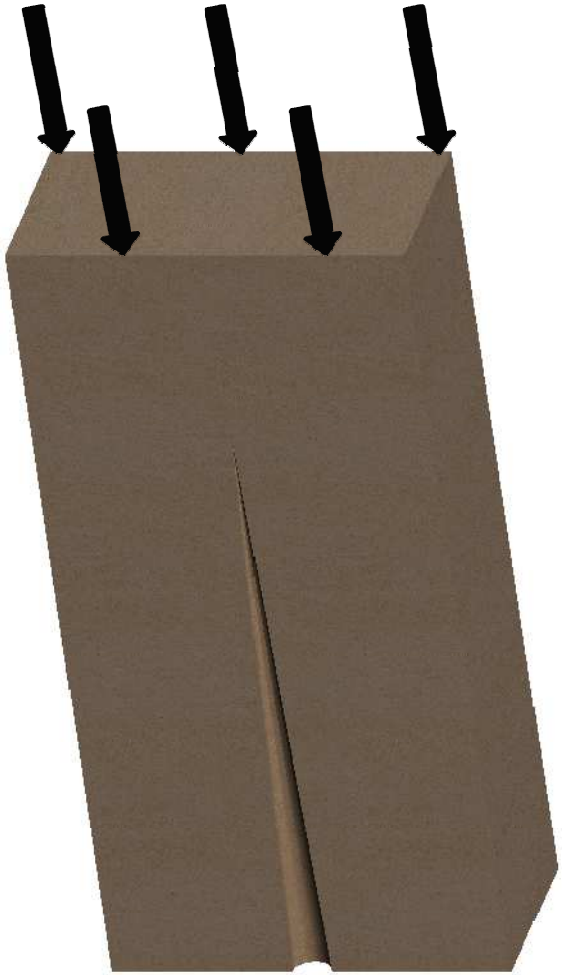
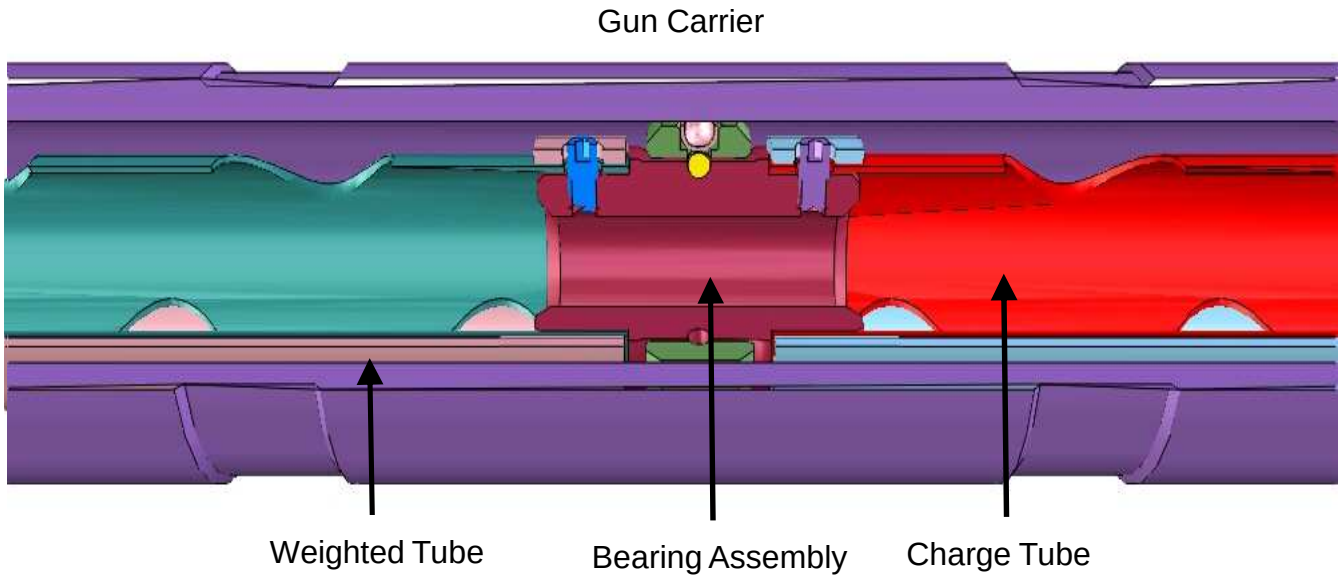
Sand Control Theory



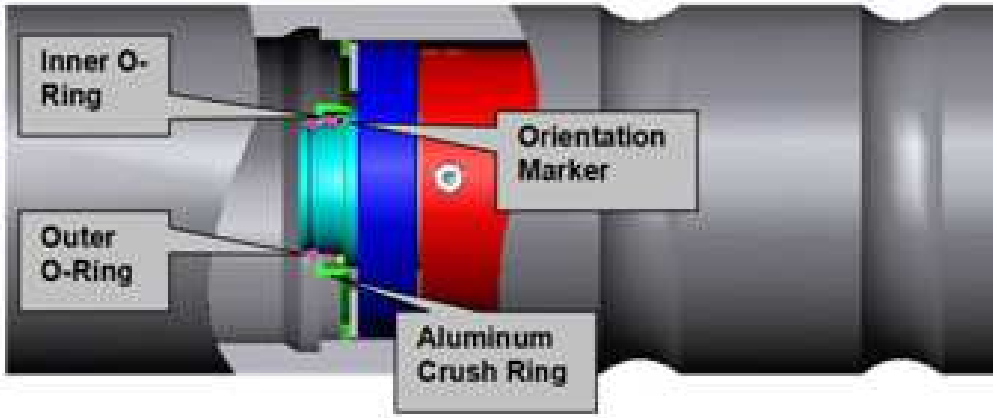


Internal Oriented Perforating System

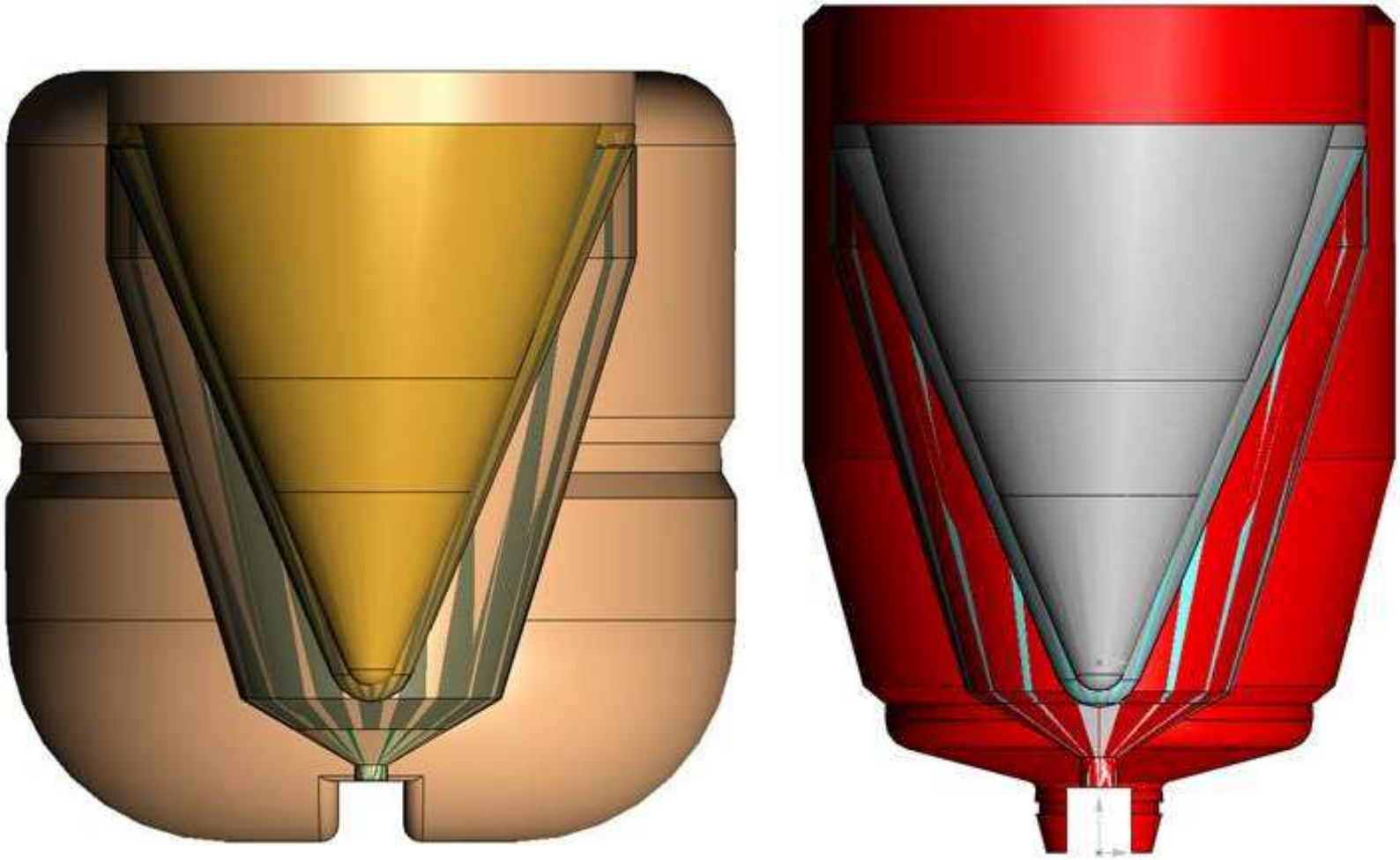
- The assembly is made up of five separate sub-assemblies allowing each charge tube to rotate independent of the gun carrier.
- These sub-assemblies are comprised of a section of charge tube and weighted tube connected to a bearing assembly.



Orientation Verification

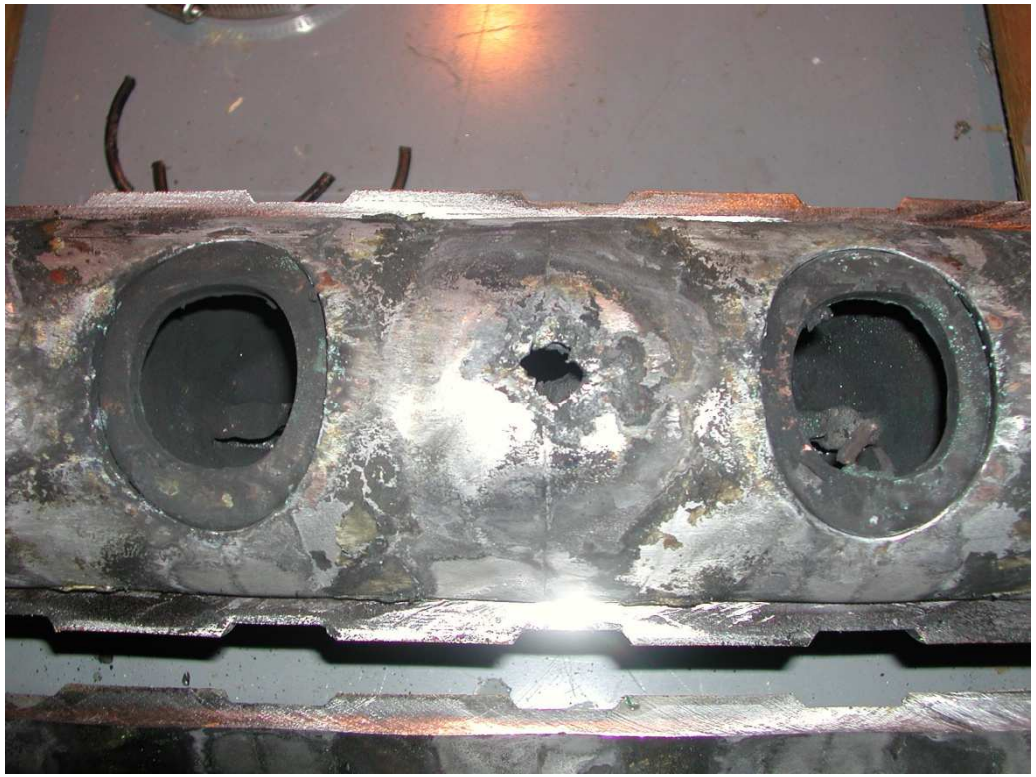


4 5/8” 39gm Ultra Low Debris Charge



4 5/8” 4 SPF Ultra Low Debris Charge Tube

- Expended gun sectioned to show charge holder with charge cases in tact
- Test conducted at JRC, Alvarado on 10-12-04

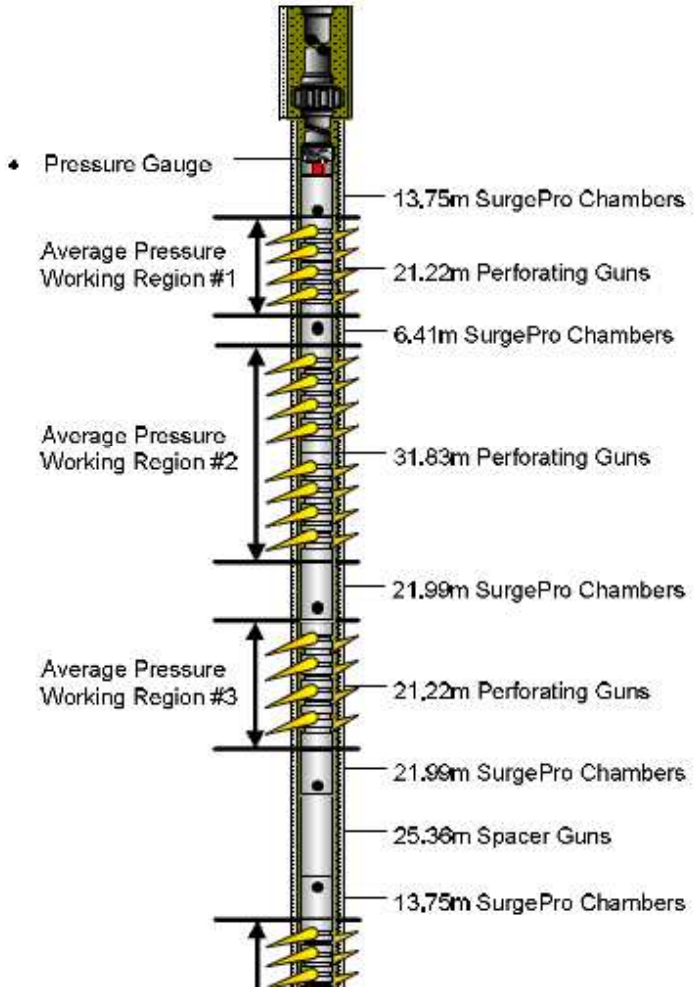


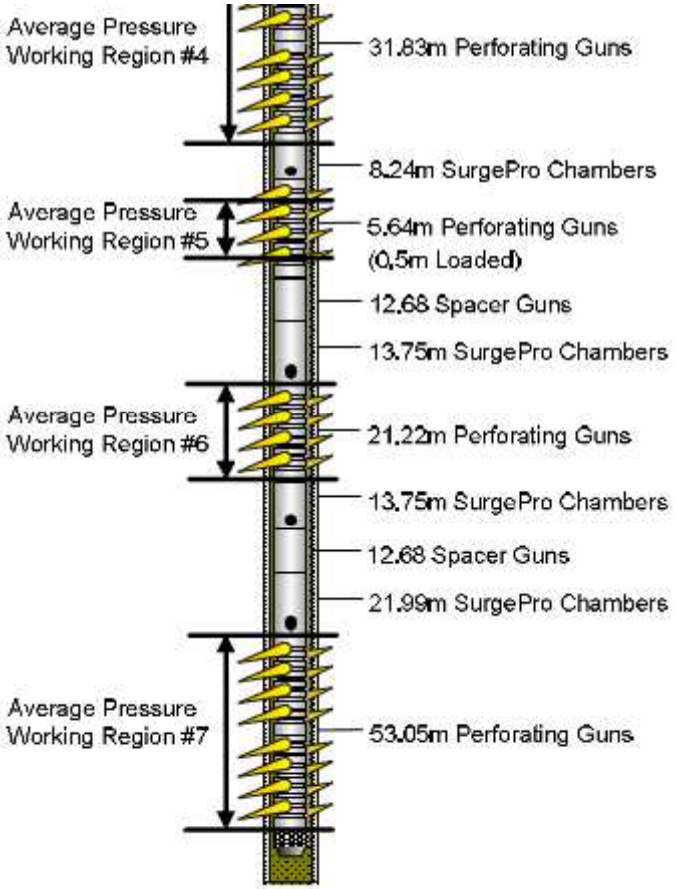
Section 5
Debris Test of 4ft 4 5/8” Ultra Low Debris Gun

	Debris Rolled From Gun, % By Weight Retained on US Sieve Sizes									
	Screen .500 In. 12.7mm	Screen .375 In. 9.53mm	Screen .250 In. 6.35mm	# 4 Sieve .187 In. 4.75 mm	# 8 Sieve .094 In. 2.36 mm	# 12 Sieve .066 In. 1.70 mm	# 20 Sieve .033 In. .85 mm	# 50 Sieve .011 In. .300 mm	Through # 50 Sieve	Total Debris Rolled From Gun
Wt. In gms		13.16	7.42	4.58	4.58	0.07	0.02	0.04	0.04	29.89
% by Wt.	0.0%	44.0%	24.8%	15.3%	15.3%	0.2%	0.1%	0.1%	0.1%	100.0%

- 29.89gm / 4ft = 7.47gm/ft

Perforating String



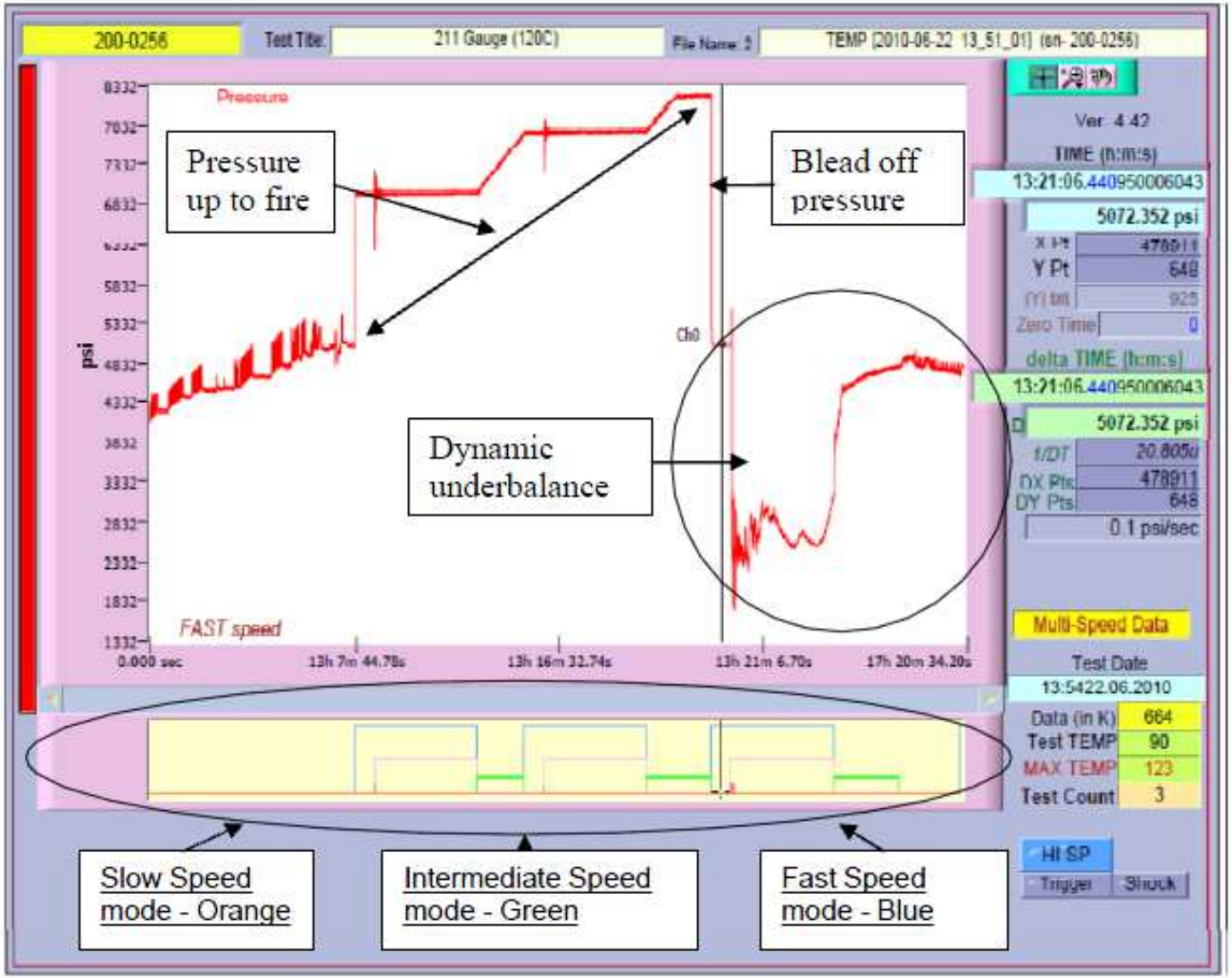


Pre-job Results

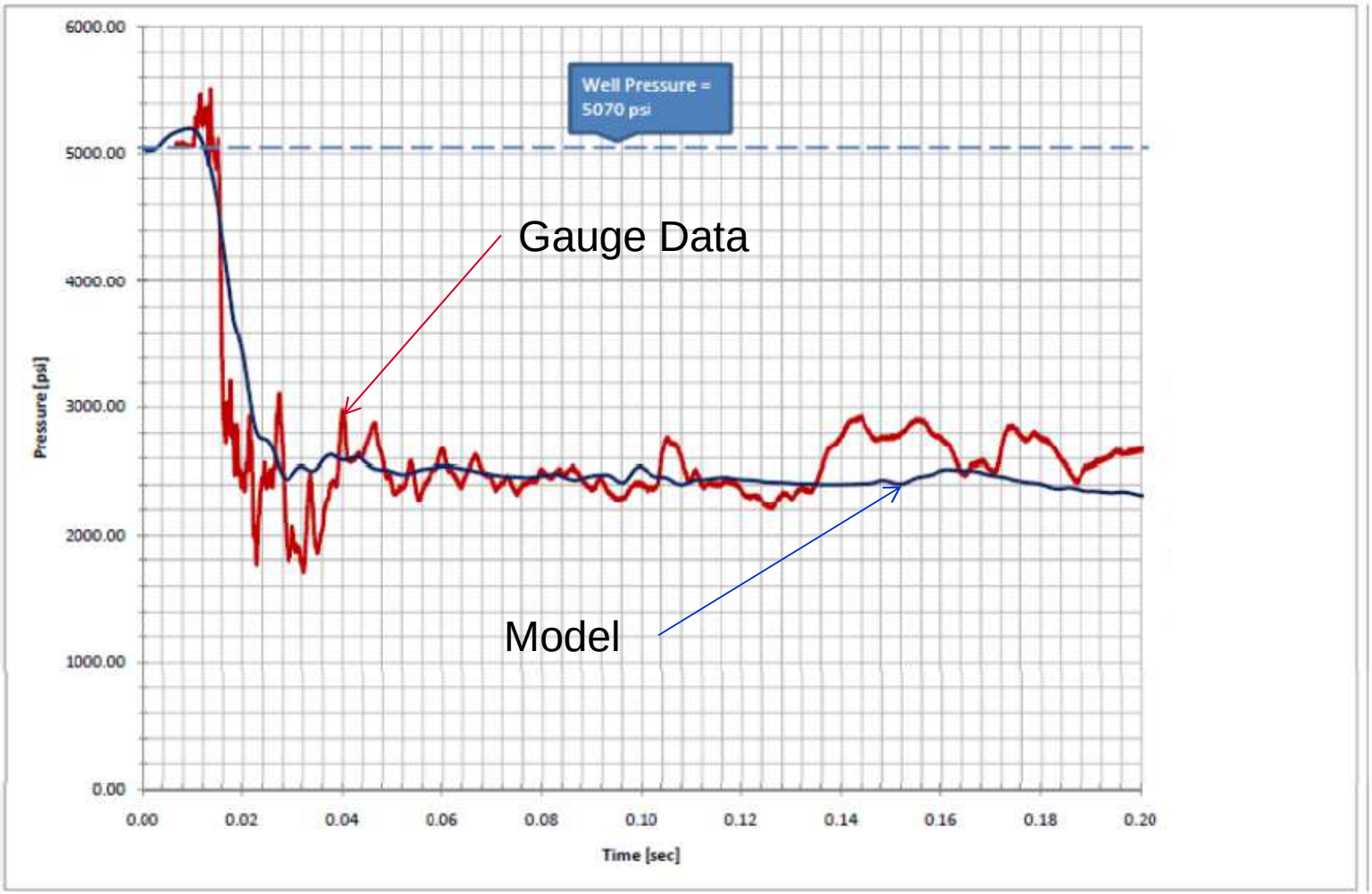
Working Zones	Perf Interval Depth (mMD)	Perf Interval (m)	Avg Well Pressure (psi)	Avg Reservoir Pressure (psi)	Avg Peak Drawdown Pressure (psi)	Avg Dynamic Surge (psi)	Perf Clean Up (%)
1	5185.5-5205.6	20.1	5308	4731	2320	2411	90
2	5213.2-5243.8	30.6	5333	4731	2618	2113	100
3	5267.0-5287.0	20	5359	3654	2512	1142	76
4	5349.3-5380.0	30.7	5436	4577	1308	3269	100
5	5391.0-5391.5	0.5	5462	4592	308	4284	100
6	5421.4-5436.5	15.1	5487	4617	2117	2500	100
7	5486.1-5538.0	51.9	5538	4158	3095	1063	99

- Porosity 21-29%
- Perm 30-3306mD

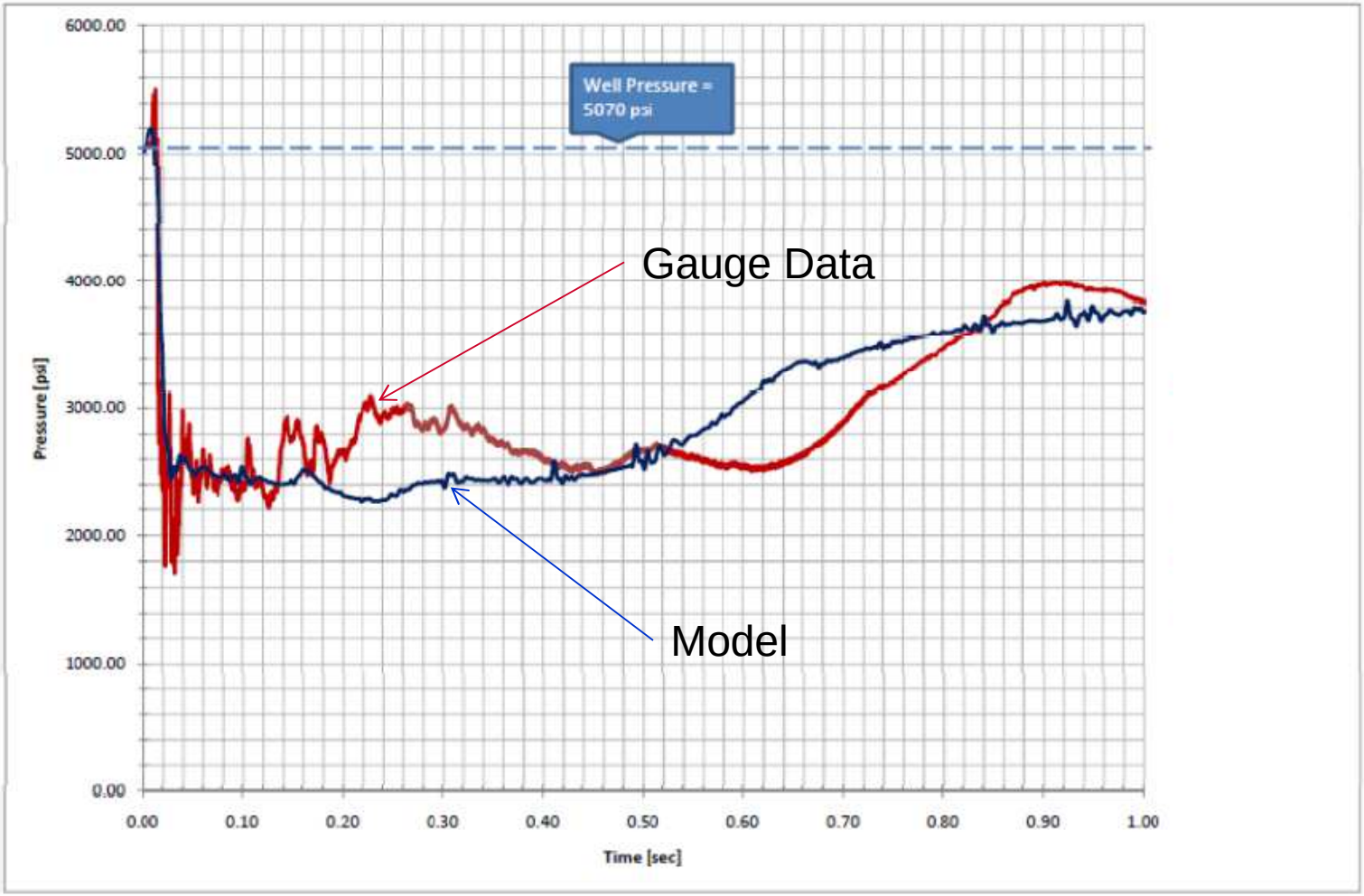
High Speed Gauge Data



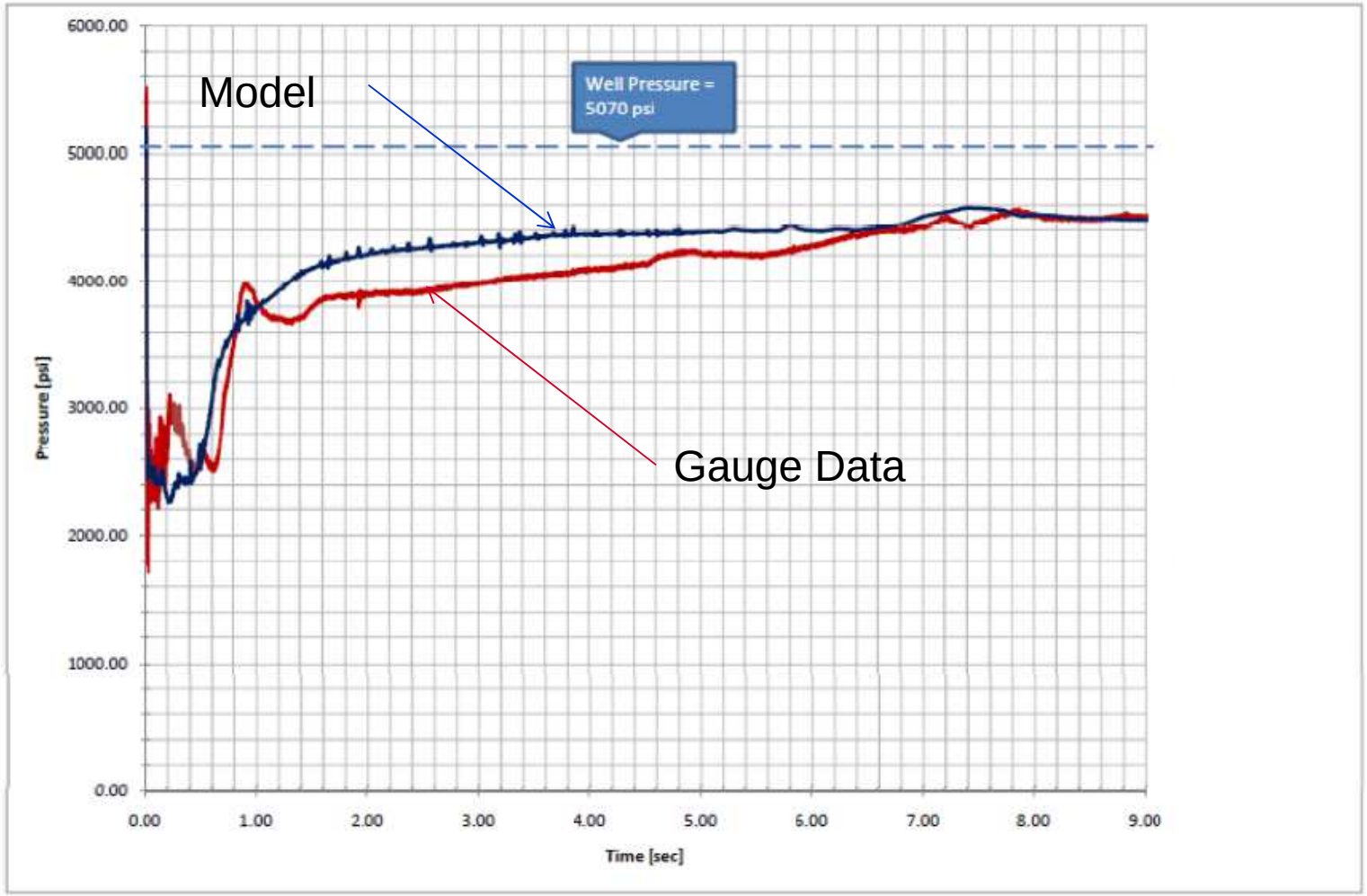
Model Validation to 0.2 second



Model Validation to 1 second



Model Validation to 9 second



Eliminating the Back Surge

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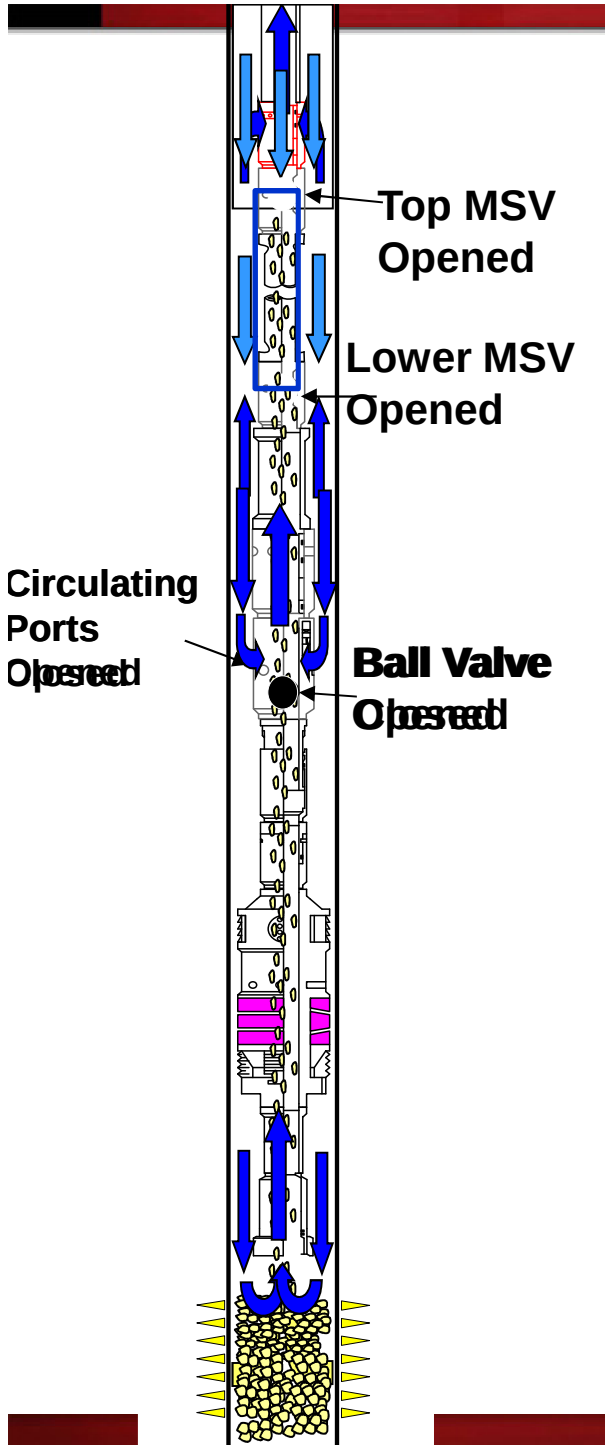


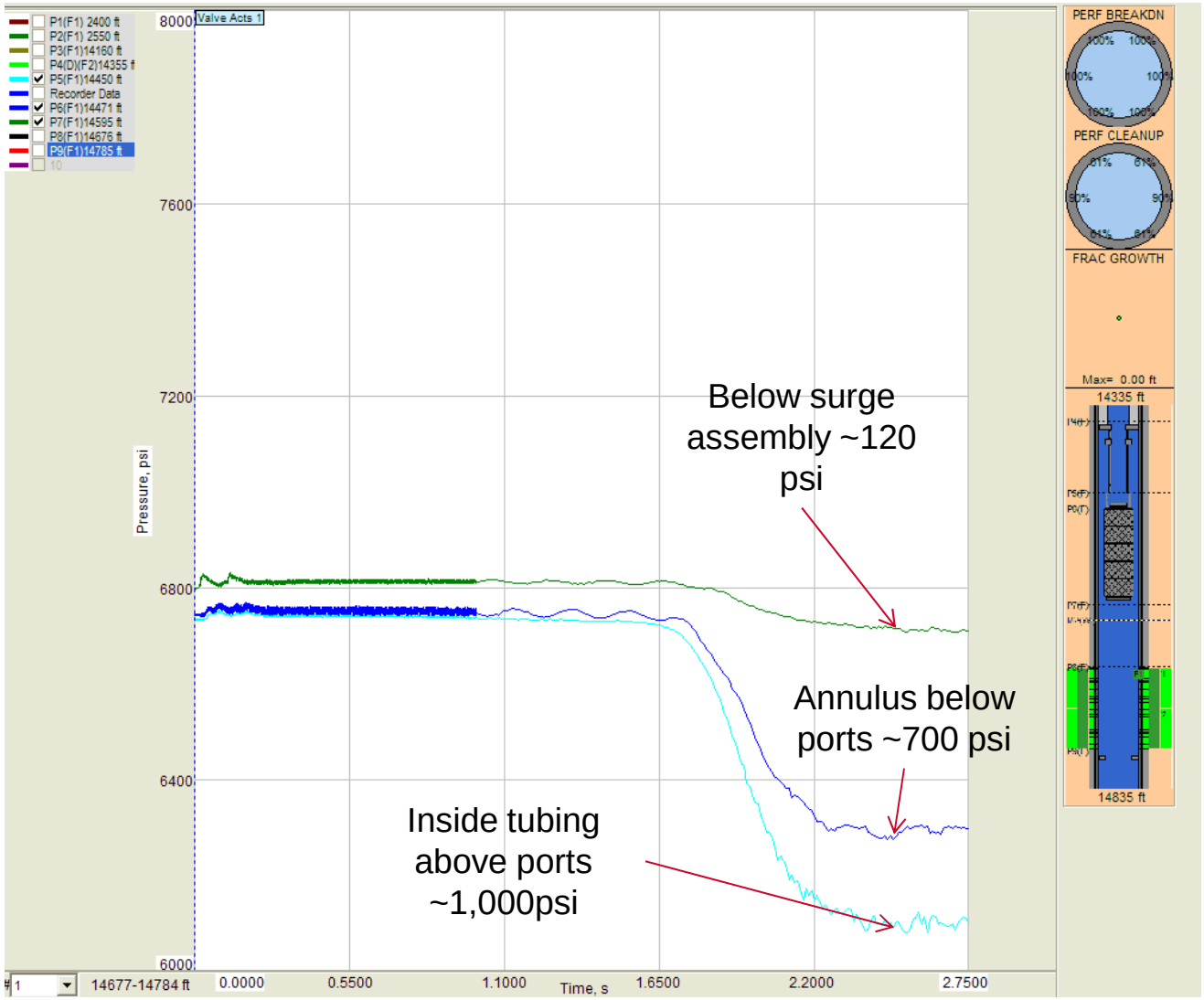
- RIH
- Make sure FAS-FIL has closed
- Set Packer
- Apply 1500psi down drill pipe
- Apply 1500psi to annulus to open bottom Multi Service Valve
- Bleed annulus pressure then tubing pressure and wait 2 hours
- Apply 1500psi to annulus to open top Multi Service Valve
- Cycle OMNI to circulate position
- Circulate 2 tubing volumes or until clean fluid at surface
- Cycle OMNI to well test position
- RIH to tag for fill
- Reverse circulate and pull packer plug if necessary
- POOH

Why Perform a Back Surge?

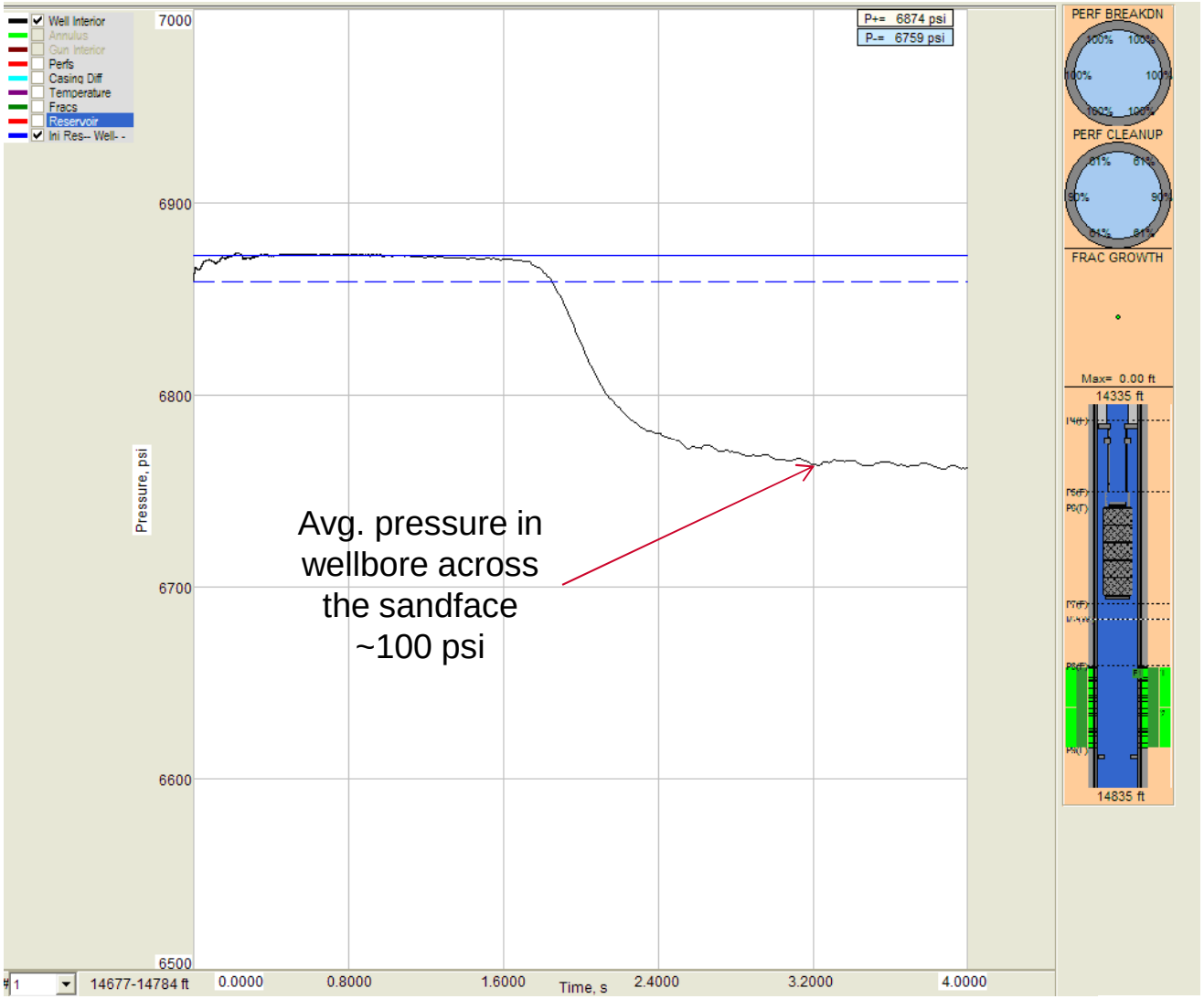
- Pros
  - To clean out perforations
  - To minimize risk of sanding up the guns
  - Can be more aggressive with UB condition

- Cons
  - Extra Trip
  - Additional tools

Surge Model: Effect UB across the sandface



Surge Model: Effect UB across the sandface



Outcome of Study

- 1,500 psi UB backsurge did not result in much differential across the sandface
- Eliminated the back surge
- Wells are to be perforated with 1,500 psi UB
- Wells left in completion plan were perforate successfully with the change in perforating procedure
- Average cost savings of 1MM per well