IPS-14-32

DEEPWATER GOM PROPELLANT ASSISTED PERFORATING INCIDENT REVIEW

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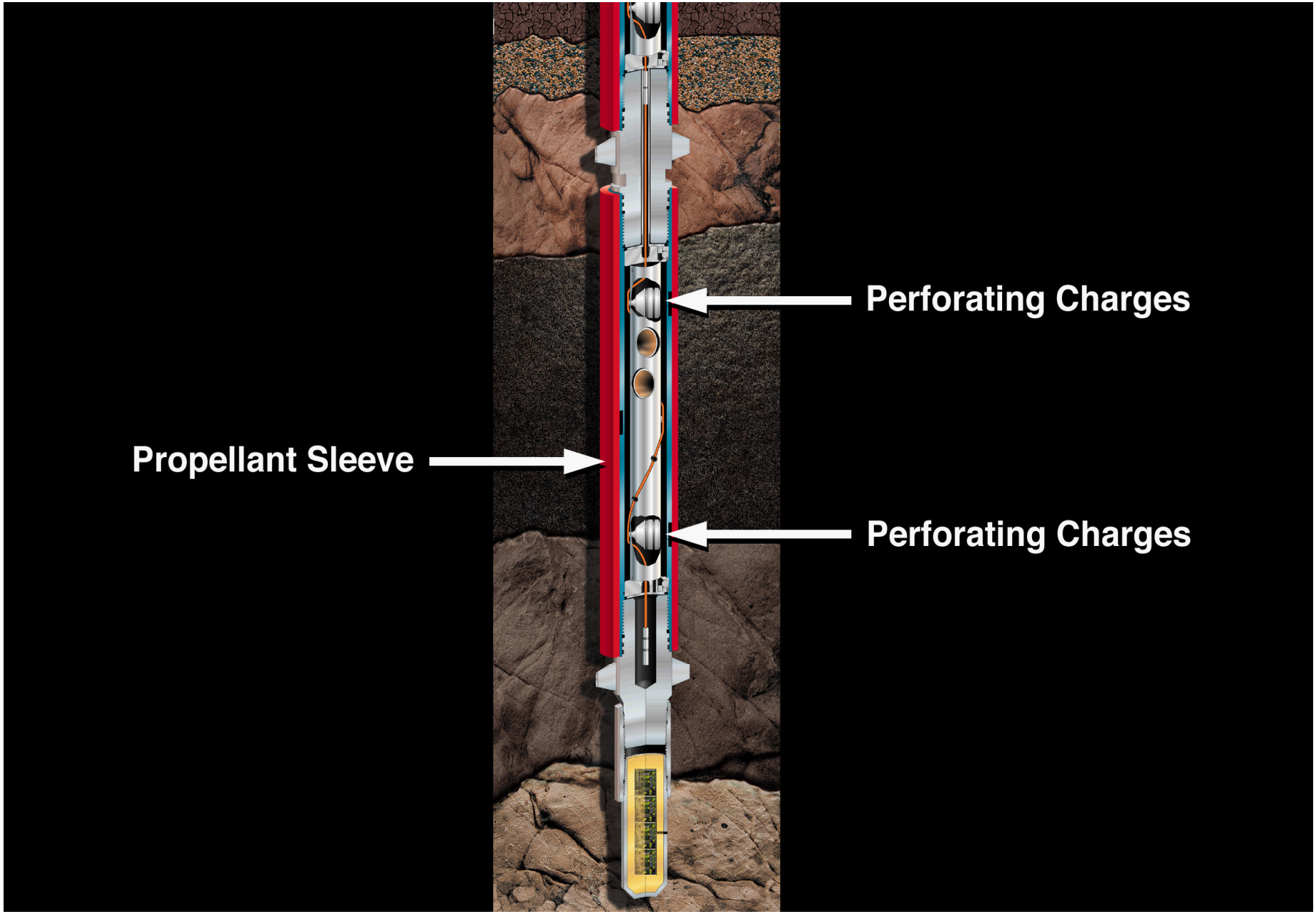
Wells Engineering Team Lead (CWI)

AGENDA

- Overview Propellant Technology for TCP Applications
- Why we use this technology
- Review of recent incidents
- Recommendations for future applications

PROPELLANT ASSEMBLY



COMPUTER MODELING

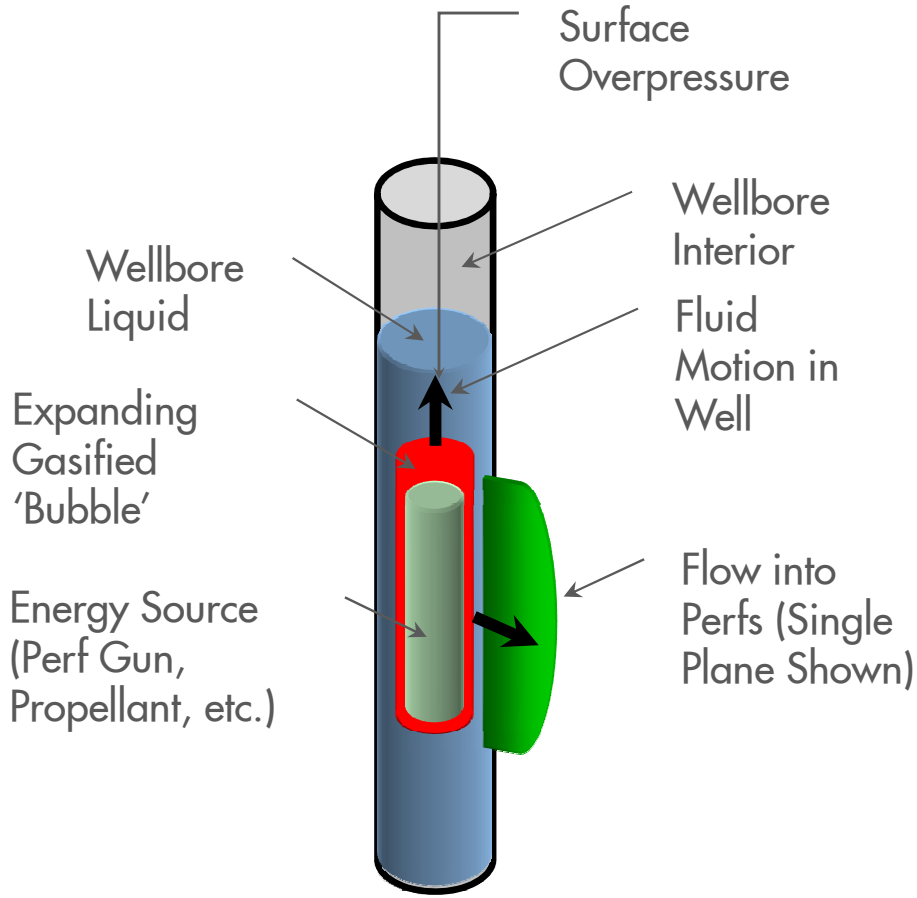
Completely physics-based

- Source thermodynamics
- Compressible transient mixed-phase flow
- Flow in and out of perfs and formation
- Flow in and out of carriers
- Solid elastic waves
- Fluid-solid coupling (drag and pressure)
- Equipment acceleration (shock), compression/tension, and motion

All done by time-marching finite differences

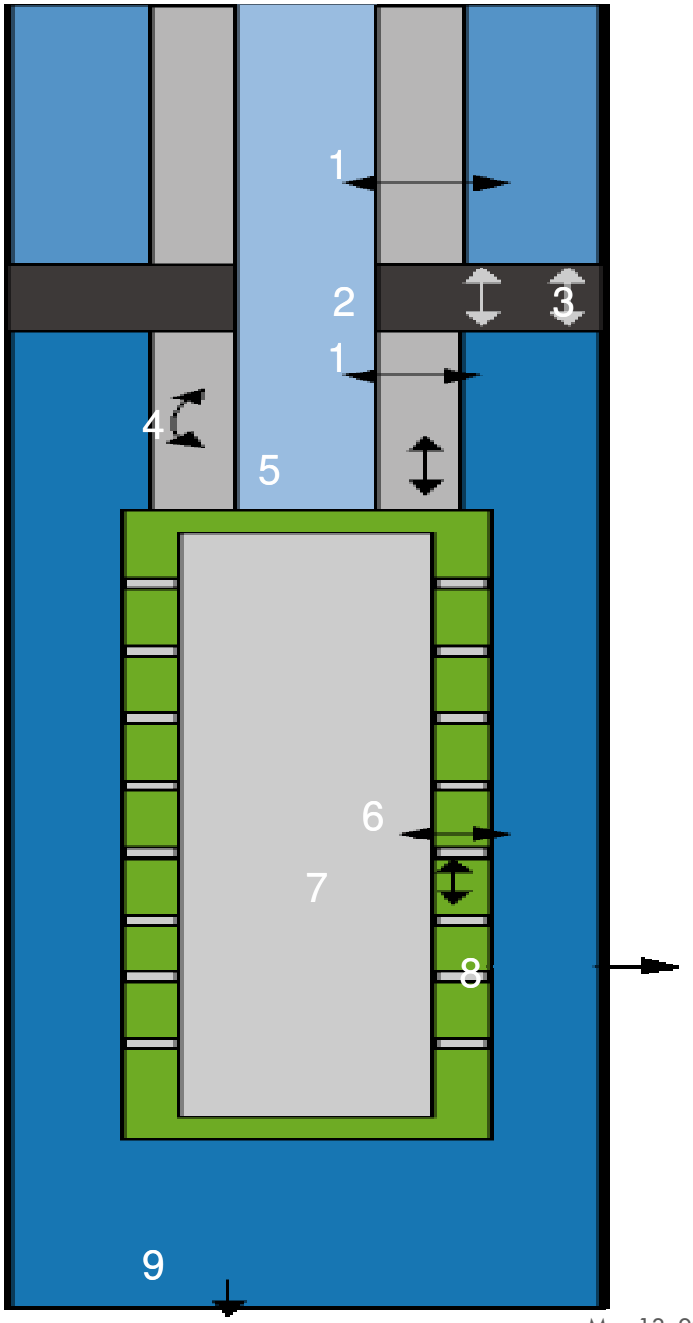
Validated with lab and field data

High-Speed Fast Gauges



DYNAMIC FAILURE MODES

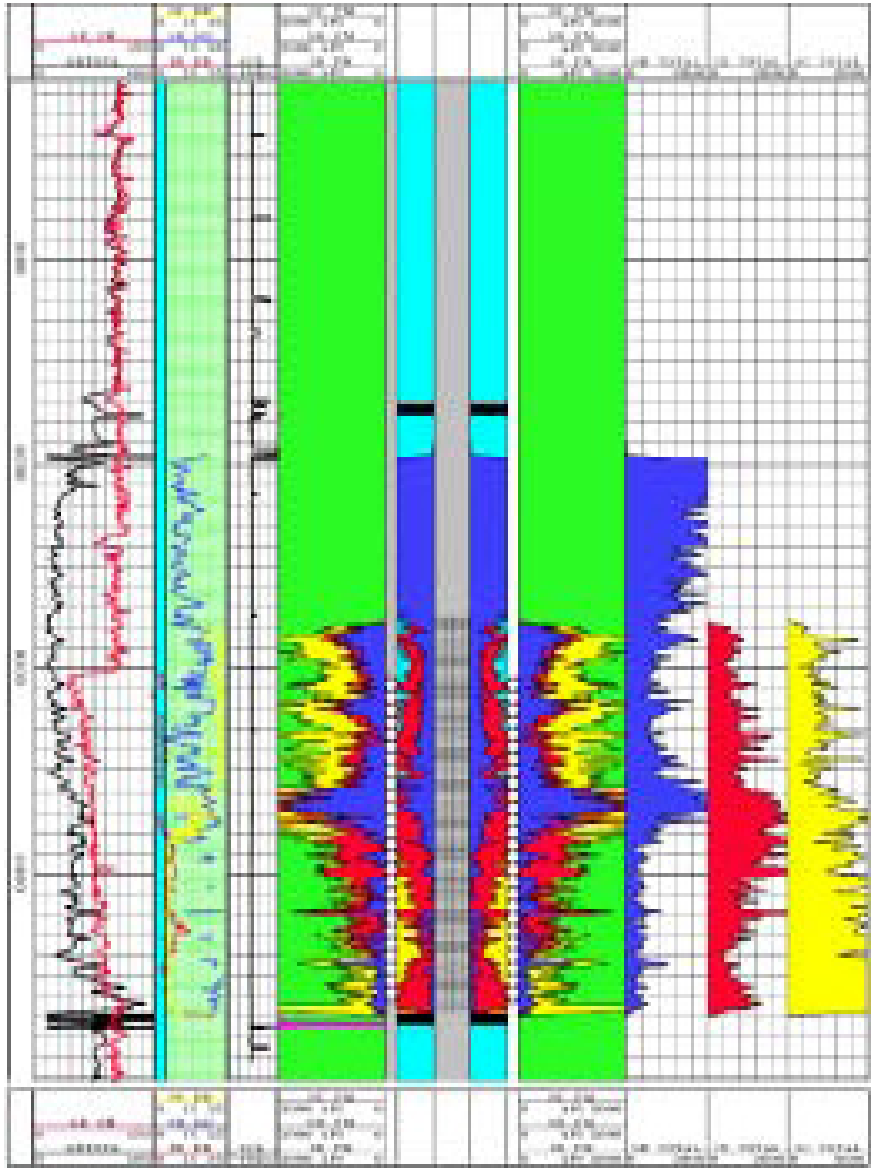
1. Tubing burst/collapse
2. Packer axial load
3. Packer bypass (leakage)
4. Tubing axial buckling (bending)
5. Tubing compressive/tensile yield
6. Gun burst/collapse
7. Gun compressive/tensile yield
8. Casing burst
9. Sump packer/plug axial load
10. Wireline tensile yield and pullout (not shown)

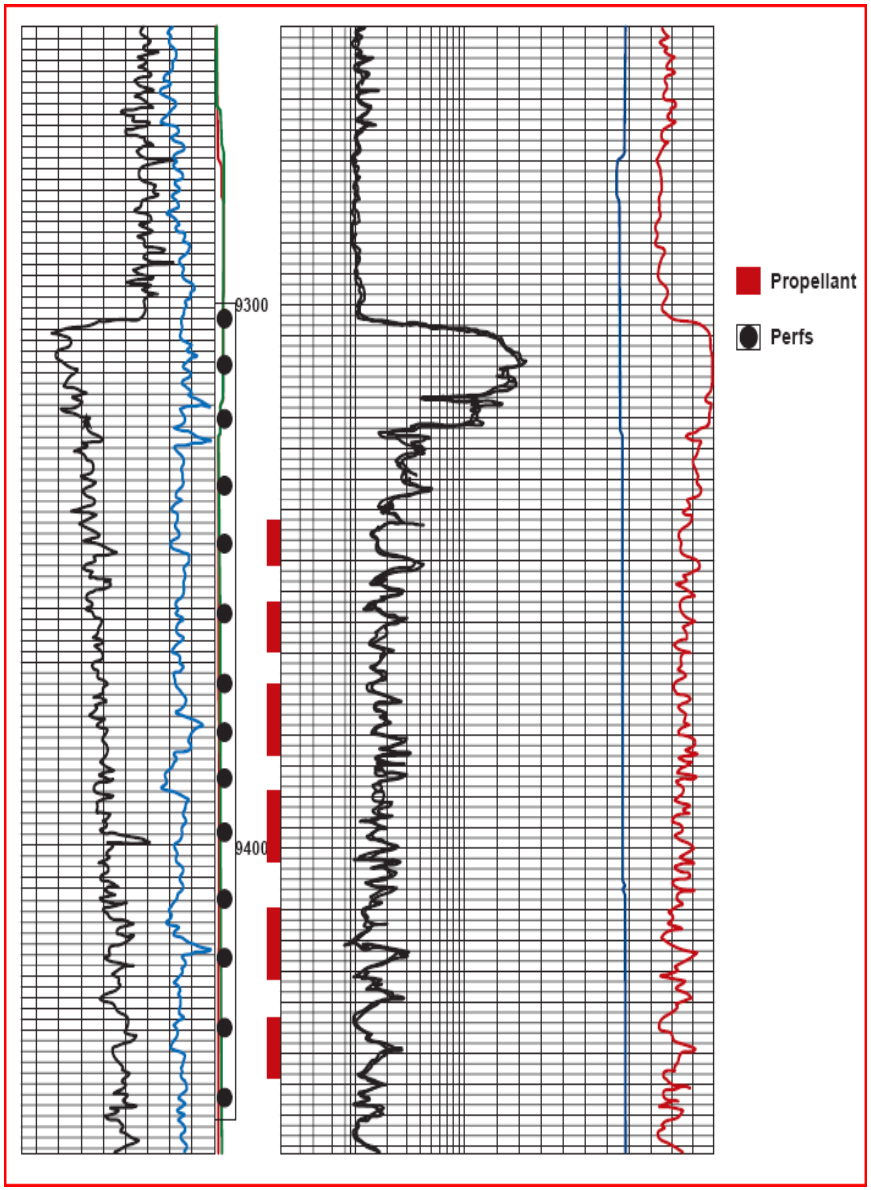


SIMULATION SHOWING TUBING DAMAGE

WHY WE USE PROPELLANT ASSISTED TCP IN GOM

SPE 71639





JOB HISTORY GOM

Date	Customer	Gun Size	Gun Length			StimGun Sleeve		Hydrostatic (psi)	Comments
			Loaded (ft)	Blank (ft)	Zones	Coverage (ft)	% Coverage		
[redacted]	[redacted]	[redacted]	32	9.27	1	20	63%	11,356	
			44	87	4	9	20%	13,862	
			105	10.08	1	51	49%	12,516	
			28	15.52	1	15	54%	8,084	
			72	15	1	33	46%	17,510	
			100	3.76	1	45	45%	17,163	
			77	3.16	1	39	51%	12,622	
			61	22.75	2	30	49%	7,938	
			90	14.16	1	18	20%	12,087	Bent tubing
			50	10.44	1	18	36%	8,617	
			100	11.88	1	36	36%	7,096	
9/30/2012		3.125" 6spf [redacted]	360	16.51	1	180	50%	13,763	Split gun
12/20/2012		4.625" 12sp[redacted]	238	52	4	117	49%	14,264	Split gun
[redacted]		[redacted]	145	3.78	1	42	29%	11,952	

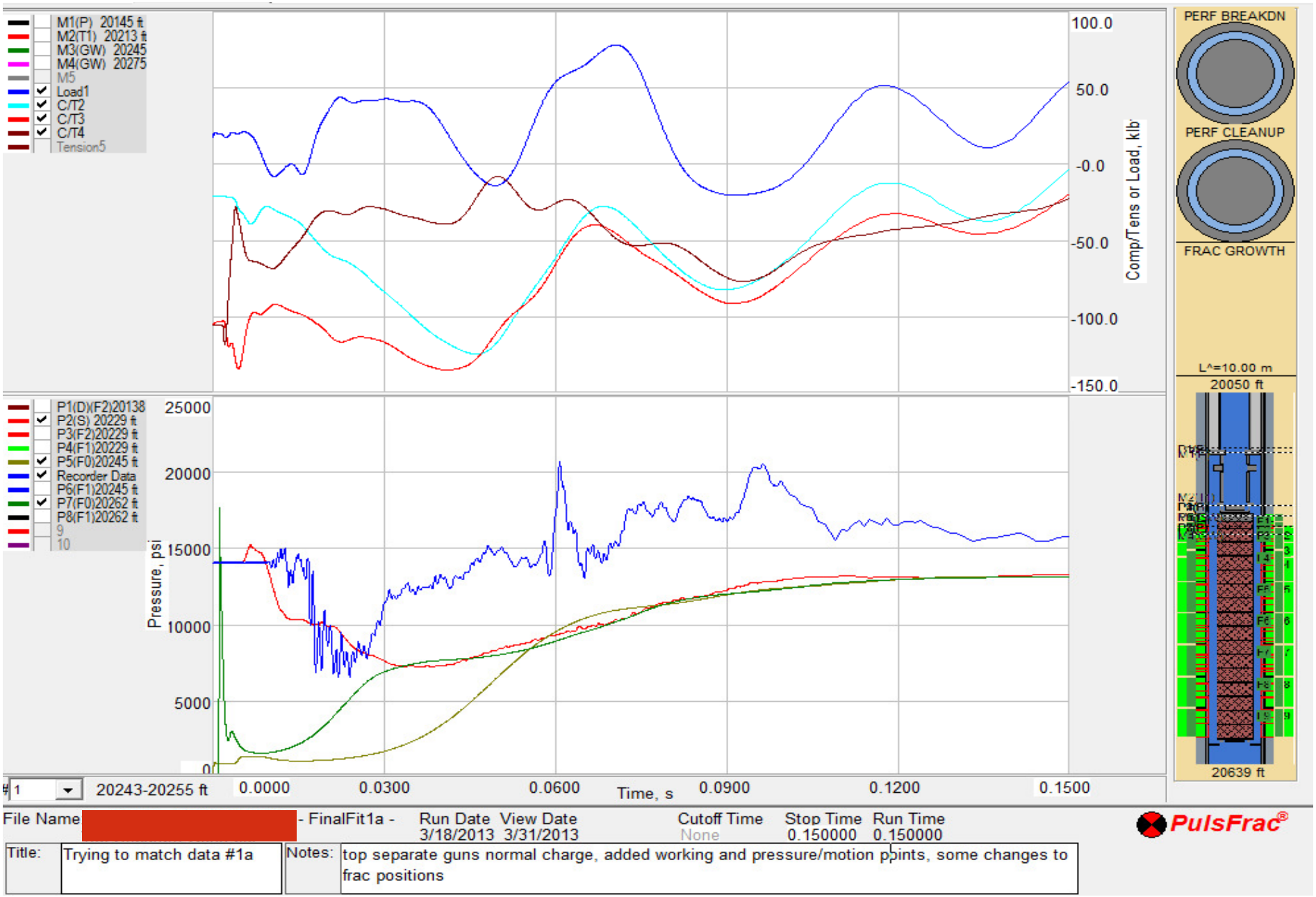
INCIDENT REVIEW

WELL #1: 3-1/8" 6 SPF (NEAR MISS)

1. StimGun application 3rd Qtr 2012
2. 360 ft of 3-1/8" 6 spf BH (steel)
3. 180 ft of Propellant
4. All fully loaded guns except top 22 ft gun with 16.5 ft of blank w/ steel dummy charges (qty 3)
5. Hit jars to retrieve BHA
6. Gun split observed on 1st gun out hole, all other guns no issues

WELL #1: 3-1/8" 6 SPF BH (22 FT – 16.5 FT B)

WELL #1: 3-1/8" 6 SPF (PRE-JOB MODELING)



WELL #1: 3-1/8" 6 SPF (POST-JOB MODELING)

File Name: [redacted] FinalFit6a -

Run Date	View Date	Cutoff Time	Stop Time	Run Time
3/31/2013	4/1/2013	None	0.150000	0.150000

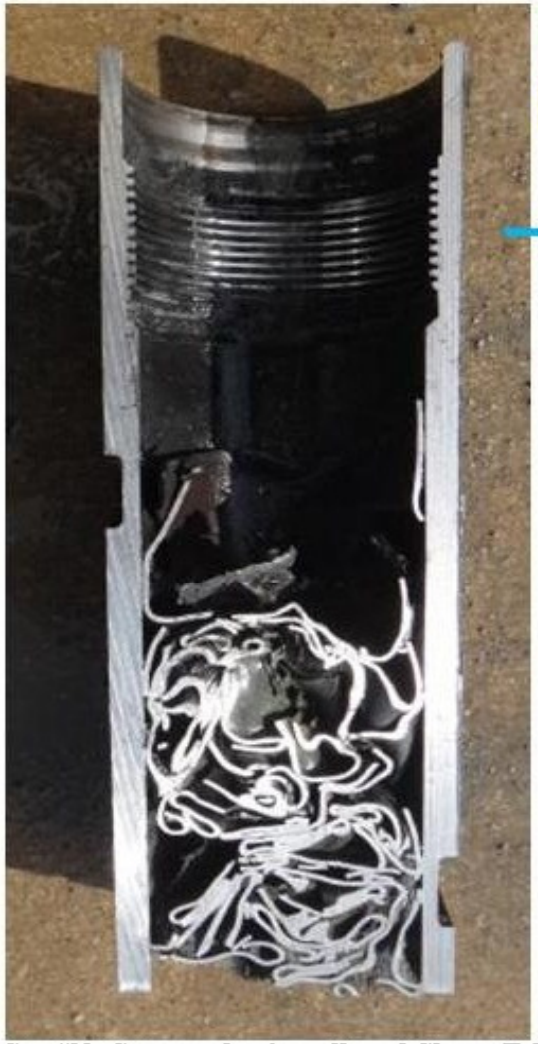
PulsFrac®

Title:	Trying to match data #6a
Notes:	top separate guns normal charge, added working and pressure/motion points, some changes to frac positions, upper plugged, simulated energy release due to failure at 50 ms

WELL #2: 4-5/8" 12 SPF BH/LD (TRAIN WRECK)

1. Stimgun application 4th Qtr 2012
2. 4-5/8" 12 spf BH/LD, 290 ft Gross/238 ft Loaded with 117 ft of propellant (15 total guns)
3. 4 Zones Perforated, multiple partially loaded gun carriers w/ zinc dummy charges
4. No issues after detonation with packer or POOH
5. Gun #8 sheared leaving 7+ guns in hole (fish) and Tubing Buckled
6. Splits observed in Guns #14, 11 and 8 (all partially loaded guns)
7. 3 weeks of fishing (NPT costs) and bottom zone not recovered (loss of reserves lower zone)

WELL #2: 4-5/8IN 12 SPF BH/LD



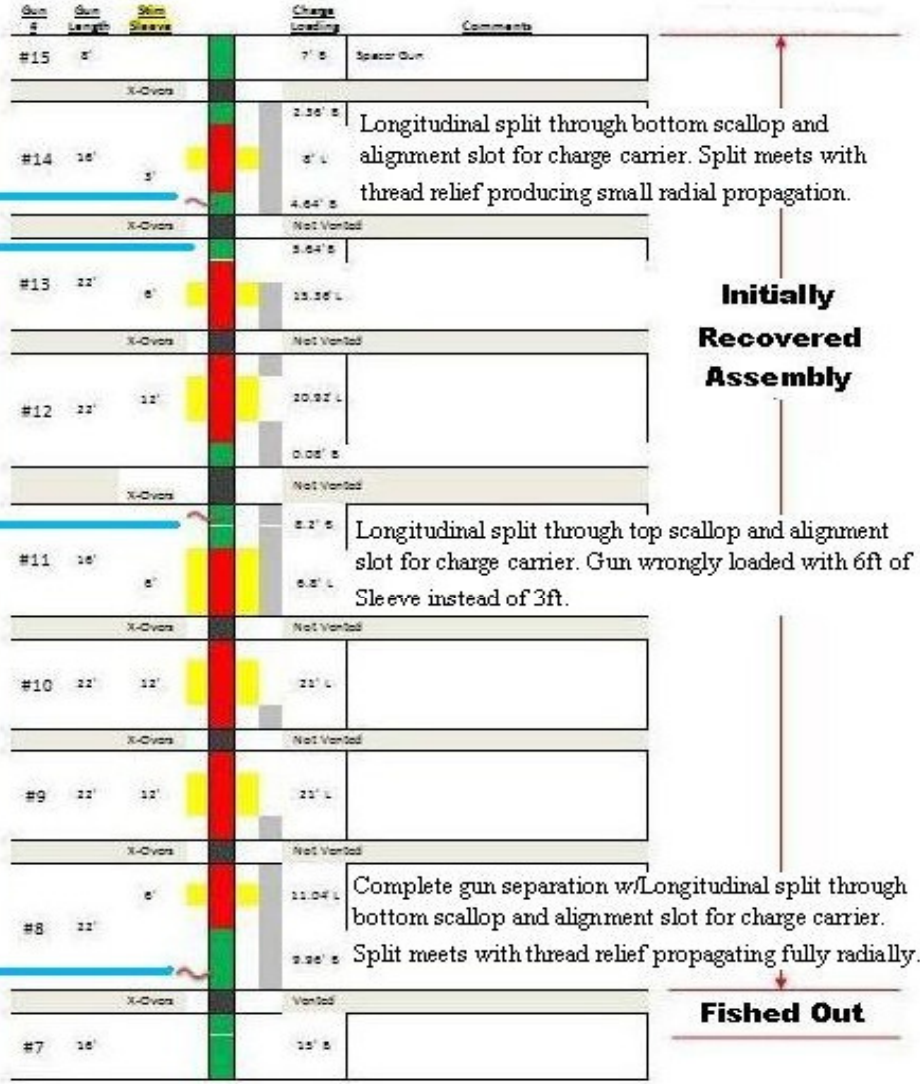
Gun #13: Cutaway showing collapsed Charge Tube
(Gun Housing not split on this one.)

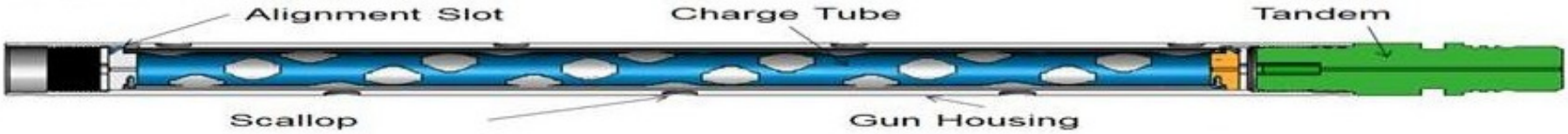
Blank Gun
Loaded Gun
Stim Sleeve

Gun #14

Gun #11

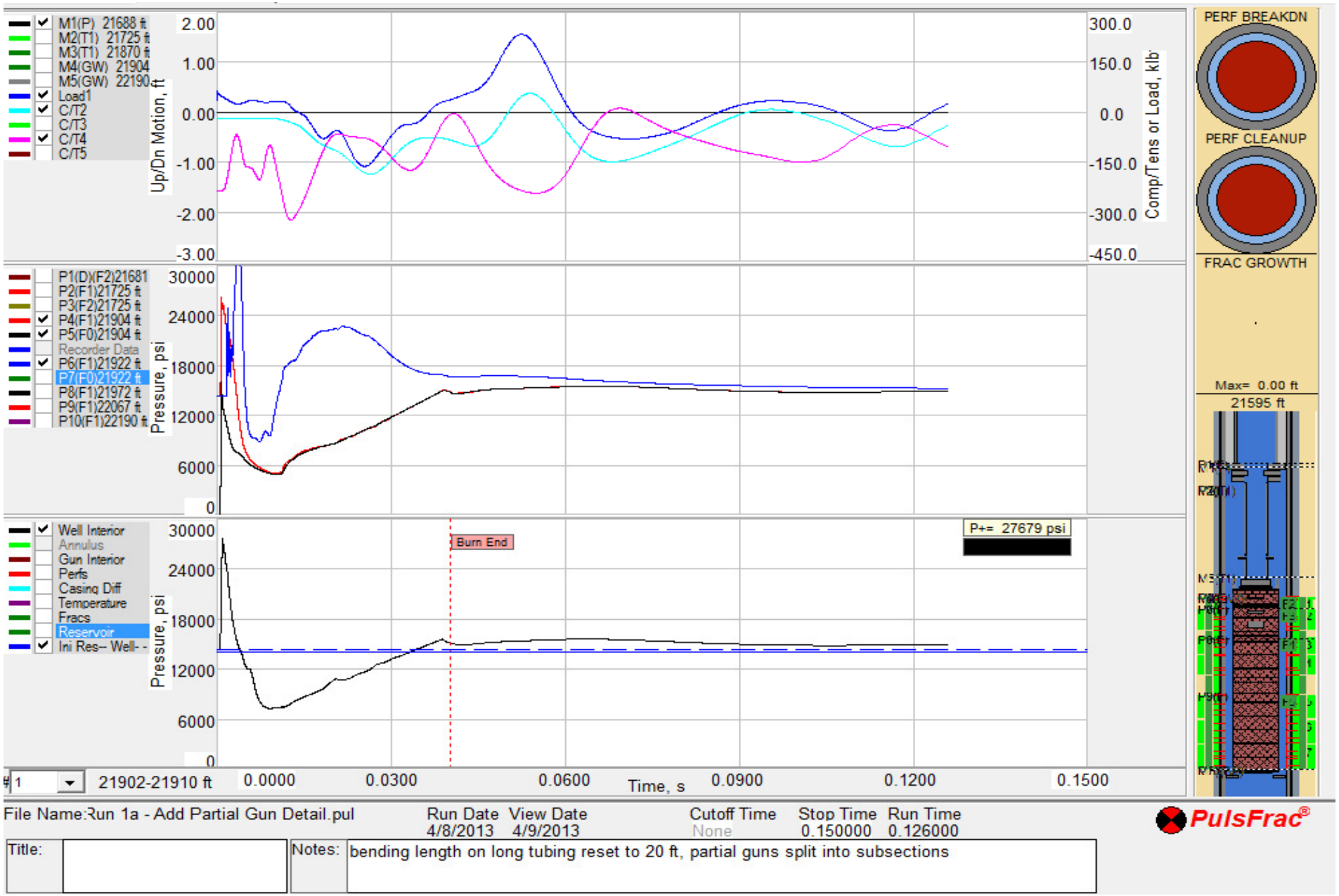
Gun #8



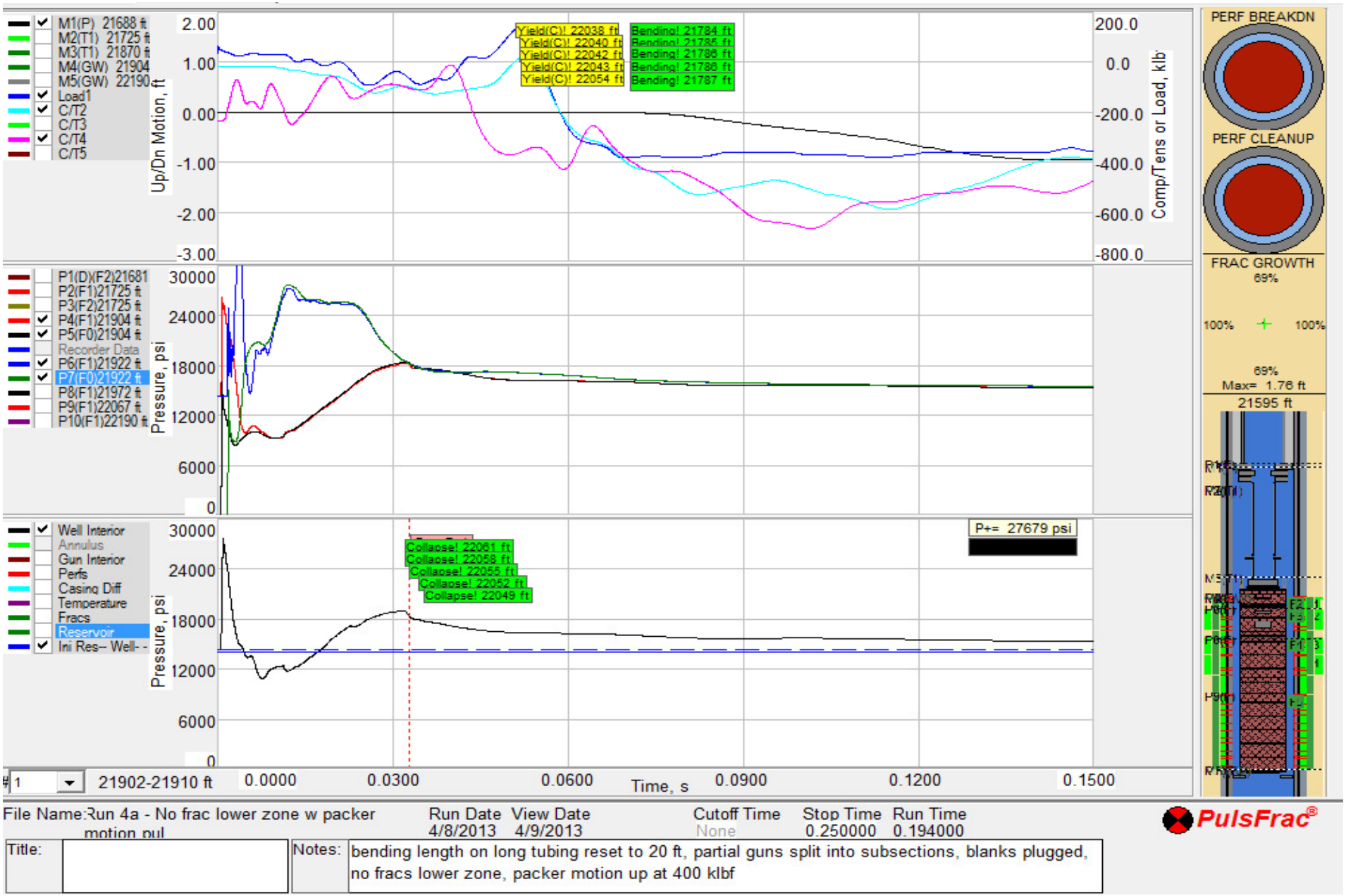


WELL #2: OTHER OBSERVATIONS – PACKER & TUBING

WELL #2 (PRE-JOB)



WELL #2 (POST-JOB)



WELL #1 & #2: CAUSAL FACTOR SUMMARY

Gun Body met the chemical, charpy impact, hardness and tensile strength requirements as specified. The material shows good toughness as shown by charpy impact test results.

Examination of the fracture area revealed a ductile mode of failure evidenced by the shear failure of the Gun Body.

All failures occur in partially loaded gun bodies, pre-job modeling didn't identify this failure mode

Material burst due to internal over-pressurization of partial blank guns:

- Charge tube collapse in a few milli-seconds, Internal pressure > 15 kpsi, charge tube acts as plug or piston being driven up or down (+/- 50 milli-second event)
- Unknown amount of fluid trapped in gun body, rapid piston driven pressure intensifier combined with an impact event
- Charges tubes observed to be collapsed in similar manner on regular TCP jobs with BH charges

RECOMMENDATIONS

Propellant Coverage

- The PulsFrac model should be used to determine the ***minimum amount of StimSleeve coverage required to produce adequate fracture growth.***
- Provide a copy of the log across the interval for perm/porosity details (Get the most detailed representation of the reservoir properties)
- Vary % Stim from 10-50 percent coverage per loaded interval (Propellant Sleeve Length [ft] / Loaded Interval [Top Shot – Bottom Shot])
- Run short time models just to see peak pressure and Frac growth.
- Note Frac growth (requires good Frac parameter inputs such as min/max horizontal stress and rock properties) and change in average pressure across the interval per model.

RECOMMENDATIONS

Partially Loaded Guns

- Minimize or eliminate the use of partially loaded sections wherever possible.
- No StimGun sleeve should be used on partially loaded gun sections, unless the job consists of only partially loaded guns.
- Run venting charges in blank sections of partially loaded guns.
- Every hole in the charge tube that is not assembled with a loaded charge should be occupied with either a venting charge or a steel case dummy charge (no zinc)

Shell Perforating SME's Review all Deepwater StimGun Applications

Q & A