Artificial Lift R&D Council

Remote Monitoring of Pressure Transient Acoustic Tests

Gustavo Fernandez, Ken Skinner, Justin Bates, Dieter Becker, Tony Podio

Echometer Company

ALRDC Artificial Lift Workshop
February 28th – March 3rd, 2022

March 2nd 2022

Abstract

Data from acoustic fluid level and surface pressure measurements during a pressure buildup test were acquired by a standalone programmable monitoring system that uses internet and cellphone communication with the Cloud for remote monitoring of pressure transient well performance.

The progress of the buildup test was monitored remotely by downloading the acquired data and reviewing the pressure trend with additional measurements acquired manually as needed.

After the buildup test was completed additional fluid level and dynamometer records were acquired during the pump-down until normal production was stabilized.

Buildup test BHP data was exported for further analysis. Well productivity was estimated from the pump-down data.

Pressure Transient Test

Monitor how BHP changes with time when flow rate at the wellbore is changed.

Buildup test:

- Initially well is flowing at constant stable rate.
- Flow is stopped and pressure is monitored for a long time.

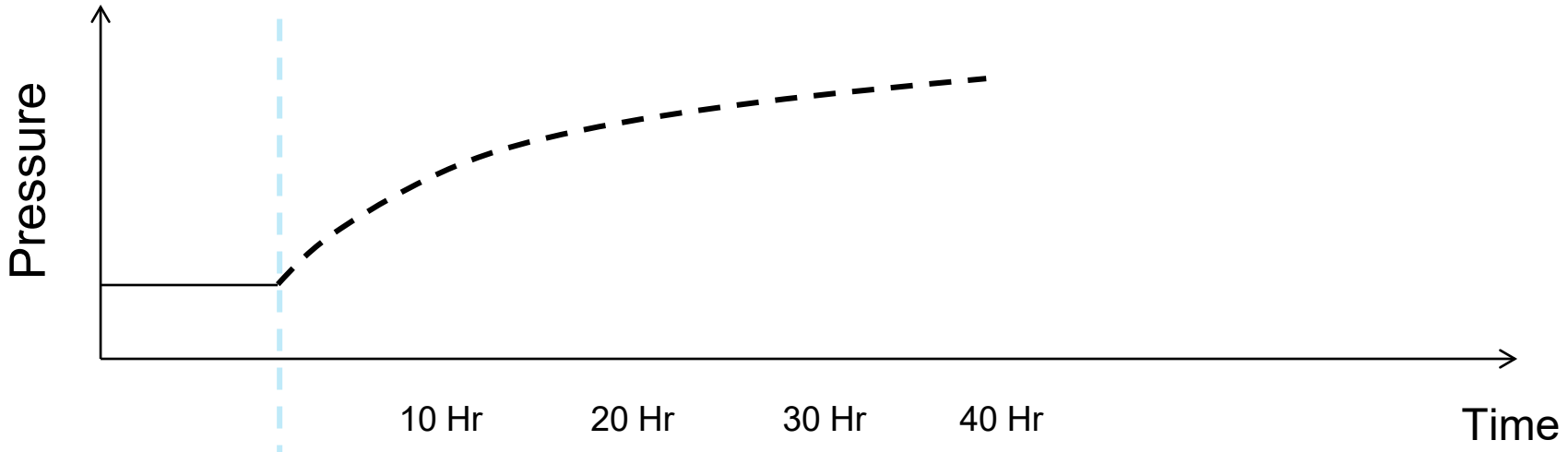
Drawdown test:

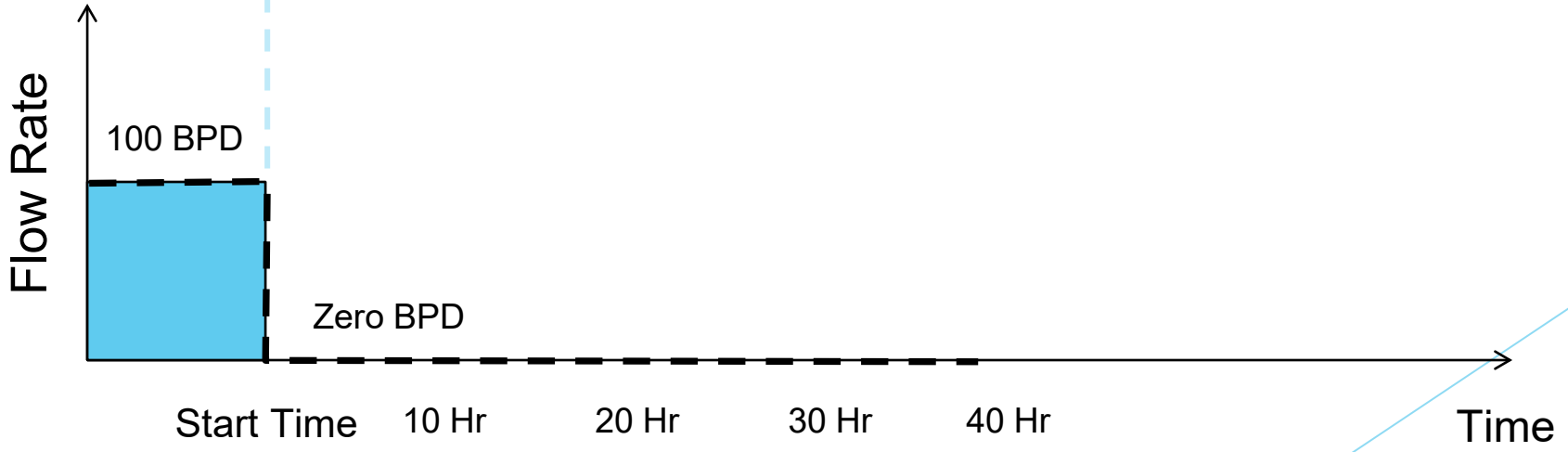
Initially well has been shut-in for a long time then pump is started at a constant rate and pressure is monitored for a long time.

Well Test Objectives

- Reservoir Pressure
- Permeability
- Skin Factor
- PI or Flow Efficiency

Buildup Test – Pressure and Flow Rate vs. Time





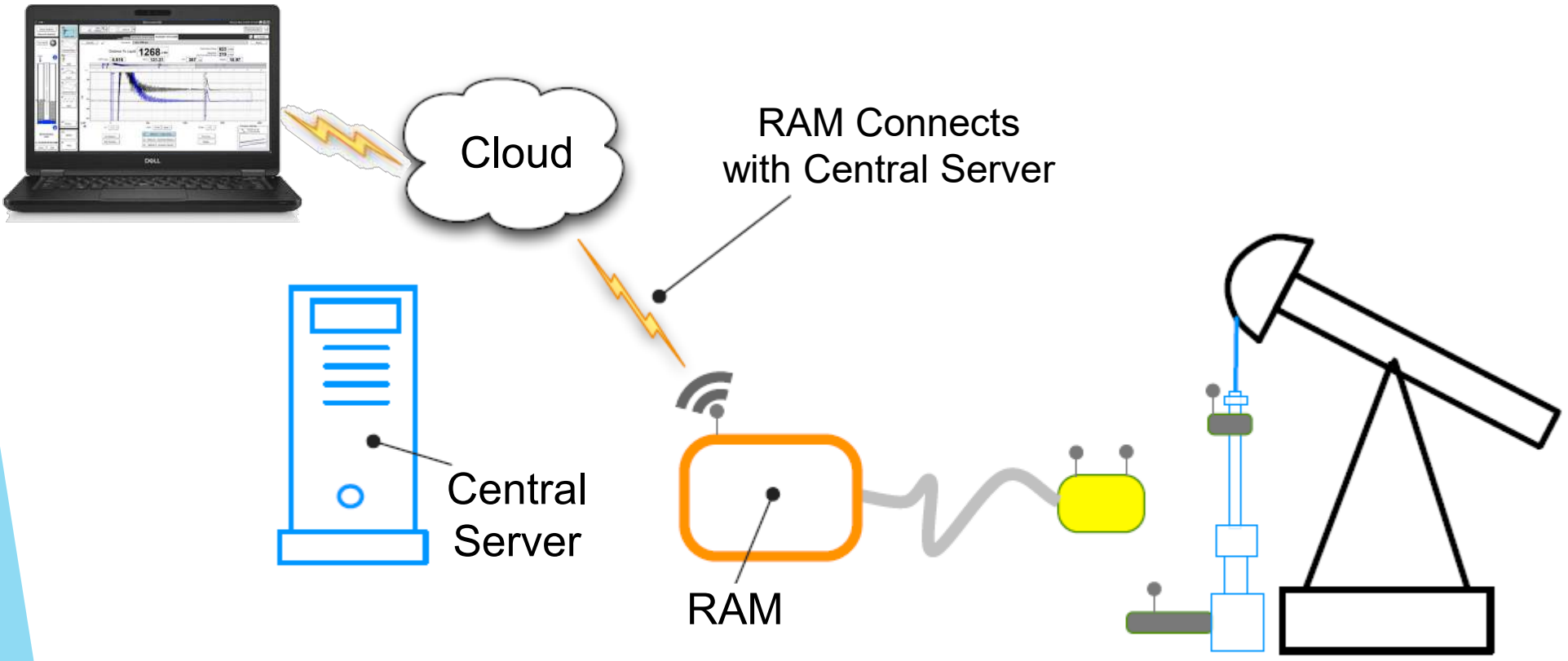
Advantages of Acoustic Buildup Pressure Measurements

- No need to pull rods & pump
  - Less cost
  - Better early time data
- Data viewed in real time
  - Ensures test objectives met
  - Well returned to production ASAP
- No downhole tools
  - Able to test highly deviated wells
  - No potential fishing

Remote Asset Monitor

- The RAM system, shown schematically in the next slide, has several objectives for improved analysis and optimization of flowing and artificial lift wells:
  - Automatically acquire data without user intervention.
  - Monitor individual well performance trends over extended periods of time.
  - Provide remote access to test equipment deployed in the field.
  - Monitor acquired data remotely and download it to user's computer.
  - Manual Data Acquisition override.
  - Increase productivity and safety of field personnel by reducing travel requirements.
- These objectives are satisfied by using a programmable system for stand-alone wireless data acquisition and communication via the Internet.

Remote Asset Monitor



RAM: When Configured With Cloud Server
- Logs into Server via cellular network
- Heart Beat, Beams up Vitals
- Uploads Acquired Data
- Looks For Request Of Direct Control From Remote TAM Session
- Provides Pass Through For "Near" Realtime Data Acquisition

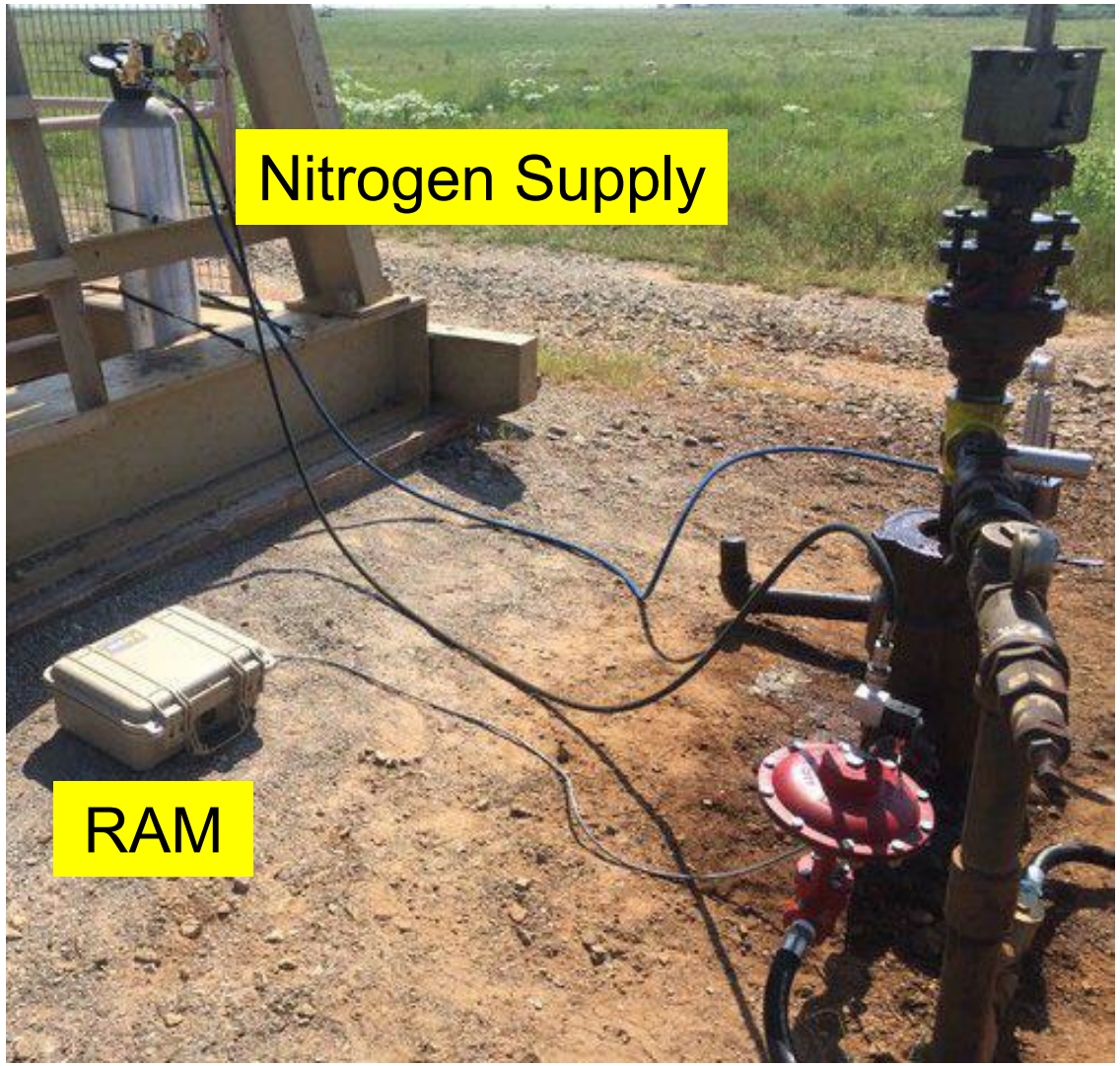
1) RAM and sensors are installed at the well
2) RAM is connected to Cloud via Cellular network
3) User connects to RAM via Cloud
4) User Acquires fluid level and dynamometer data remotely
5) User downloads measurement schedule to RAM
6) Schedule is activated and automatic measurements begin.
7) User logs out
8) At later time user logs in retrieves data and/or modifies schedule

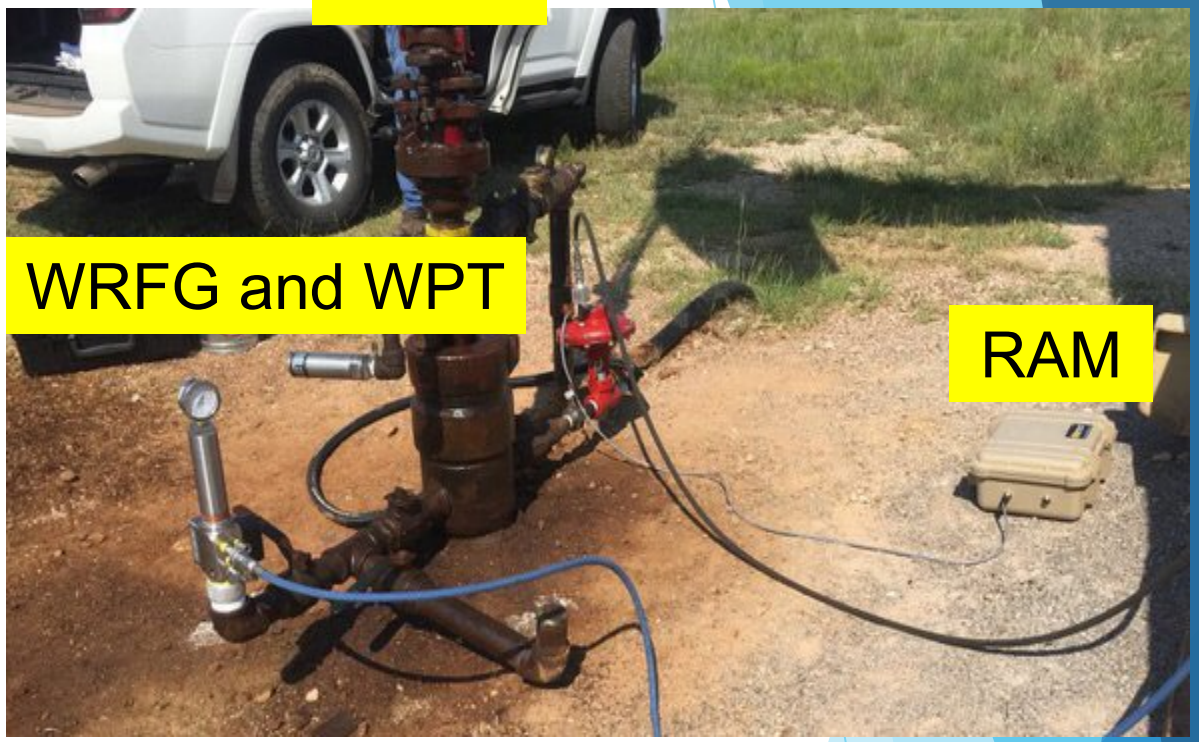
Pressure Transient Test Setup

Artificial Lift R&D Council

- **HARDWARE**
- RAM
- Wireless Acoustic Remote Fired Gun with pressure sensor
- Nitrogen Supply with Pressure regulator
- External Power Supply
- **TEAMWORK**
- Verify team knows test will be conducted
- Make sure no one will operate well during test
- Lock Out / Tag Out
- **WELL CONDITION**
- Inspect well prior to start of pressure transient test
- Run dynamometer and determine liquid level prior to pt test
- Verify well is stabilized
- Verify stuffing box will handle additional pressure
- Eliminate leaks

RAM Set Up

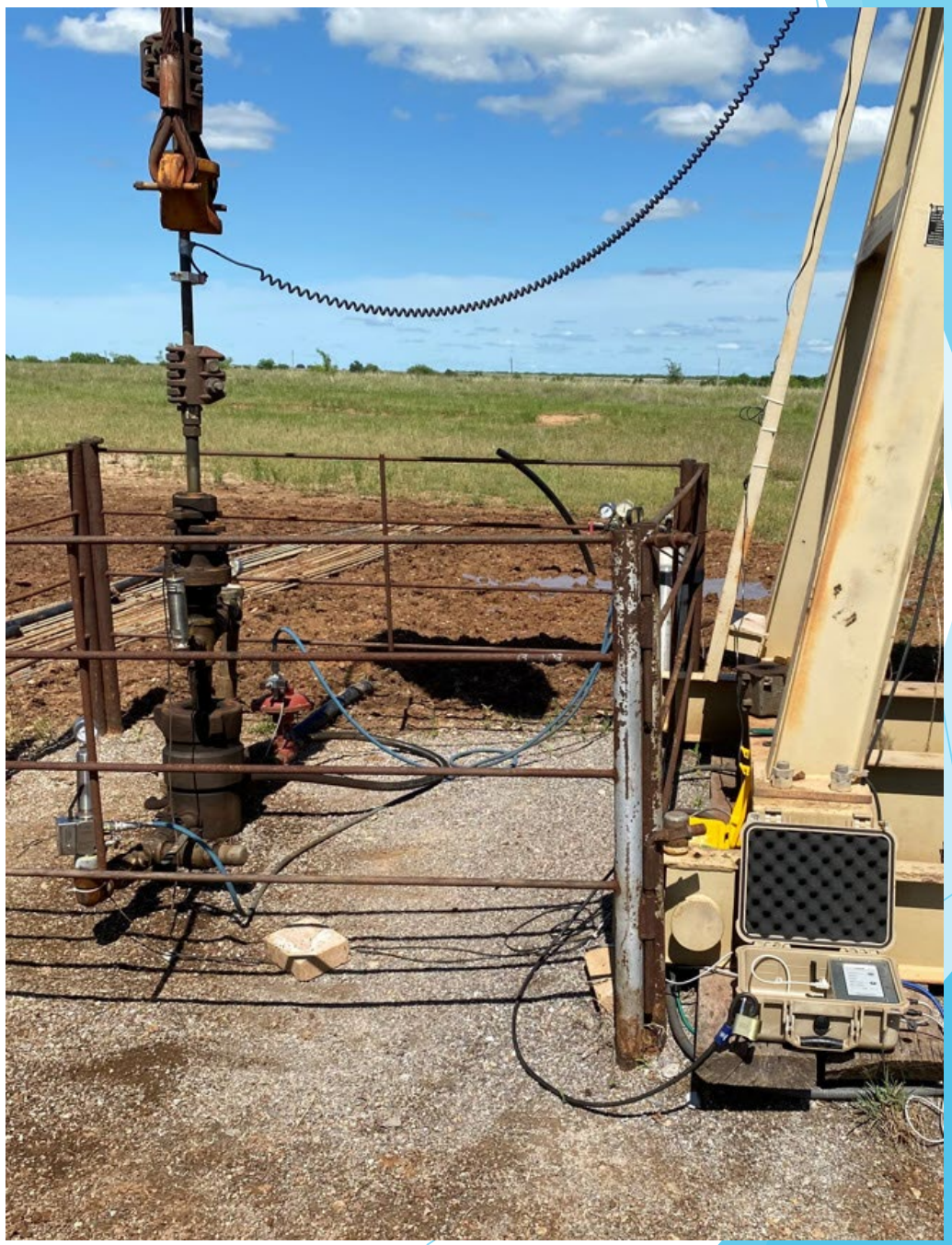




Field Installation for Scheduled Stand Alone or Remote Acquisition of Fluid Level Records and Dynamometer and Tubing Pressure Data

RAM installation for Buildup Pressure Test

- Verify no Leaks
- O-Rings Should be in Good Condition and Lubricated
- Mount Gun Vertically to Prevent Freezing
- Check for good wireless signals



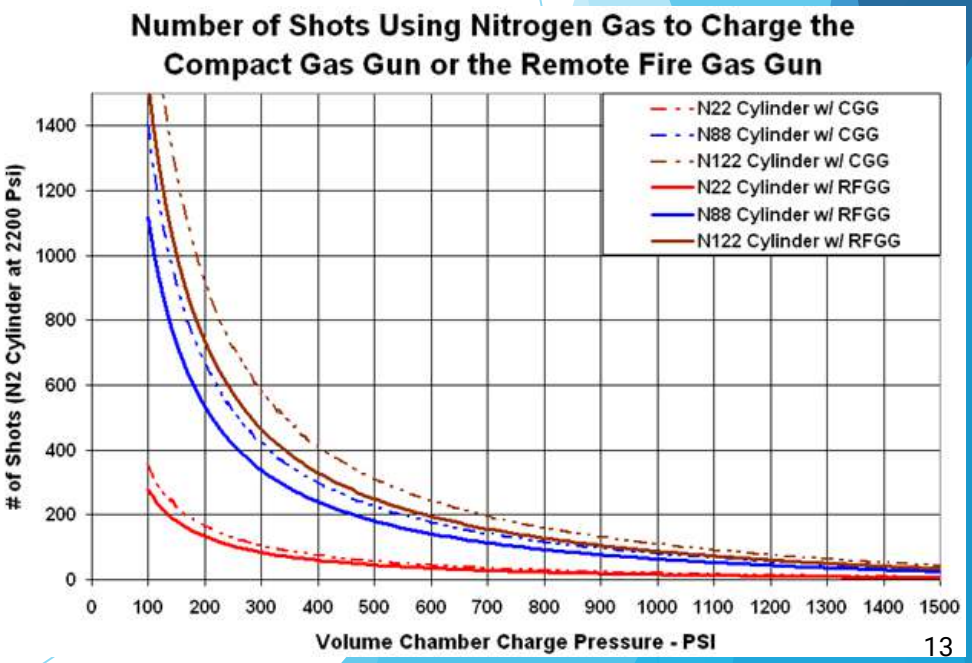
Artificial Lift R&D Council

RAM Controls

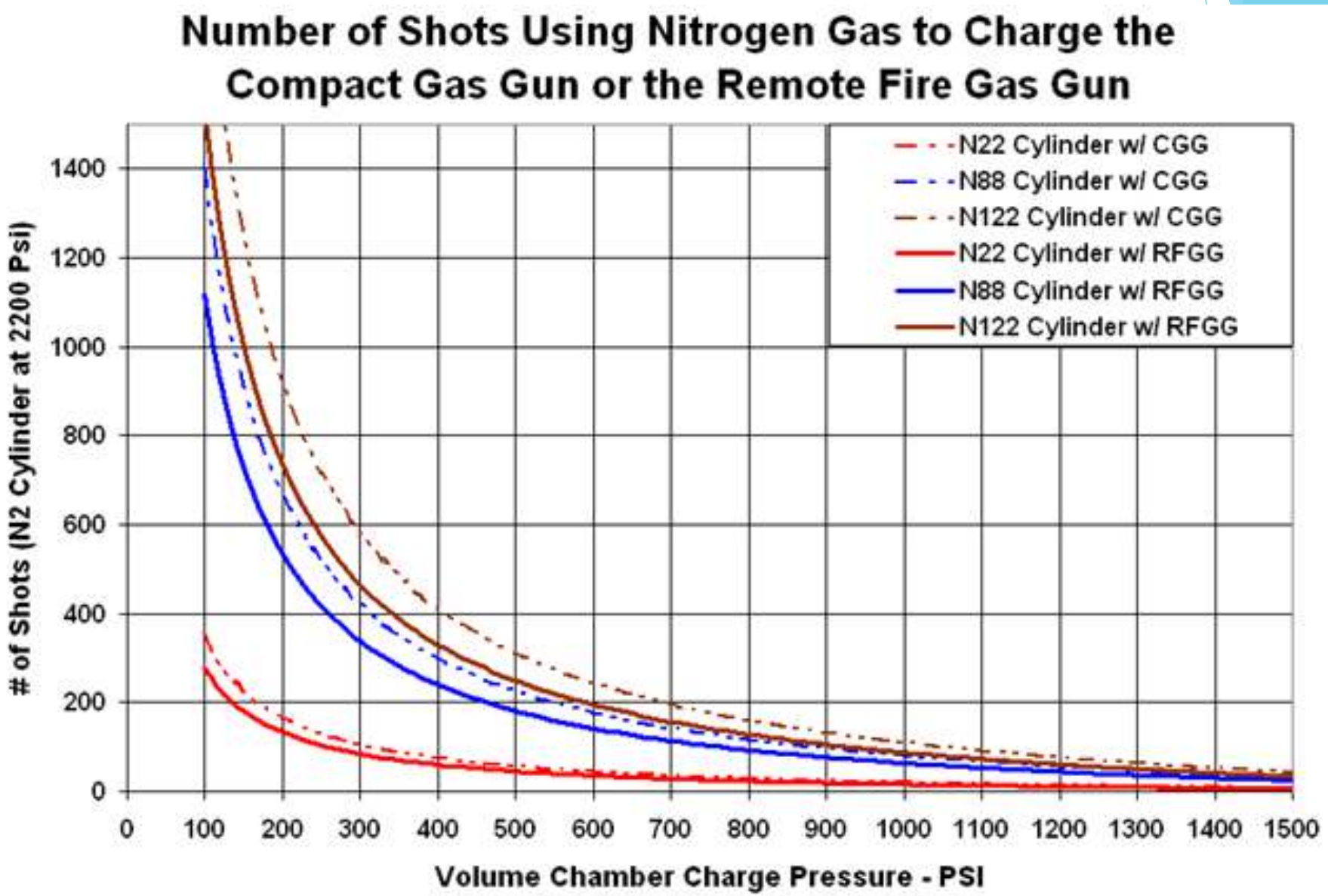
- RAM with Wireless Base

External Power and N2 Gas Supply

- Deep cycle battery for RAM and sensors
- Nitrogen recommended



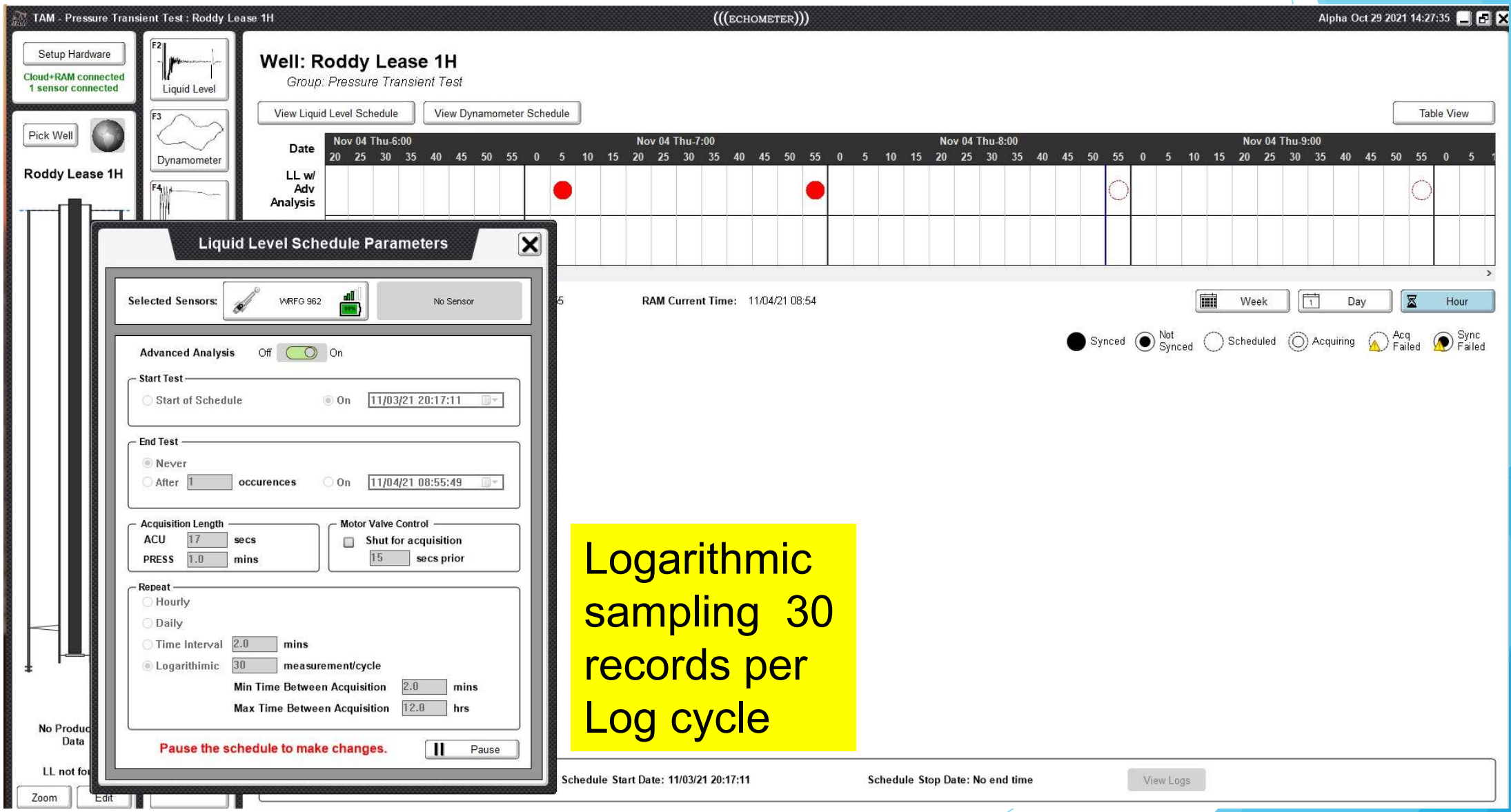
External Power and N2 Gas Supply



Software Setup

- At field site
- Open TAM
- Verify well data is up to date.
- Connect to RAM locally.
- Check sensors are online.
- Setup Schedule of acquisitions.
- Start schedule first then stop pump and shut-in well.
- Verify schedule is running.
- Disconnect from RAM and Close TAM

Buildup Schedule Setup



Logarithmic sampling 30 records per Log cycle

Pressure Buildup Test - RTTT and Casing Pressure during 471 hours.

SESSION 11/03/2021 03:17:11PM

Adv Anlys History

Session Info

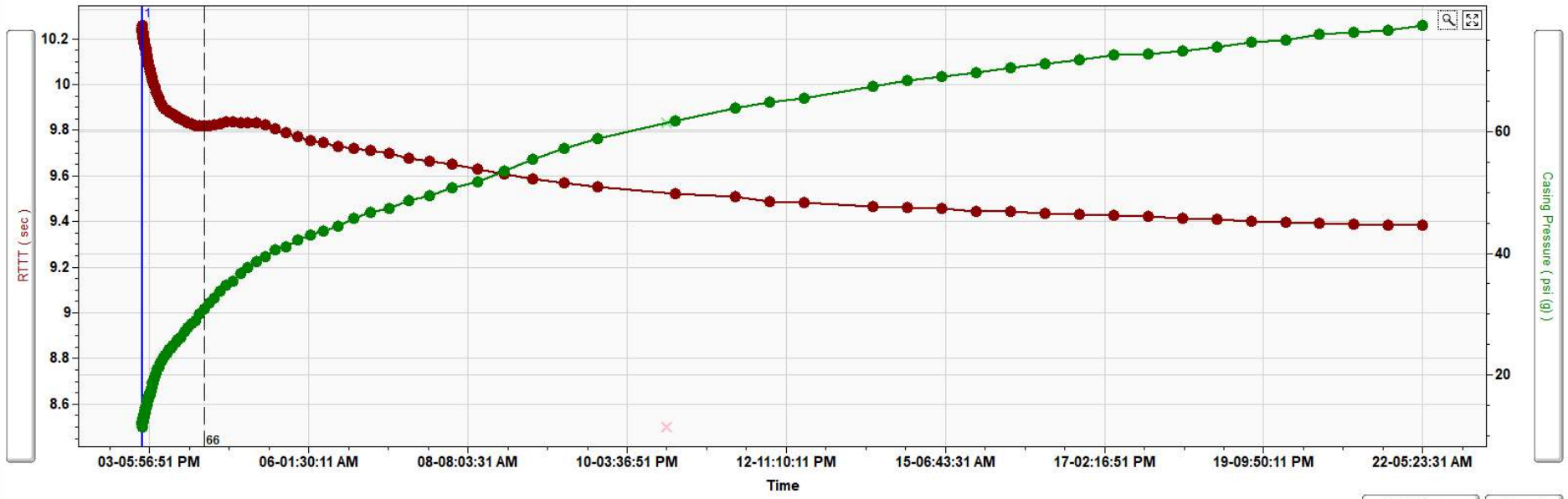
Comments: Liquid Level from downhole marker TA depth.

Report

Select Analysis Default + ×

Merge Details

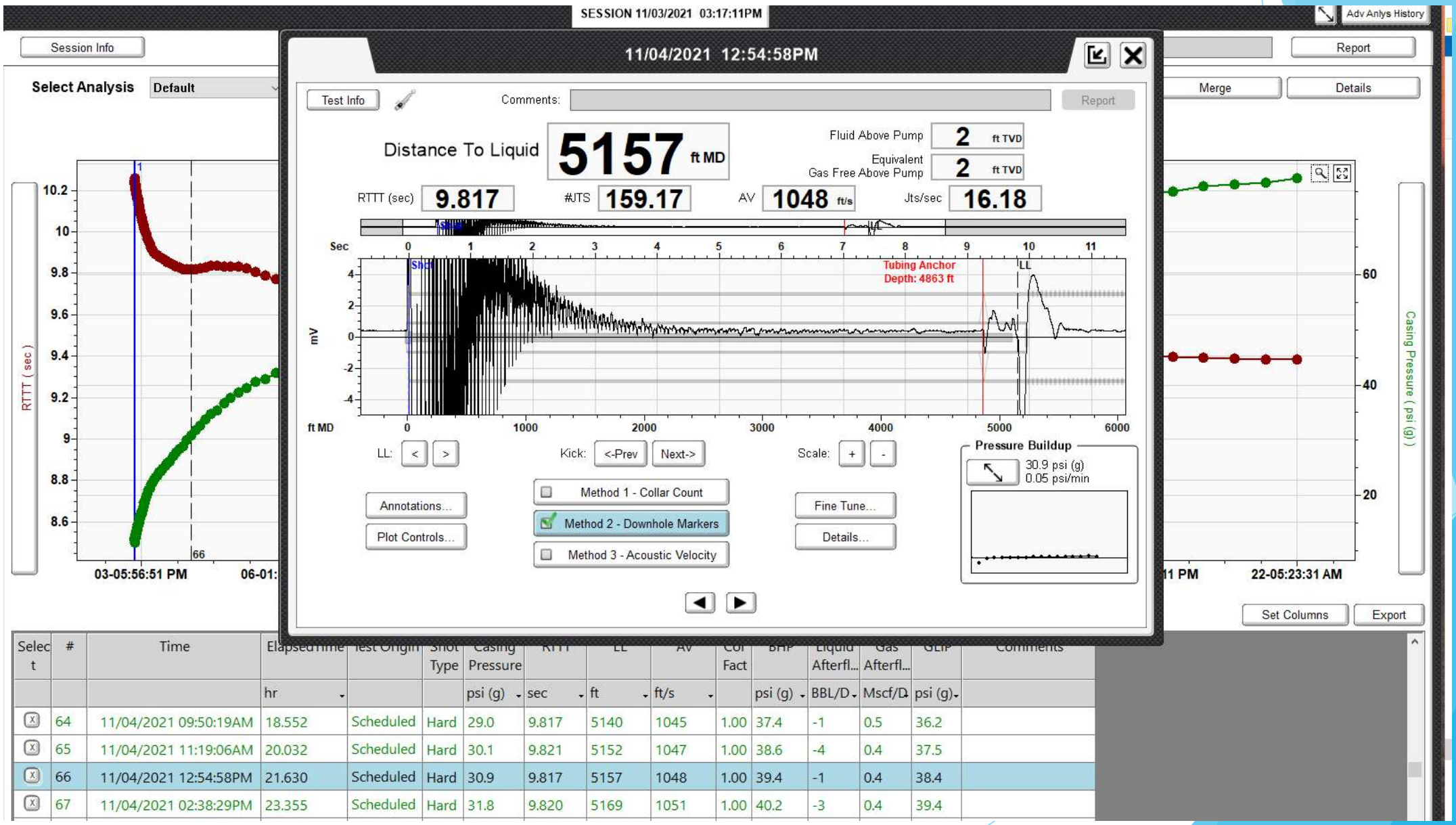
Shots | Velocity Analysis | Log-Log Plot | MDH Plot | Horner Plot



Set Columns Export

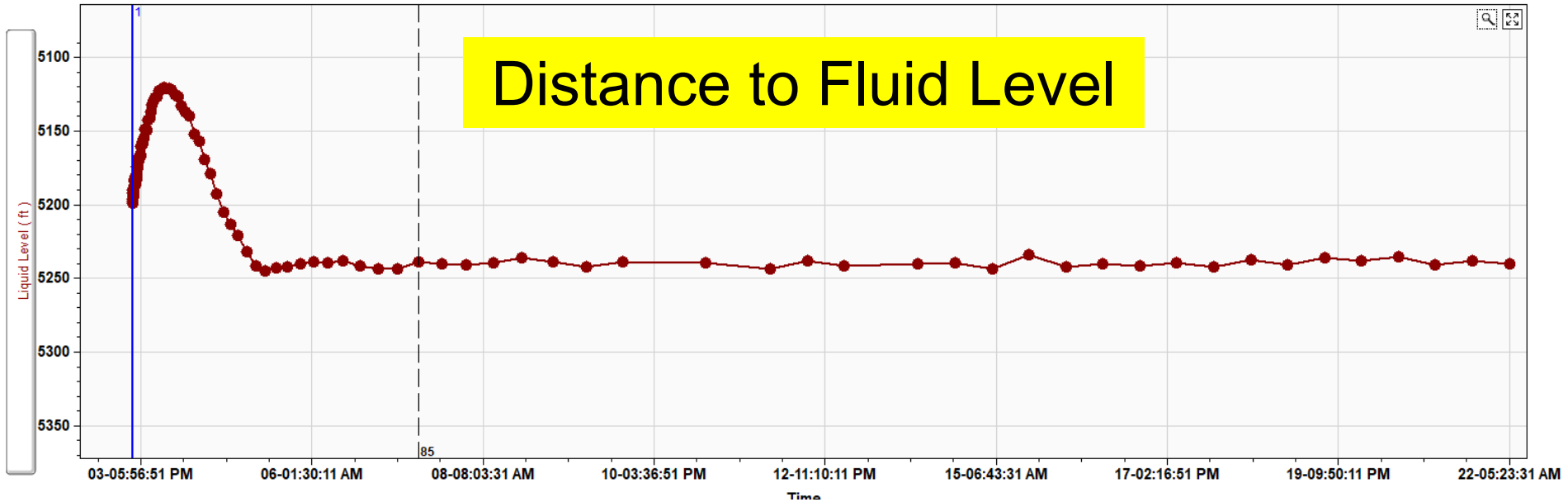
Select	#	Time	ElapsedTime	Test Origin	Shot Type	Casing Pressure	RTTT	LL	AV	Cor Fact	BHP	Liquid Afterfl...	Gas Afterfl...	GLIP	Comments
			hr			psi (g)	sec	ft	ft/s		psi (g)	BBL/D	Mscf/D	psi (g)	
☐	64	11/04/2021 09:50:19AM	18.552	Scheduled	Hard	29.0	9.817	5140	1045	1.00	37.4	-1	0.5	36.2	
☐	65	11/04/2021 11:19:06AM	20.032	Scheduled	Hard	30.1	9.821	5152	1047	1.00	38.6	-4	0.4	37.5	
☐	66	11/04/2021 12:54:58PM	21.630	Scheduled	Hard	30.9	9.817	5157	1048	1.00	39.4	-1	0.4	38.4	
☐	67	11/04/2021 02:38:29PM	23.355	Scheduled	Hard	31.8	9.820	5169	1051	1.00	40.2	-3	0.4	39.4	
☐	68	11/04/2021 04:30:16PM	25.218	Scheduled	Hard	32.6	9.822	5179	1052	1.00	41.1	-2	0.4	40.4	
☐	69	11/04/2021 06:30:58PM	27.230	Scheduled	Hard	33.8	9.826	5193	1055	1.00	42.2	-3	0.4	41.7	

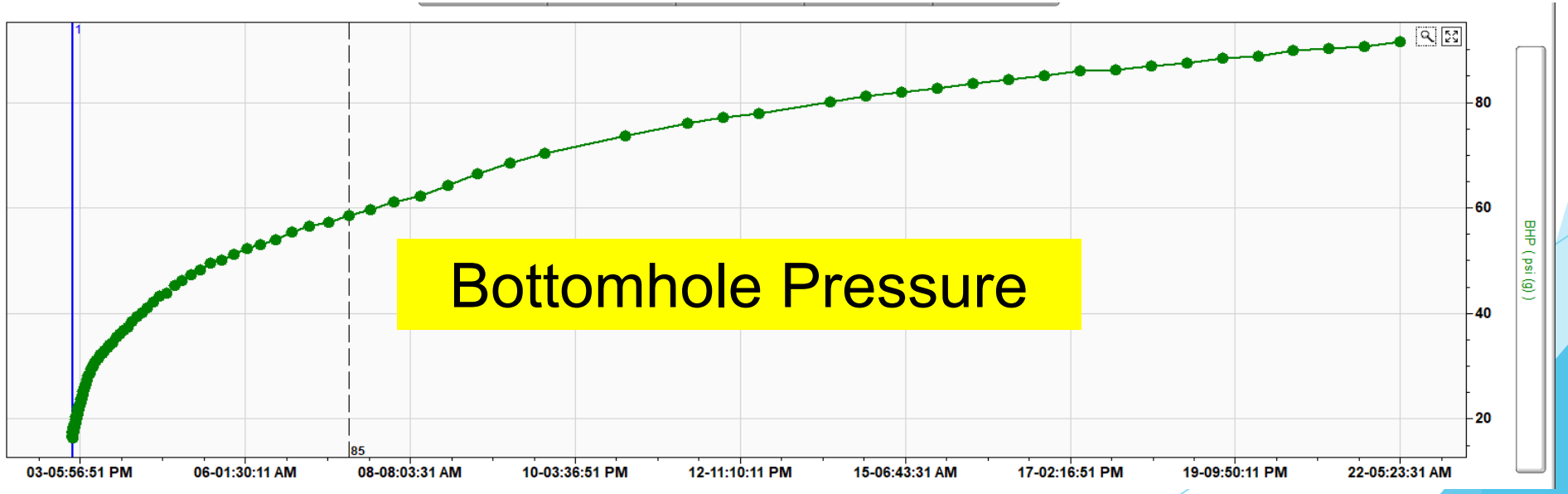
Typical Acoustic Record



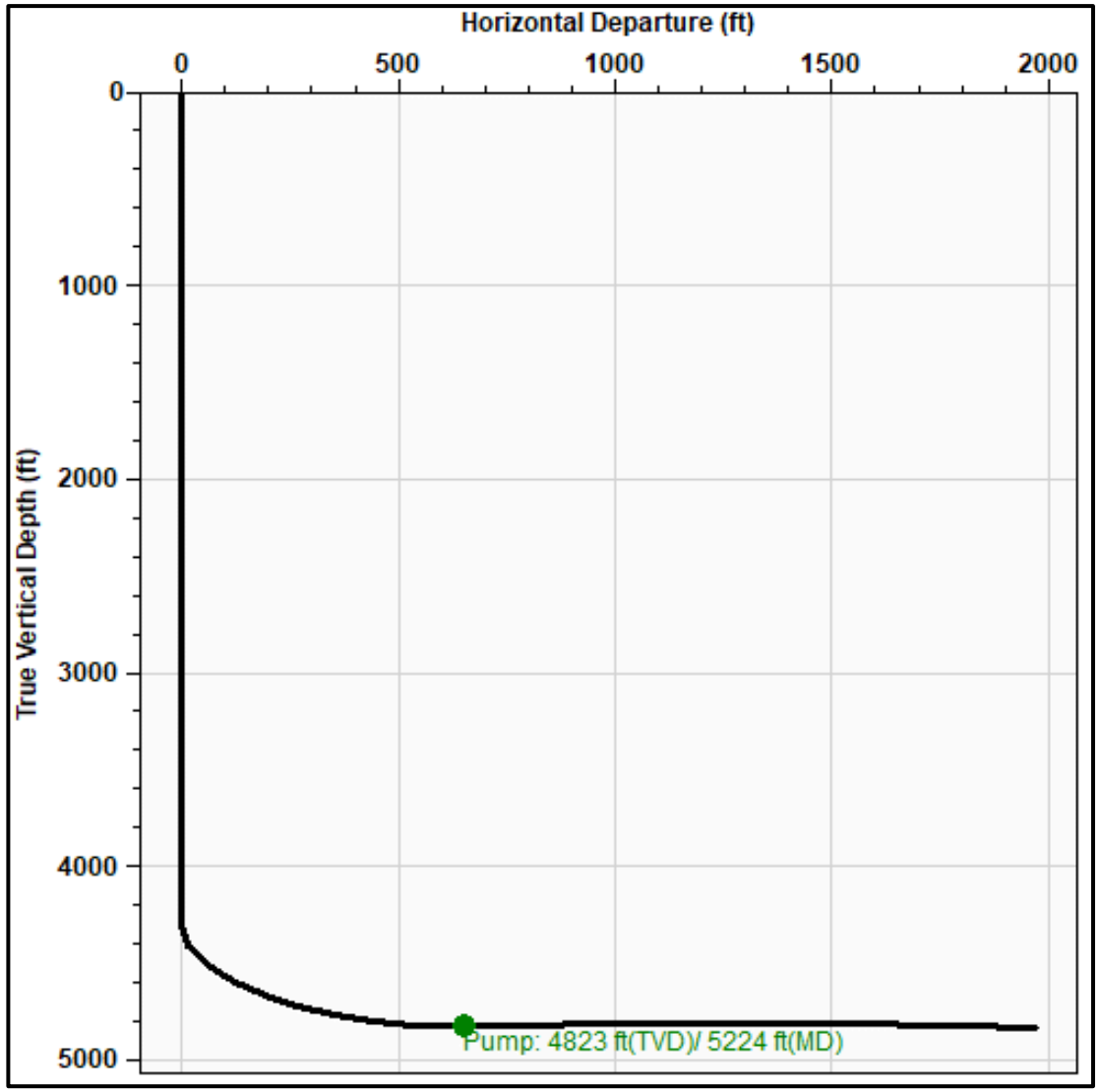
Select	#	Time	Elapsed Time	Test Origin	Shot Type	Casing Pressure	RTTT	LL	AV	Coil Fact	BHP	Liquid Afterfl...	Gas Afterfl...	GLIP	Comments
			hr			psi (g)	sec	ft	ft/s		psi (g)	BBL/D	Mscf/D	psi (g)	
X	64	11/04/2021 09:50:19AM	18.552	Scheduled	Hard	29.0	9.817	5140	1045	1.00	37.4	-1	0.5	36.2	
X	65	11/04/2021 11:19:06AM	20.032	Scheduled	Hard	30.1	9.821	5152	1047	1.00	38.6	-4	0.4	37.5	
X	66	11/04/2021 12:54:58PM	21.630	Scheduled	Hard	30.9	9.817	5157	1048	1.00	39.4	-1	0.4	38.4	
X	67	11/04/2021 02:38:29PM	23.355	Scheduled	Hard	31.8	9.820	5169	1051	1.00	40.2	-3	0.4	39.4	

Liquid Level and BHP during Buildup Test



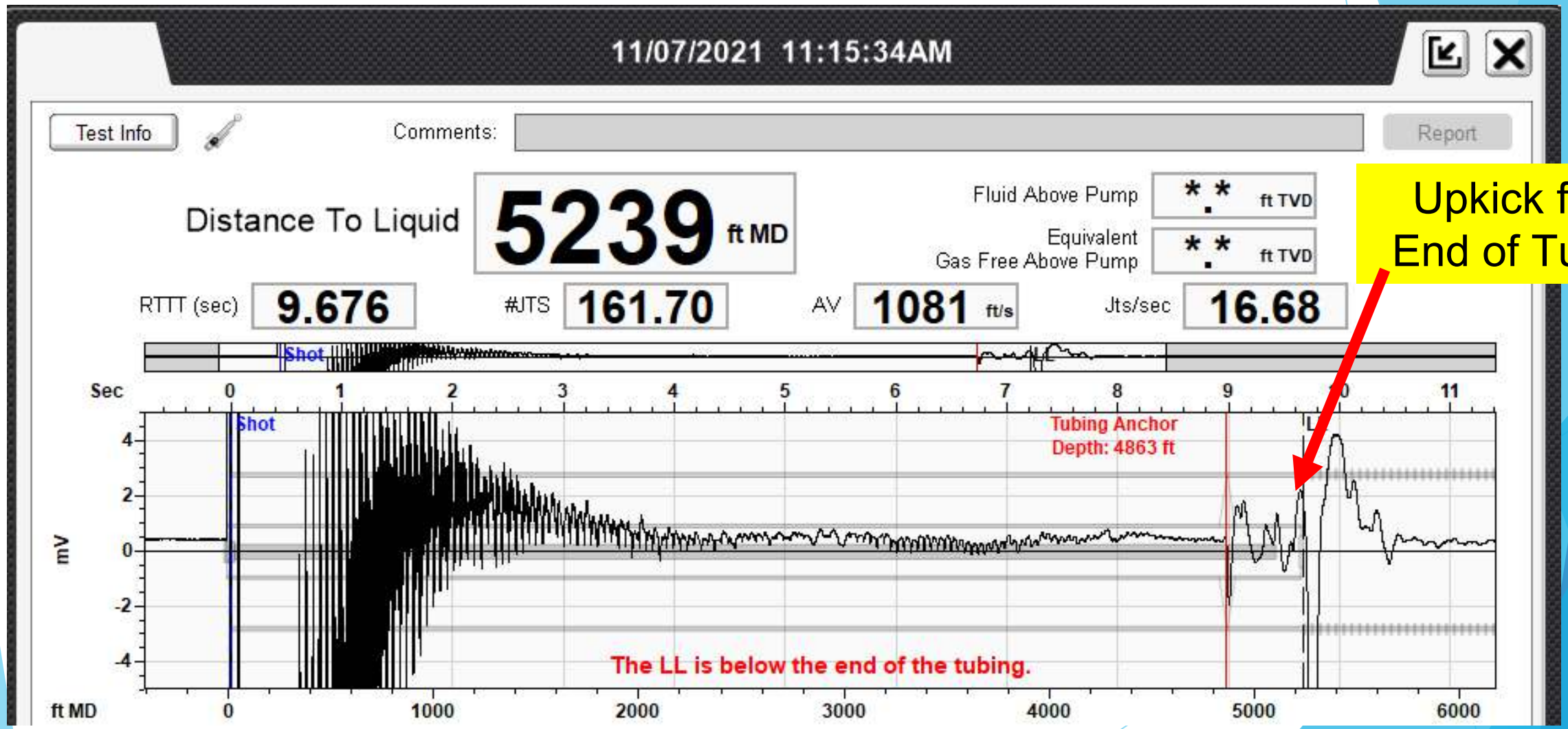


Pump set in Horizontal



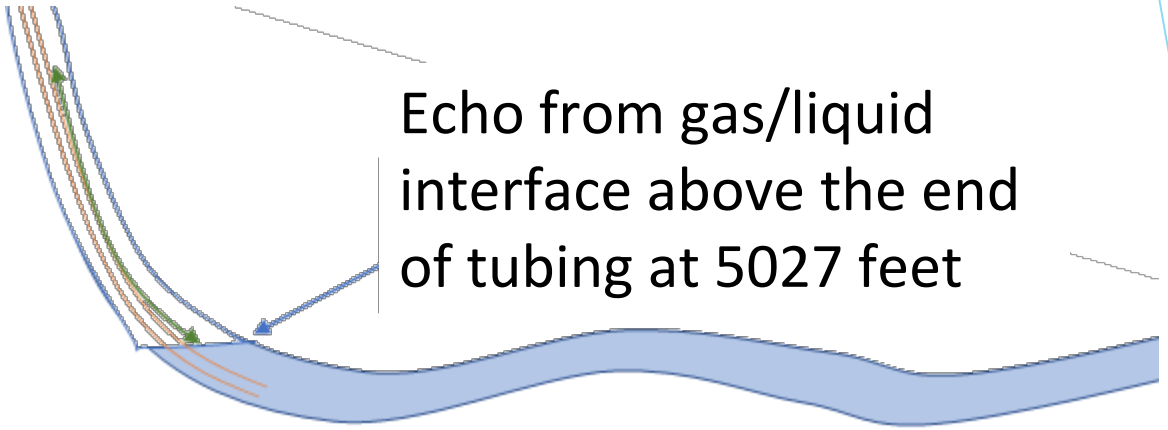
During Buildup test as the casing pressure increases due to gas after-flow the liquid in the annulus may be depressed past the end of the tubing.

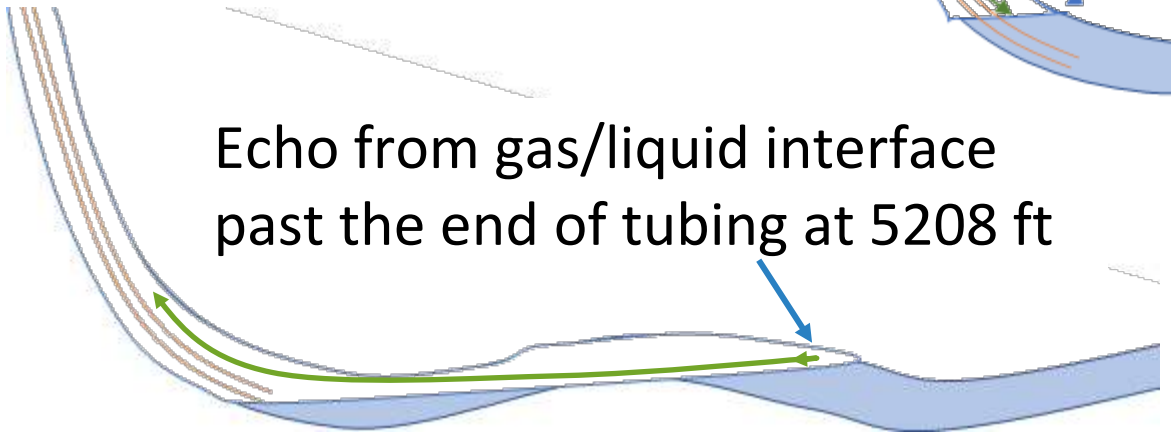
Liquid Level Past End of Tubing – Record #85



Upkick from End of Tubing

Echoes in Horizontal Completions





Undulations in the “horizontal” wellbore leave low spots where liquid accumulates at bottom and gas pockets at top.

As the liquid is pushed down, by the increasing casing pressure, past the end of the tubing there is a path for the sound wave to travel to the next gas/liquid interface and generate a significant echo

Formation and Fluid Properties for Analysis of Transient Test

Producing Intervals

#	Top MD	Bottom ...	Name	Type	Oil Pres...	Water P...	Gas Pro...
	ft	ft					
1	5240	6532		Perforat...	Yes	Yes	Yes
2							
3							
4							
5							
6							
7							

Formation Volume Factors

Oil	1.190	RB/STB
Water	1.020	RB/STB
Gas	0.010	RB/Mscf

Zone

Net Pay	34.00	ft
Wellbore Radius	0.33	ft
Drainage Area	10.00	acre

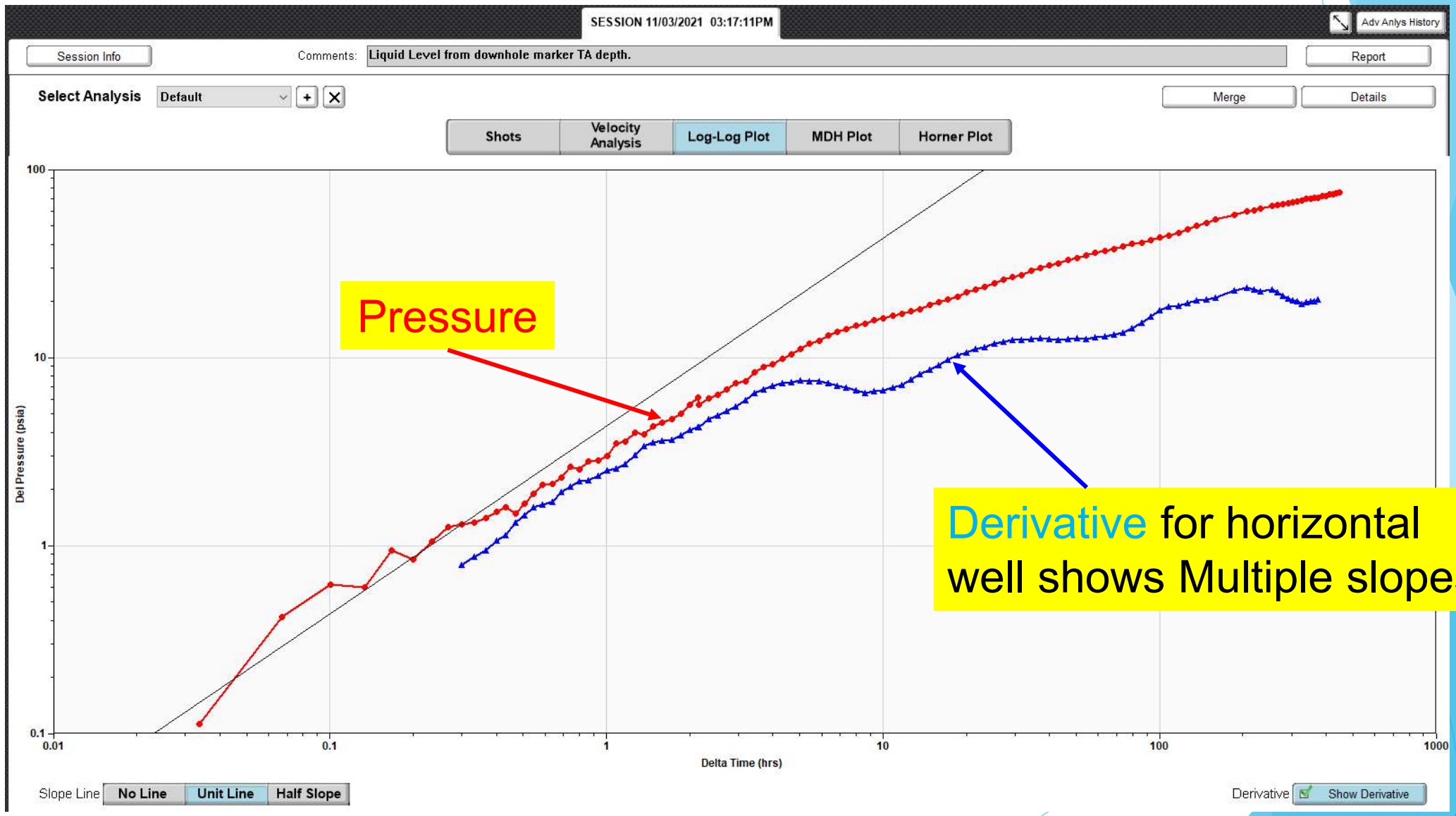
Viscosities

Oil	1.020	cp
Water	0.555	cp
Gas	0.014	cp

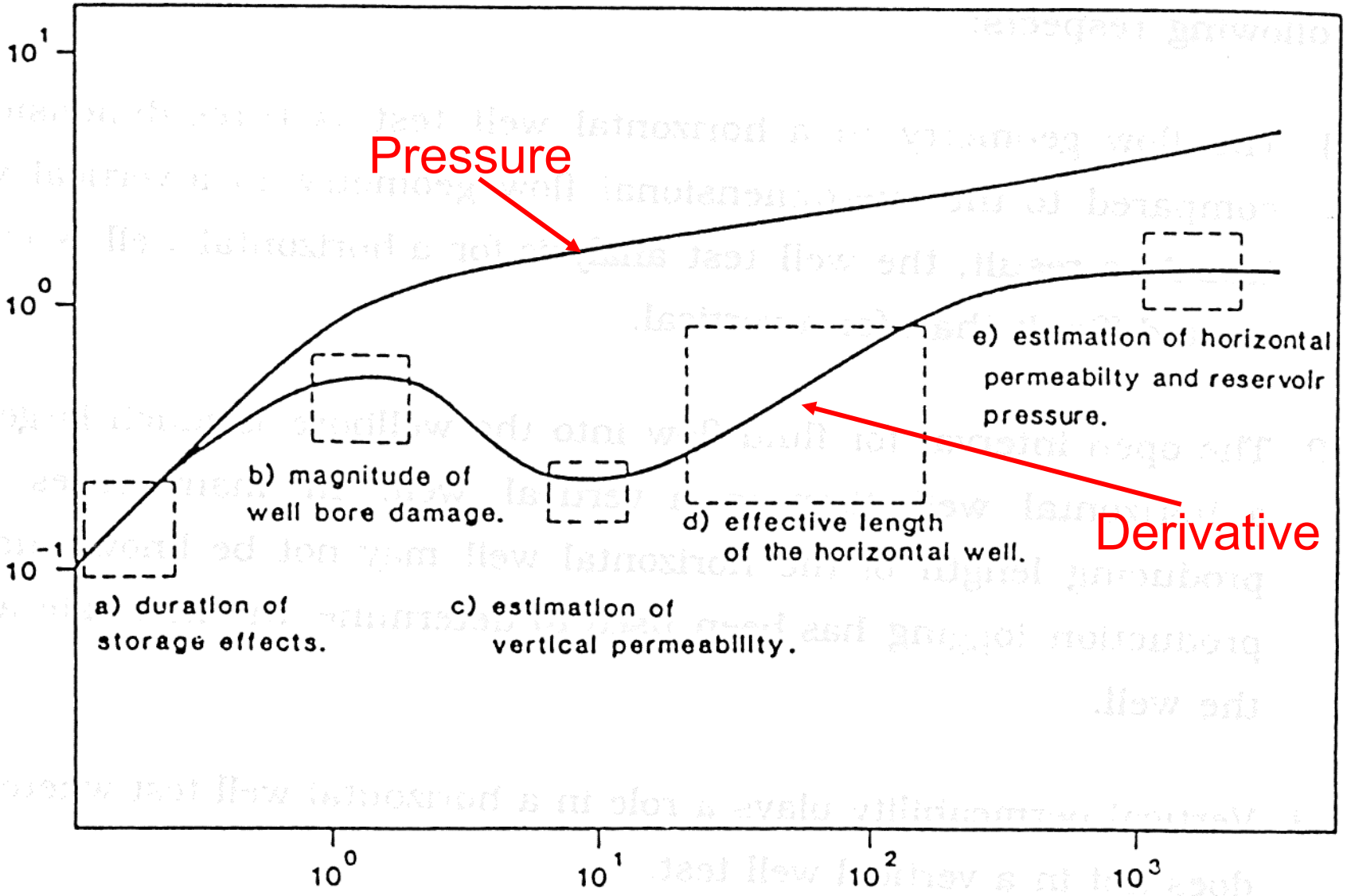
Reservoir Properties

Porosity	0.20	fraction
Total Compressibility	3.00E-05	1/psi

Log P vs Log dt

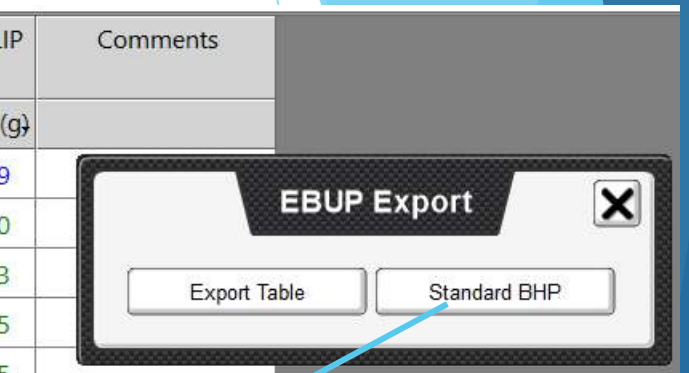


Horizontal Well Pressure Response

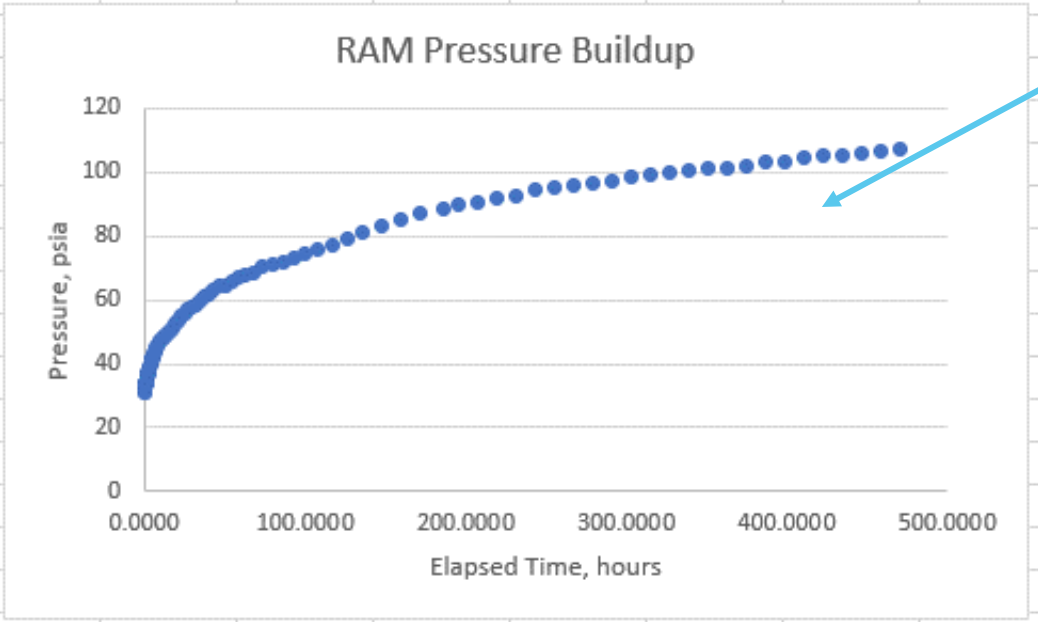


Data Exported to Spreadsheet for Input to Specialized Transient Analysis Software

Select	#	Time	Elapsed Time	Test Origin	Shot Type	Casing Pressure	RTTT	LL	AV	Cor Fact	BHP	Liquid Afterflow	Gas Afterflow	GLIP	Comments
			hr			psi (g)	sec	ft	ft/s		psi (g)	BBL/D	Mscf/D	psi (g)	
	1	11/03/2021 03:17:11PM	0.000	Scheduled	Hard	11.5	10.259	5198	1011	0.84	16.4	0	4.0	15.9	
	2	11/03/2021 03:19:12PM	0.034	Scheduled	Hard	11.5	10.247	5192	1011	0.85	16.5	695	3.8	16.0	
	3	11/03/2021 03:21:12PM	0.067	Scheduled	Hard	11.8	10.250	5196	1012	0.94	16.9	19	1.4	16.3	
	4	11/03/2021 03:23:12PM	0.100	Scheduled	Hard	11.9	10.241	5190	1011	0.86	17.0	18	3.5	16.5	
	5	11/03/2021 03:25:12PM	0.134	Scheduled	Hard	12.0	10.240	5199	1013	0.84	17.0	-137	3.9	16.5	



Elapsed Time	BHP
hrs	psi-a
0.0000	31.1453
0.0340	31.2226
0.0670	31.5859
0.1000	31.7341
0.1340	31.706
0.1670	32.0597
0.2000	31.9518
0.2340	32.1833
0.2670	32.3669
0.3000	32.4065
0.3340	32.4554
0.3670	32.52
0.4000	32.6316
0.4340	32.7166
0.4680	32.5984
0.5050	32.7729



Pumping Down the Well after Buildup Test

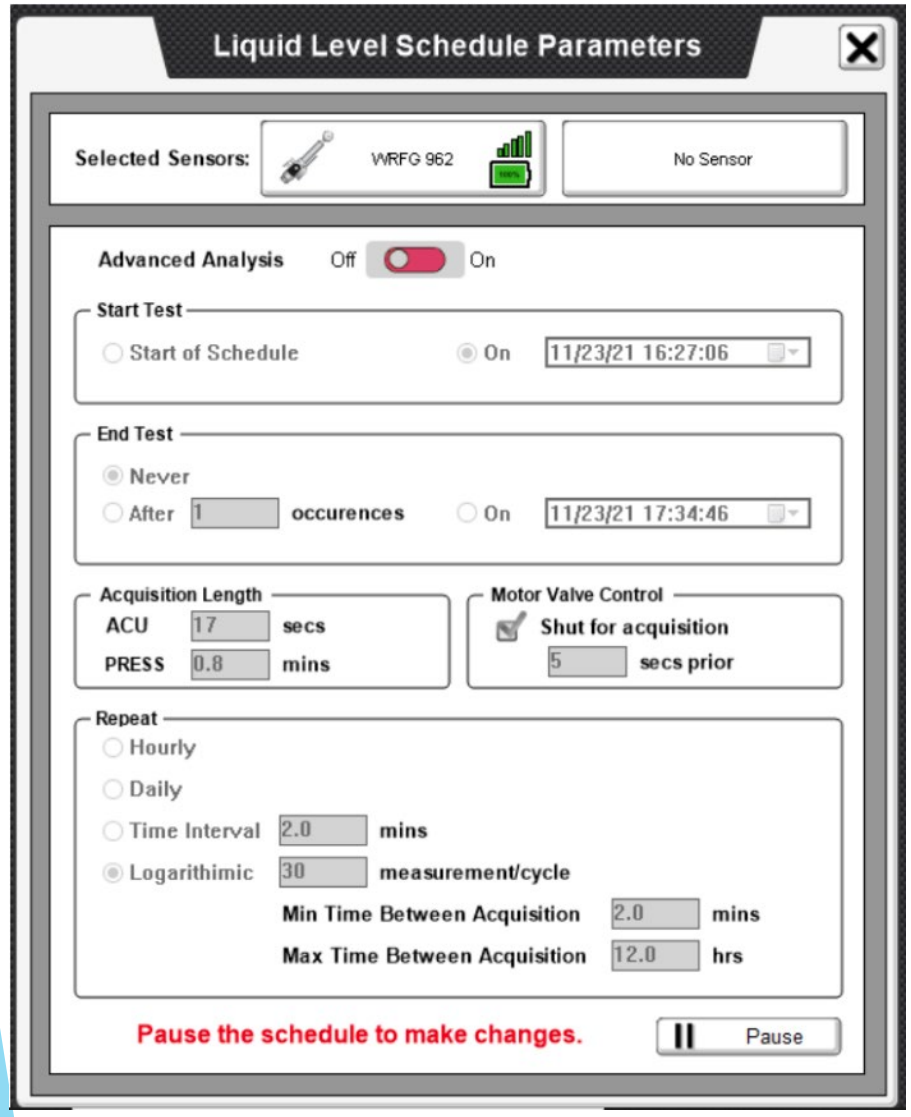
- SEQUENCE OF OPERATIONS

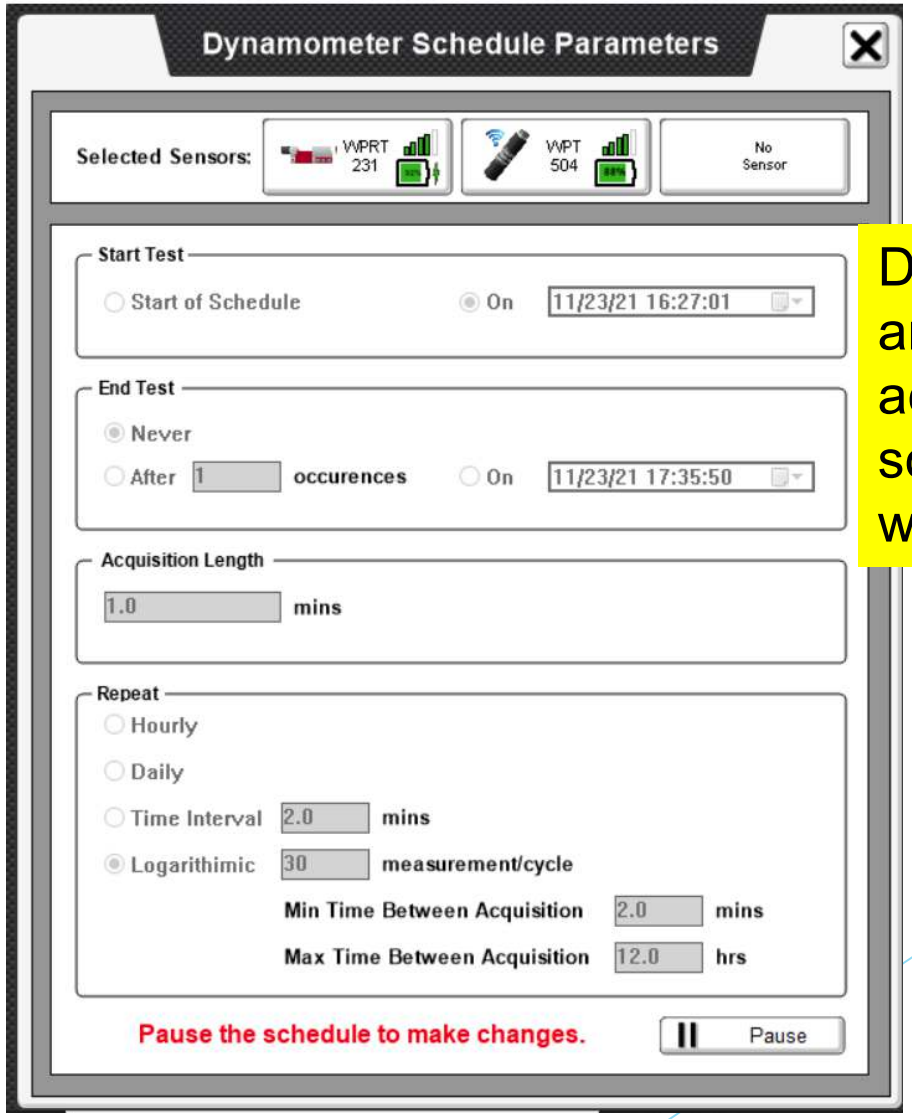
1. Bleed Casing Pressure to normal operating pressure.
2. Acquire periodically fluid level records until casing pressure stabilizes.
3. Install Wireless Polished Rod sensor for dynamometer measurements.
4. Start pump and acquire manual dynamometer record.
5. Setup schedule to acquire fluid level and dynamometer records as the well pumps down.
6. Remotely monitor progress of pump down by downloading accumulated data.
7. Stop schedule once production has stabilized.

De-pressuring Casing

The fluid level increased from 5260 feet to 4971 feet MD as the casing pressure was bled down from 78.41 psi to 42.3 psi.

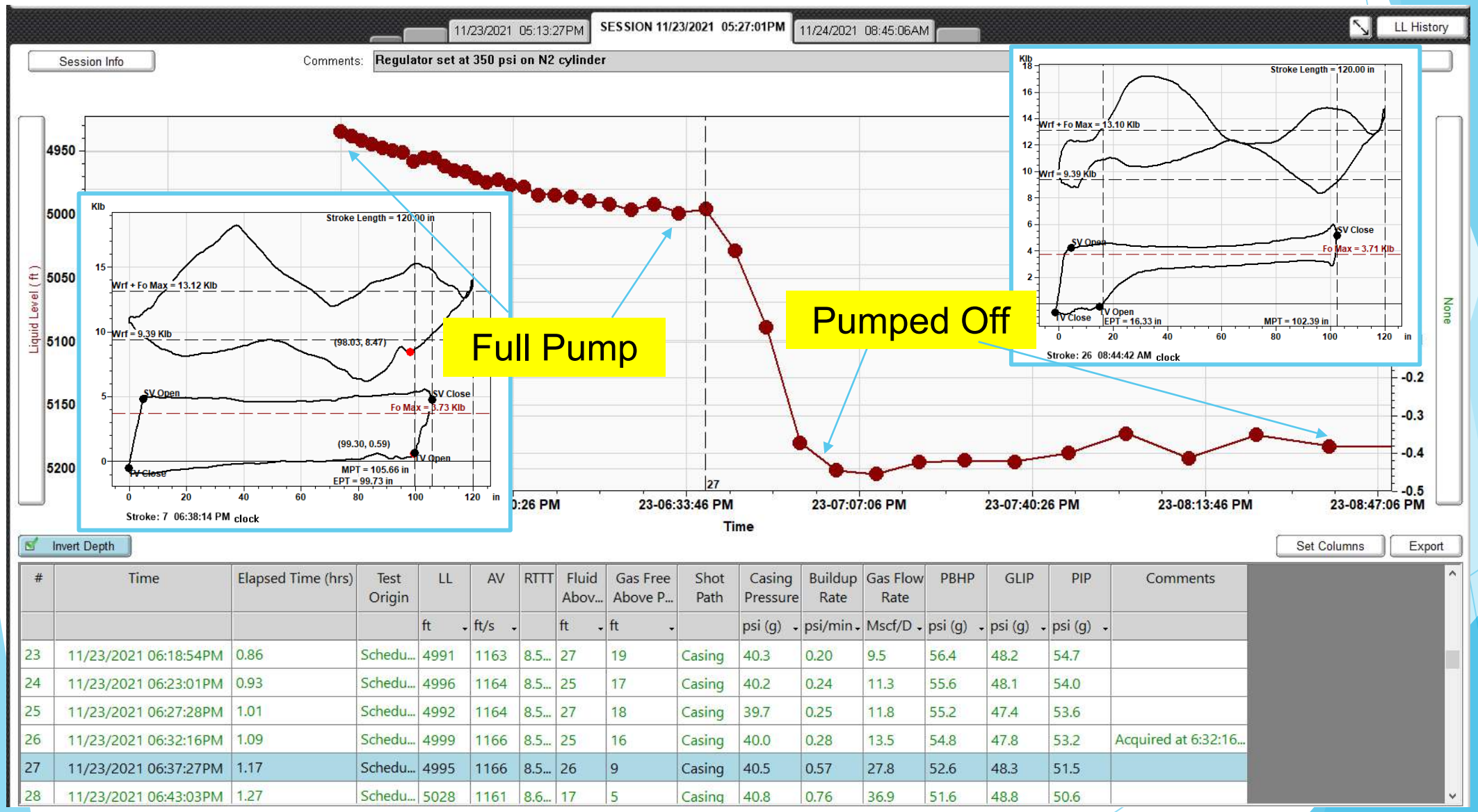
Pump Down RAM Schedules





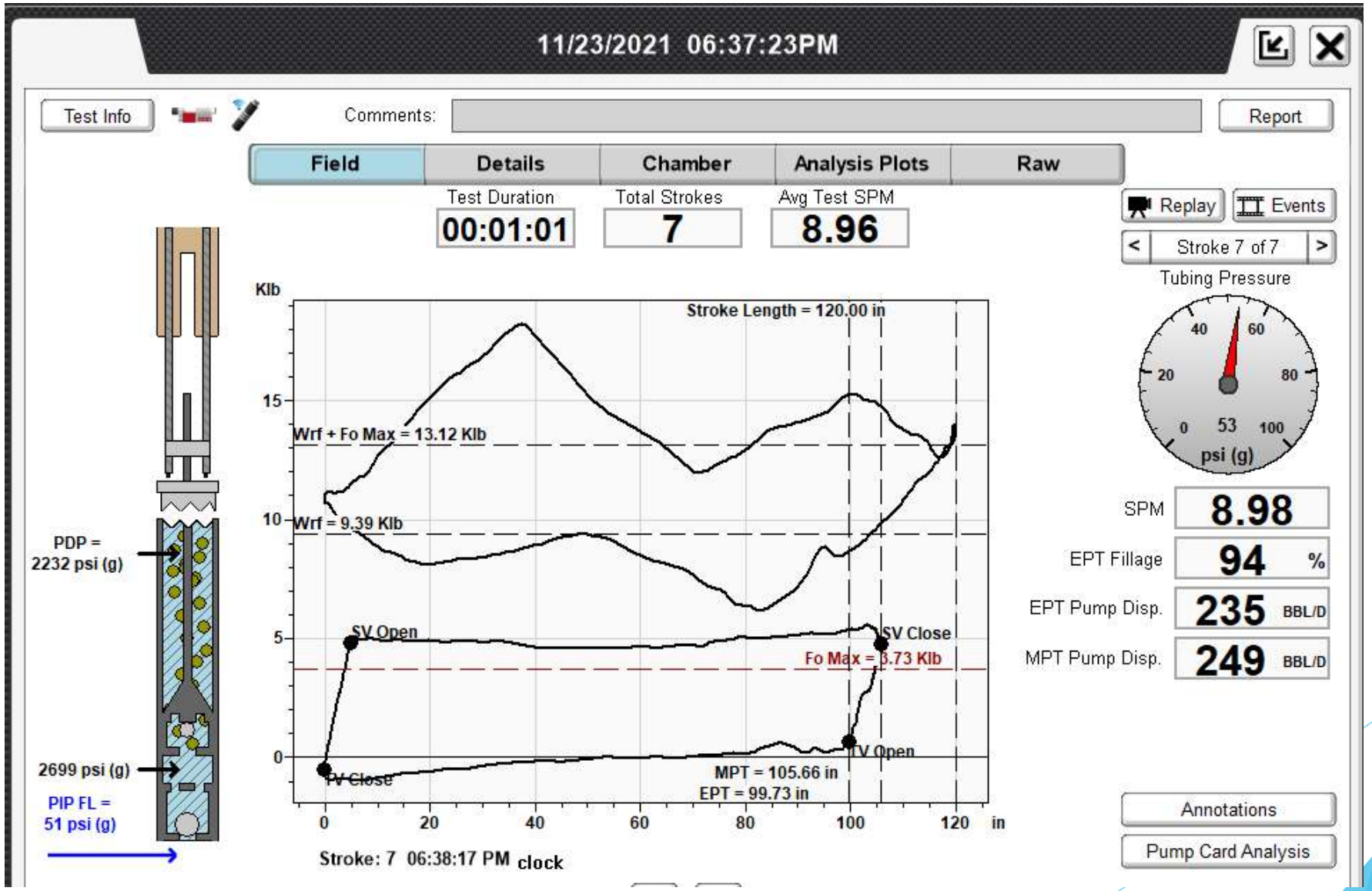
Dynamometer records and Fluid Level records acquired at same scheduled times while well was pumping down.

Liquid level while pumping down

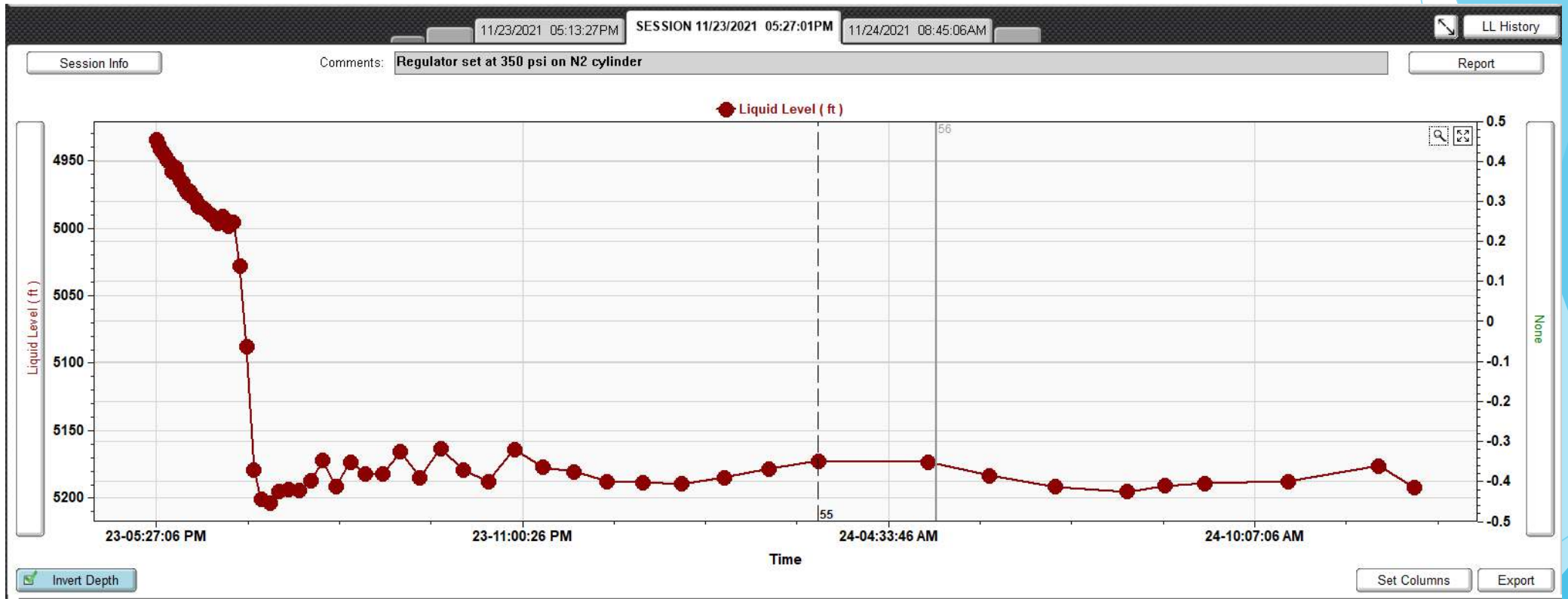


#	Time	Elapsed Time (hrs)	Test Origin	LL	AV	RTTT	Fluid Abov...	Gas Free Above P...	Shot Path	Casing Pressure	Buildup Rate	Gas Flow Rate	PBHP	GLIP	PIP	Comments
				ft	ft/s		ft	ft		psi (g)	psi/min	Mscf/D	psi (g)	psi (g)	psi (g)	
23	11/23/2021 06:18:54PM	0.86	Schedu...	4991	1163	8.5...	27	19	Casing	40.3	0.20	9.5	56.4	48.2	54.7	
24	11/23/2021 06:23:01PM	0.93	Schedu...	4996	1164	8.5...	25	17	Casing	40.2	0.24	11.3	55.6	48.1	54.0	
25	11/23/2021 06:27:28PM	1.01	Schedu...	4992	1164	8.5...	27	18	Casing	39.7	0.25	11.8	55.2	47.4	53.6	
26	11/23/2021 06:32:16PM	1.09	Schedu...	4999	1166	8.5...	25	16	Casing	40.0	0.28	13.5	54.8	47.8	53.2	Acquired at 6:32:16...
27	11/23/2021 06:37:27PM	1.17	Schedu...	4995	1166	8.5...	26	9	Casing	40.5	0.57	27.8	52.6	48.3	51.5	
28	11/23/2021 06:43:03PM	1.27	Schedu...	5028	1161	8.6...	17	5	Casing	40.8	0.76	36.9	51.6	48.8	50.6	

Last Full Pump Stroke Detail



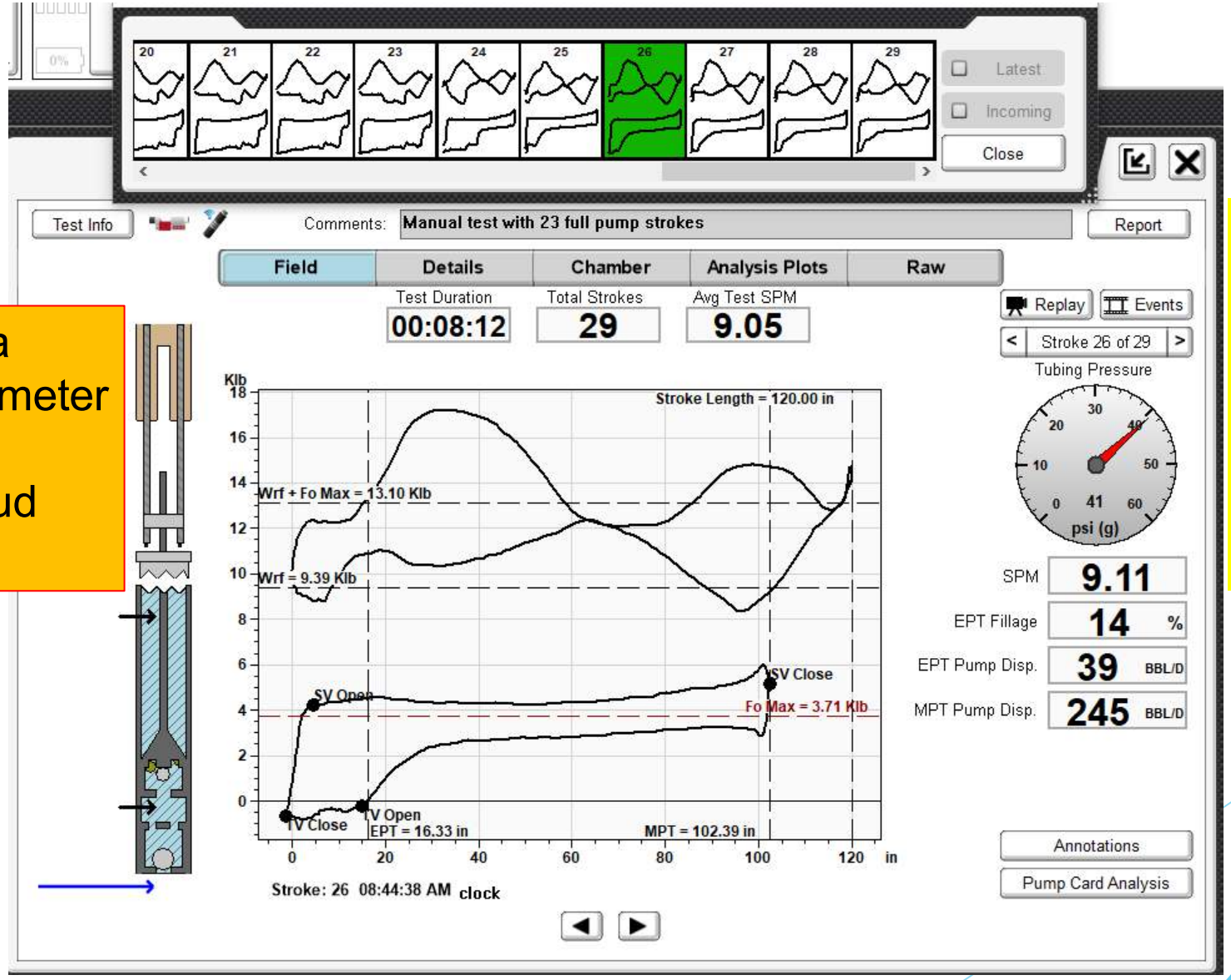
Liquid Level record from Pump-down Until Stabilization



#	Time	Elapsed Time (hrs)	Test Origin	LL	AV	RTTT	Shot Path	Casing Pressure	Buildup Rate	Gas Flow Rate	PBHP	GLIP	PIP	Comments
				ft	ft/s			psi (g)	psi/min	Mscf/D	psi (g)	psi (g)	psi (g)	
52	11/24/2021 01:25:39AM	7.98	Schedu...	5190	1109	9.340	Casing	39.1	0.21	10.1	47.8	47.3	47.3	
53	11/24/2021 02:03:49AM	8.61	Schedu...	5185	1108	9.338	Casing	39.2	0.18	8.6	48.1	47.5	47.5	
54	11/24/2021 02:45:02AM	9.30	Schedu...	5178	1106	9.340	Casing	38.7	0.21	10.2	47.5	46.9	46.9	
55	11/24/2021 03:29:32AM	10.04	Schedu...	5172	1105	9.340	Casing	38.5	0.20	9.8	47.4	46.7	46.7	

POC active after Liquid Level Pump Down

Note: This was a manual dynamometer record acquired remotely via cloud connection.

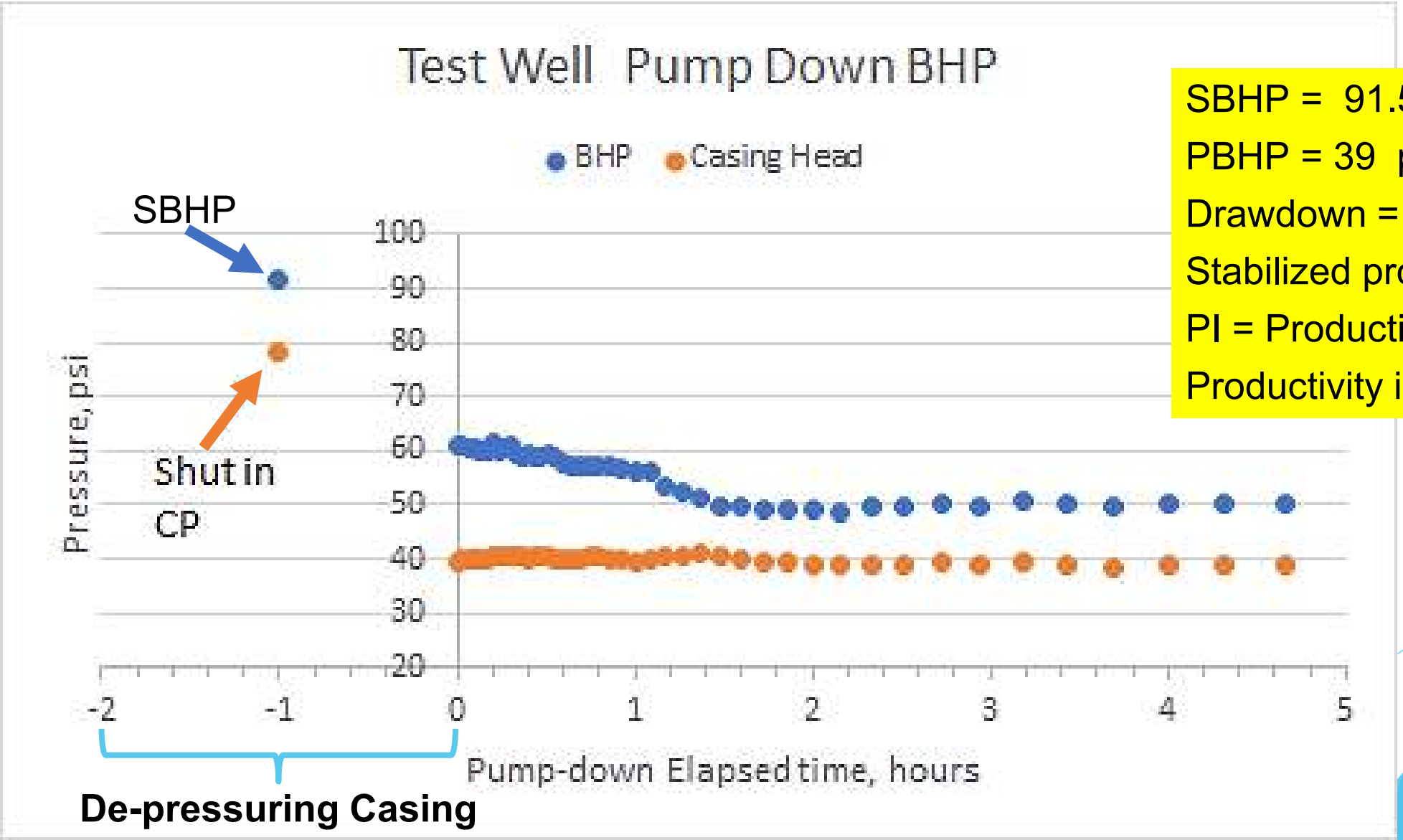


Pump Off Controller Settings

Fillage to turn OFF = 70%

Shut Down Time = 30 Minutes

BHP Drawdown and PI Estimate



SBHP = 91.5 psi

PBHP = 39 psi

Drawdown = 52.5 psi

Stabilized production = 11 BPD

PI = Production Rate/ Drawdown

Productivity index PI = 0.21 BPD/psi

Summary

- Pressure buildup test was monitored remotely during 24 days via cloud connection to the RAM.
- Data was downloaded via Internet at various times during progress of the buildup.
- Operator visited the well only to check Nitrogen gas supply.
- Fluid level records were processed to accurately compute BHP
- BHP data vs. elapsed time was exported for detailed analysis with specialty software.
- Well pump down was monitored remotely with dynamometer and fluid level records.
- Buildup SBHP and stabilized producing BHP were used to compute well productivity.

Acknowledgements

A special thank you to:

Addax Operating, LLC
Jimmy James
Frank Wilson

Echometer Company
Justin Bates
Ken Skinner
Dieter Becker
Tony Podio

Copyright

Disclaimer

The following disclaimer shall be included as the last page of a Technical Presentation or Artificial Lift Learning Course. A similar disclaimer is included on the Artificial Lift Workshop webpage.

The Artificial Lift Research and Development Council and its officers and trustees, and the Artificial Lift Workshop Steering Committee members, and their supporting organizations and companies (here-in-after referred to as the Sponsoring Organizations), and the author(s) of this Technical Presentation or Artificial Lift Learning Course and their company(ies), provide this presentation and/or training material at the Artificial Lift Workshop "as is" without any warranty of any kind, express or implied, as to the accuracy of the information or the products or services referred to by any presenter (in so far as such warranties may be excluded under any relevant law) and these members and their companies will not be liable for unlawful actions and any losses or damage that may result from use of any presentation as a consequence of any inaccuracies in, or any omission from, the information which therein may be contained.

The views, opinions, and conclusions expressed in these presentations and/or training materials are those of the author and not necessarily those of the Sponsoring Organizations. The author is solely responsible for the content of the materials.

The Sponsoring Organizations cannot and do not warrant the accuracy of these documents beyond the source documents, although we do make every attempt to work from authoritative sources. The Sponsoring Organizations provide these presentations and/or training materials as a service. The Sponsoring Organizations make no representations or warranties, express or implied, with respect to the presentations and/or training materials, or any part thereof, including any warrantees of title, non-infringement of copyright or patent rights of others, merchantability, or fitness or suitability for any purpose.