

Utilising Drilling Simulations to Determine Rig and Well Control Considerations for CO2 Wells

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Core CO₂ Challenges for a Rig

Cold

Heavier than Air

Novel

Toxicity concentration >%5

Corrosive

Choke Specs

Mud Room
Mods

CO₂
Dispersion

Material
Reviews

Procedure
Updates

Upkeep

Inspections

Trainings

Muster,
Alarms &
Evacuation

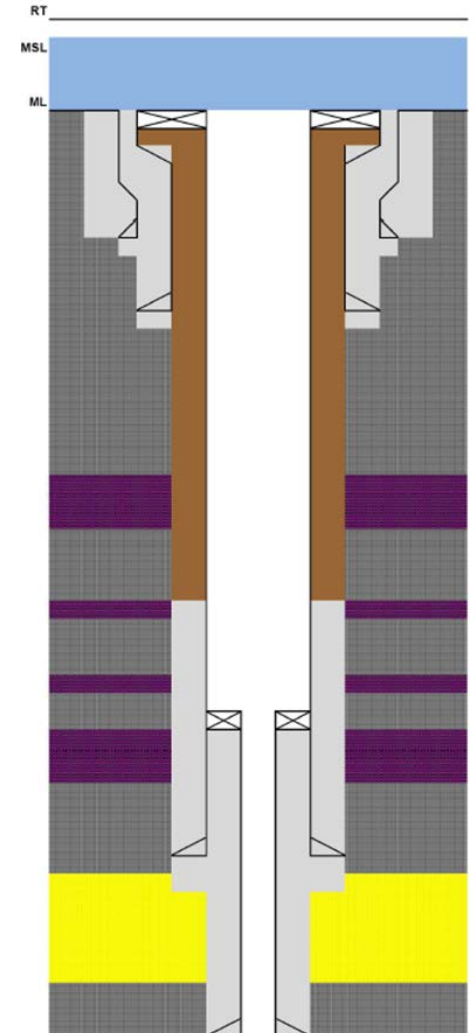
Impurities

Well Control

Mud Gas
Separators

Simulating a CO₂ Kick

- Partnered with a simulation company
- Designed a basic vertical well through bunter sandstone that stored supercritical CO₂ at 1200 meters TVD
- Simulated the phase of drilling when the 12 ¼" section penetrated the bunter sandstone

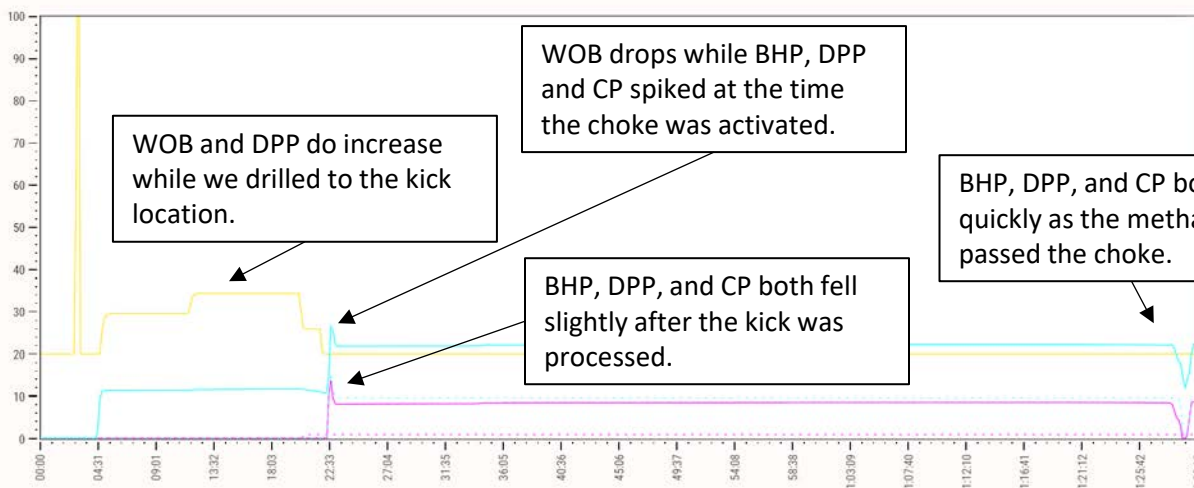


Simulated Operations

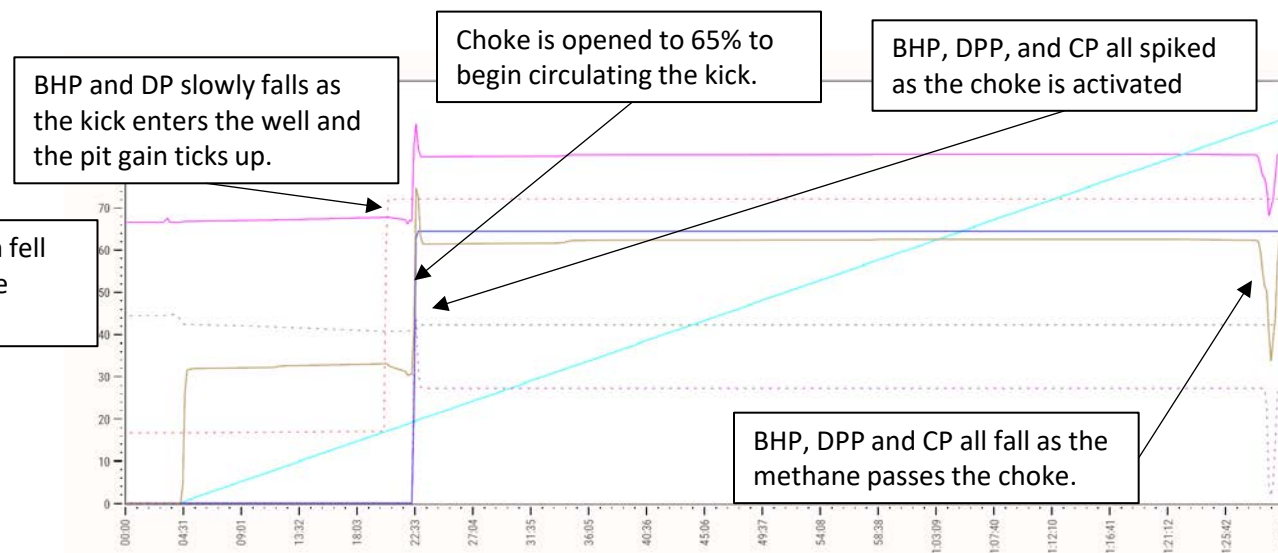
Number	Scenario
1	Baseline Methane Kick
2	Kick while Drilling – 1
3	Kick while Drilling – 2
4	Kick while Drilling – 3
5	Kick while Drilling – 4
6	Bullheading – 1

Number	Scenario
7	Bullheading – 2
8	Bullheading – 3
9	Water Based Mud – 1
10	Water Based Mud - 2
11	High Influx Rate – 1
12	High influx Rate – 2

Baseline Methane Kick



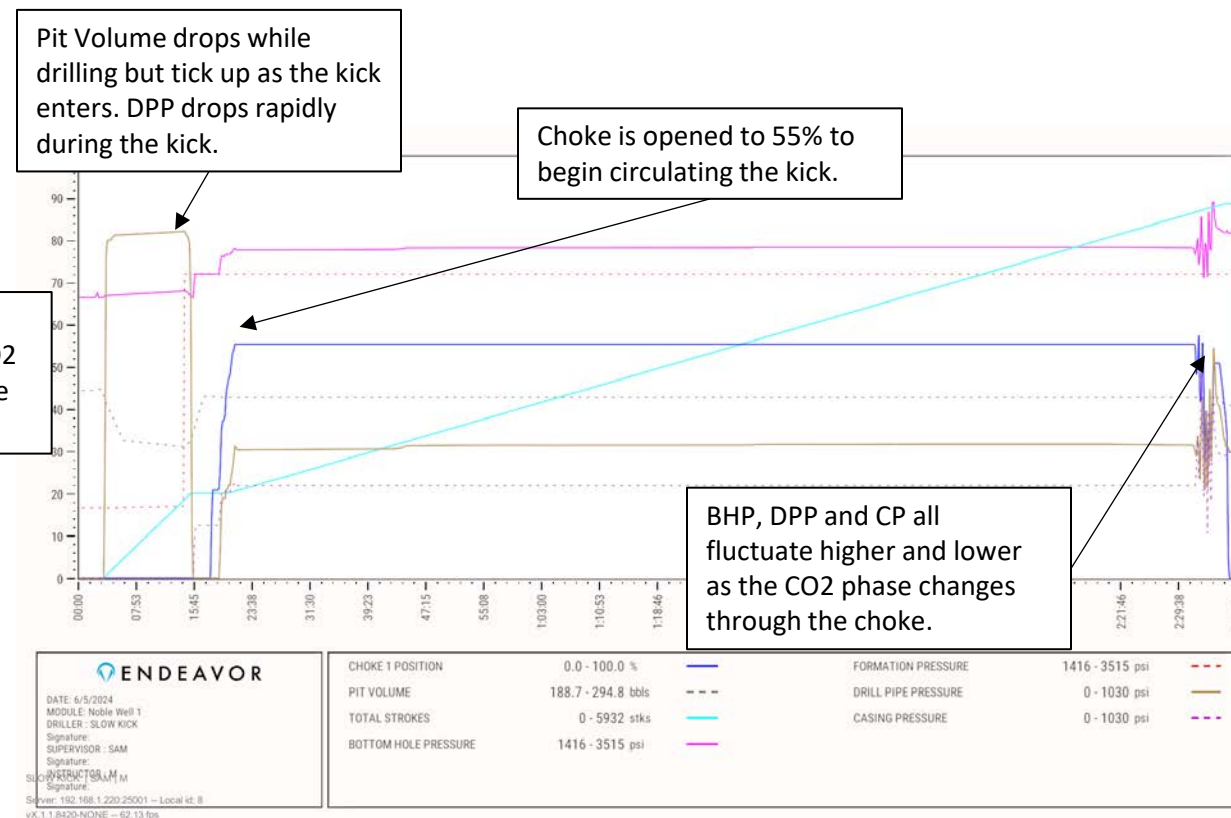
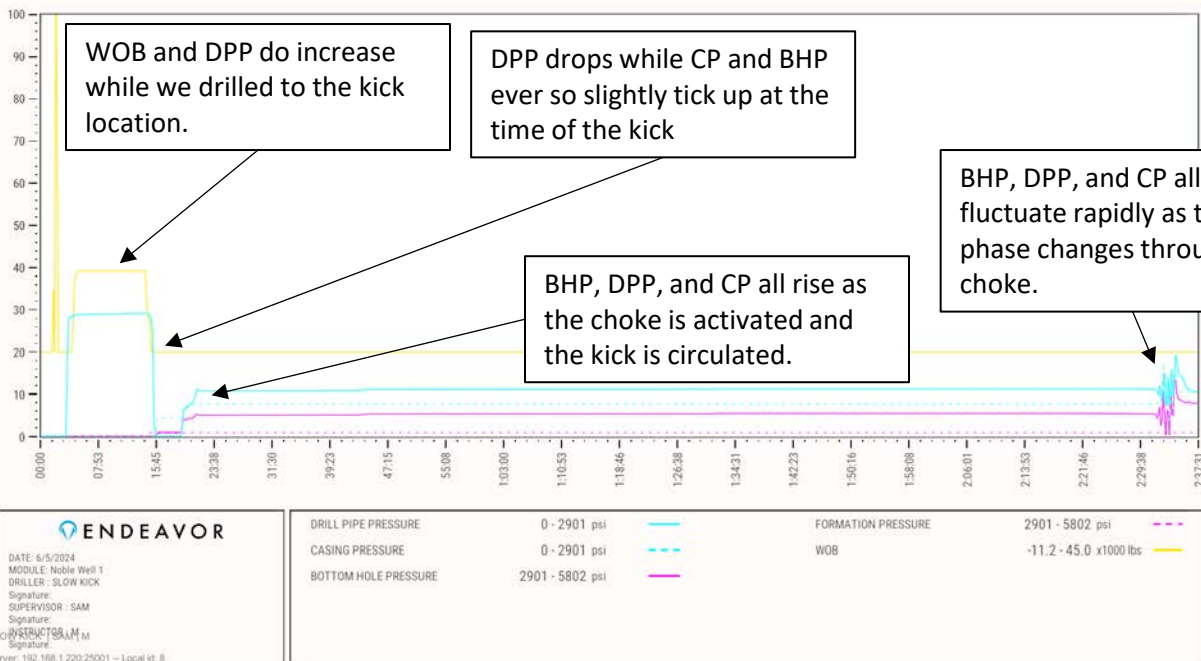
 DATE: 6/5/2024 MODULE: Noble Well 1 DRILLER: COMPARISON WELL Signature: SUPERVISOR: M Signature: INSTRUCTOR: M M M Signature: Server: 192.168.1.220:25001 - Local kit: 8 vX: 1.1.8420-NONE - 64.58 fps	DRILL PIPE PRESSURE	0 - 2901 psi	—	FORMATION PRESSURE	2901 - 5802 psi	- - -
	CASING PRESSURE	0 - 2901 psi	- - -	WOB	-11.2 - 45.0 x1000 lbs	—
	BOTTOM HOLE PRESSURE	2901 - 5802 psi	—			



 DATE: 6/5/2024 MODULE: Noble Well 1 DRILLER: COMPARISON WELL Signature: SUPERVISOR: M Signature: INSTRUCTOR: M M M Signature: Server: 192.168.1.220:25001 - Local kit: 8 vX: 1.1.8420-NONE - 64.58 fps	CHOKES 1 POSITION	0.0 - 100.0 %	—	FORMATION PRESSURE	1416 - 3515 psi	- - -
	PIT VOLUME	188.7 - 294.8 bbbls	- - -	DRILL PIPE PRESSURE	0 - 1032 psi	—
	TOTAL STROKES	0 - 5676 stks	—	CASING PRESSURE	0 - 1032 psi	- - -
	BOTTOM HOLE PRESSURE	1416 - 3515 psi	—			

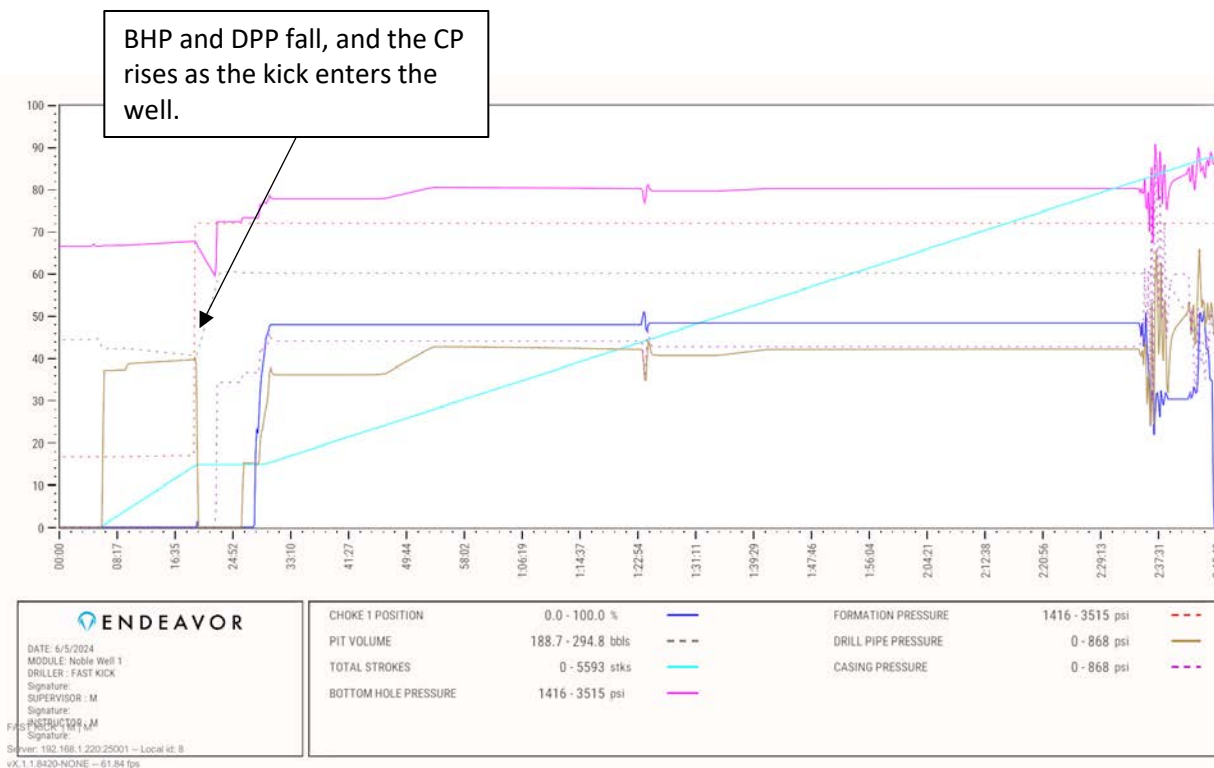
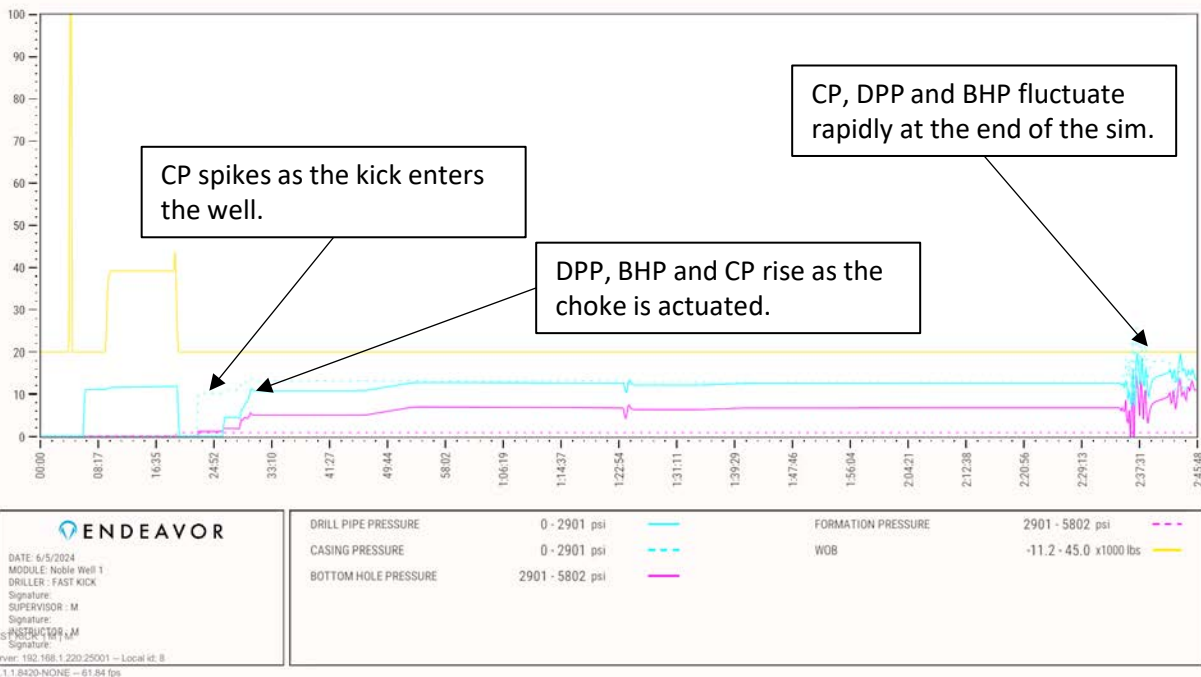
- Bottomhole Pressure (BHP), Drillpipe Pressure (DPP) and Casing Pressure (CP) all spiked at the time of kick
- BHP, DPP and CP fell as the chokes were activated
- BHP, DPP and CP dropped as the kick was circulated through the choke

Kick while Drilling – 1



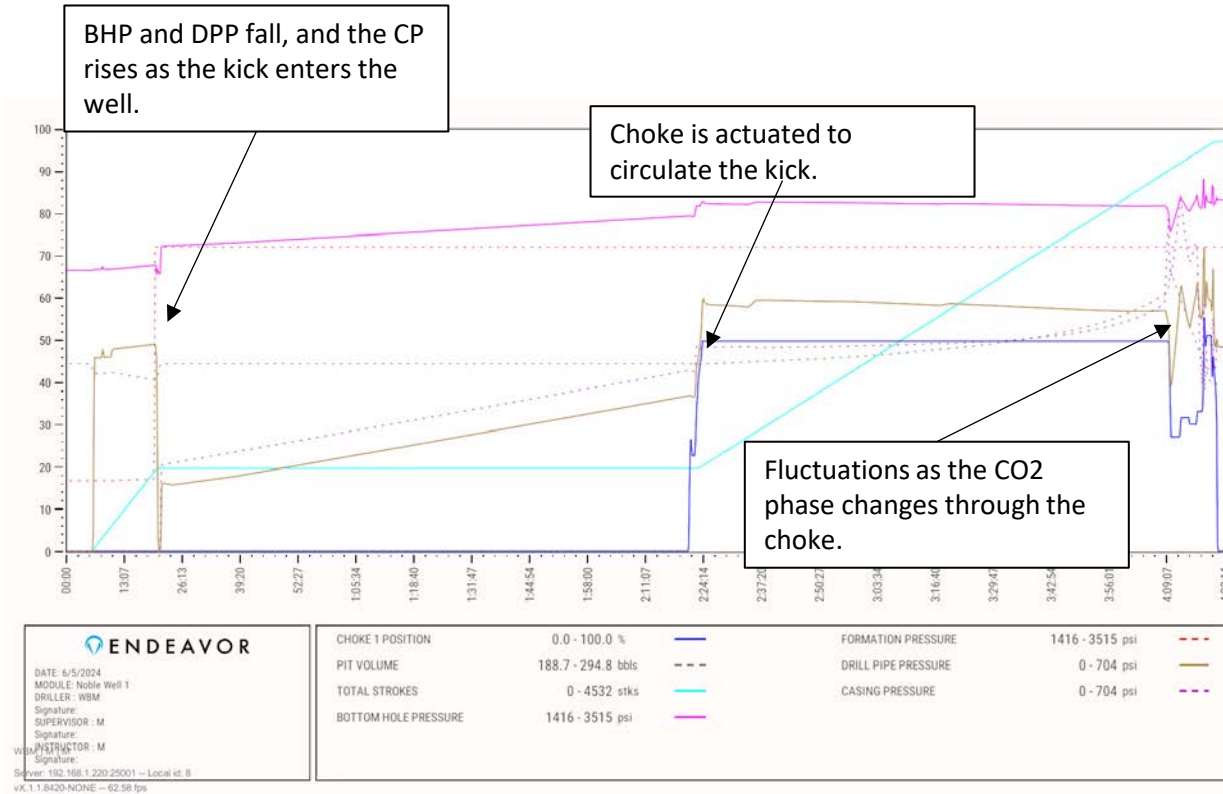
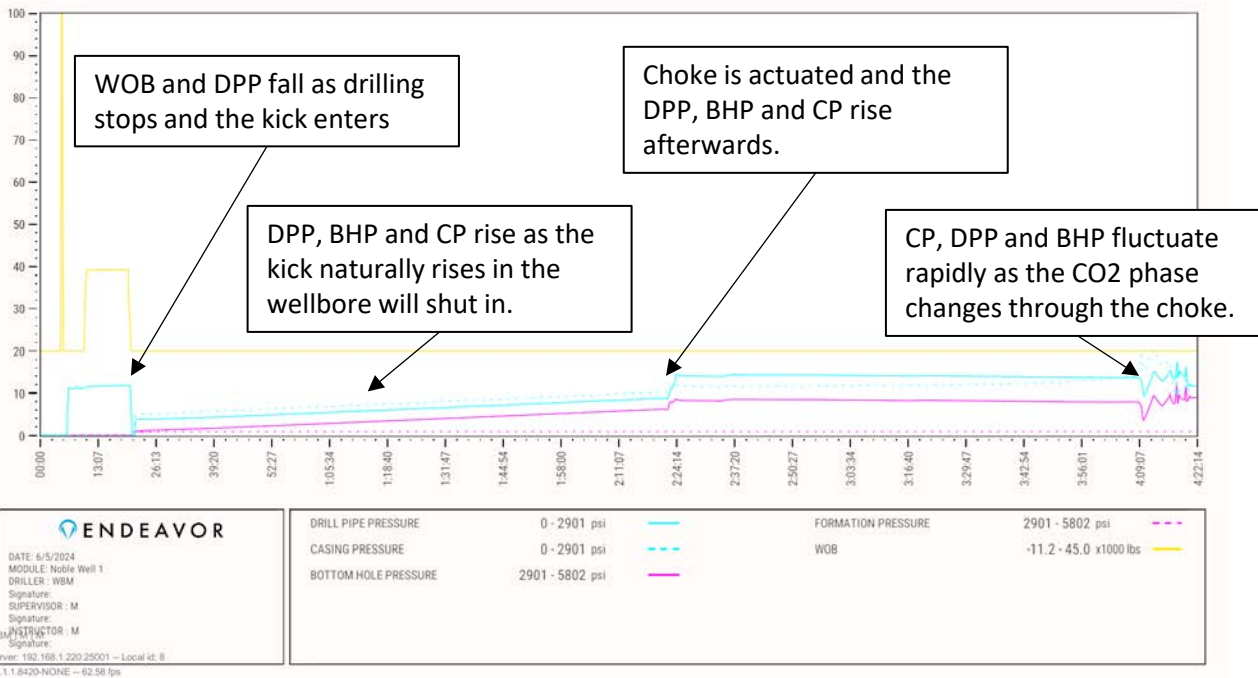
- Unlike with methane, DPP tails to zero when shut in
- Casing pressure rose during the kick unlike with the methane
- Pressures fluctuated as the CO2 phased change through the choke

Bullhead 3



- Simulations behaved abnormally
- Must work with geophysical formation software that specialize in this operation
- Successful operations was dependent on kick size

Water Based Mud – 1



- CO2 kick will migrate during shut in for WBM but not OBM
- This natural migration leads to different pressure profiles during shut in
- Phase change at the choke is less violent as the CO2 kick is less compact

Conclusions

- Tough to detect
- OBM vs. WBM
- Bullheading requires a quick response
- CO₂ kicks stayed supercritical and soluble
- Violent phase change at the choke

Considerations for the Well Control Equipment

- Upgrade materials and seals
- Choke mitigation measures
- Quick reaction time
- New vent lines
- Integration to legacy systems
- Rules & Regulations

