AADE
AMERICAN ASSOCIATION of DRILLING ENGINEERS
HOUSTON CHAPTER
"The Industry forum for Drilling practices and technology"

MPD, DwC, and SES - Prevention and Mitigation Strategies for Lost Circulation

Fluids Management Group Meeting
25 September 2013

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Weatherford International

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Presentation Outline

- Problem Definition
- Closed Loop Drilling
  - Managed Pressure Drilling (MPD)
  - Pressurized Mud Cap Drilling
- Drilling With casing (DwC)
- Solid Expandable System (SES)
- Conclusions

Losses - Classification

Classification	Typical Loss Rate	Typical Formation Characteristics	Preventative Solutions	Mitigation Solutions
Seepage	<10 bbl/hr	• Sands • Sandstones • Silt	• Particulate LCM • **Managed Pressure Drilling** • **Drilling with Casing**	• Particulate LCM
Partial	10-50 bbl/hr	• Unconsolidated sand or gravel • Small natural fractures • Small induced fractures	• Particulate LCM • **Managed Pressure Drilling** • **Drilling with Casing** • **Solid Expandable Systems**	• Particulate/Fiber LCM • Cross-linkable LCM
Severe	>50 bbl/hr	• Unconsolidated sand or gravel • Large natural fractures • Large induced fractures	• **Managed Pressure Drilling** • **Drilling with Casing** • **Solid Expandable Systems**	• Particulate/Fiber LCM • Cross-linkable LCM
Total	No returns	• Cavernous formations • Large, and/or numerous natural and/or induced fractures	• **Managed Pressure Drilling** • **Drilling with Casing** • **Solid Expandable Systems**	• Particulate/Fiber LCM • Cross-linkable LCM

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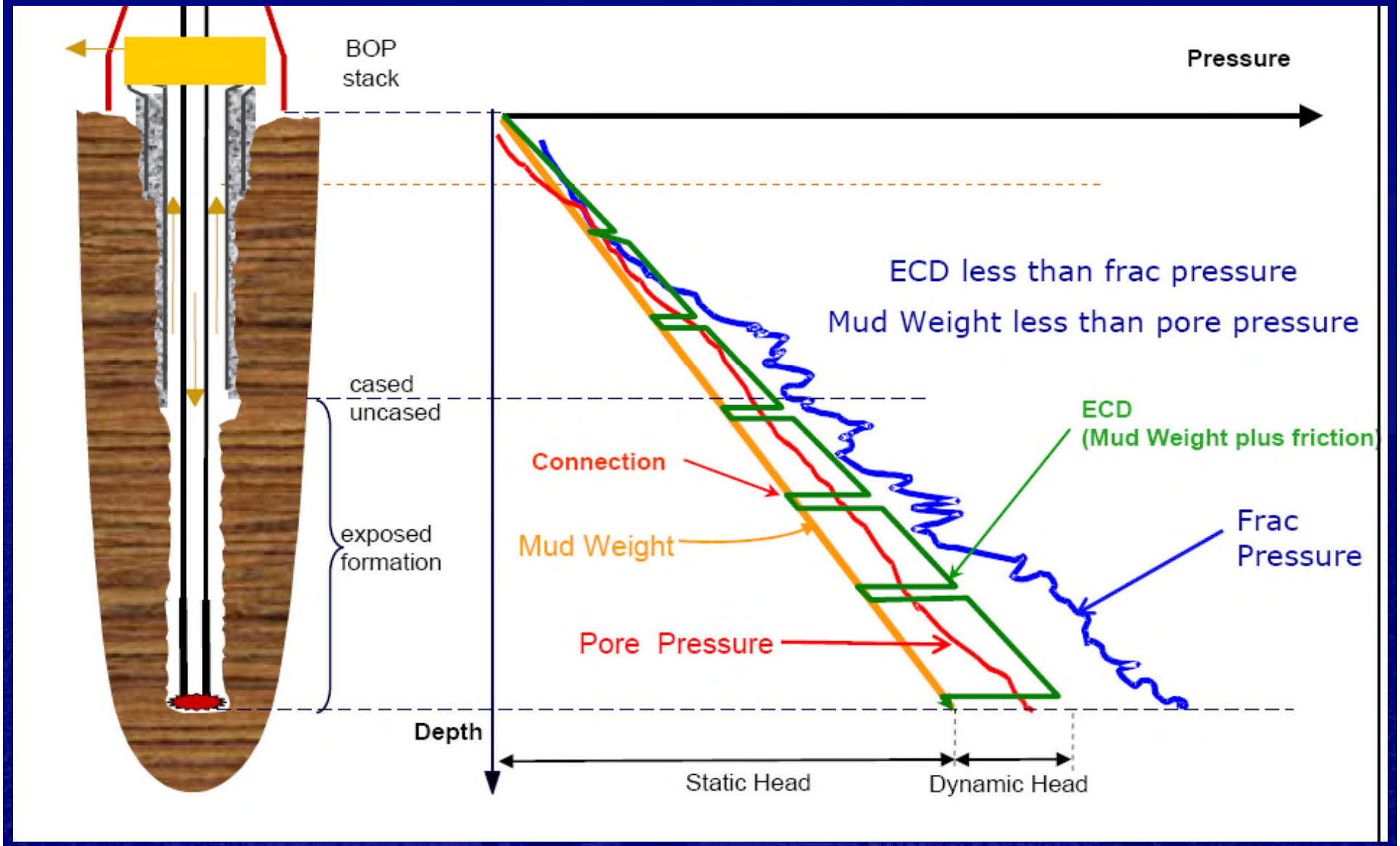
MPD Concept



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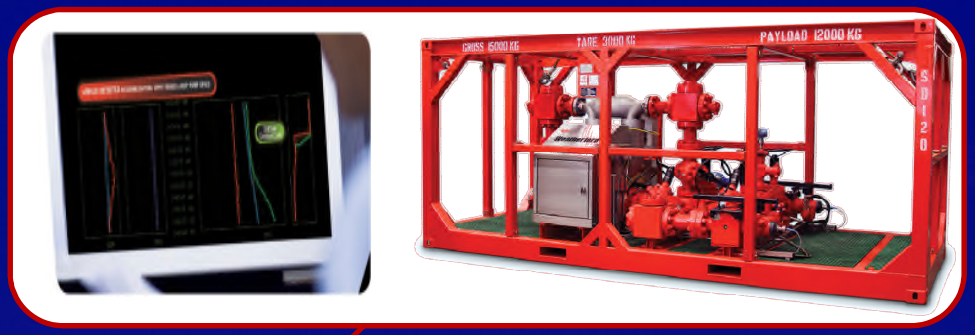
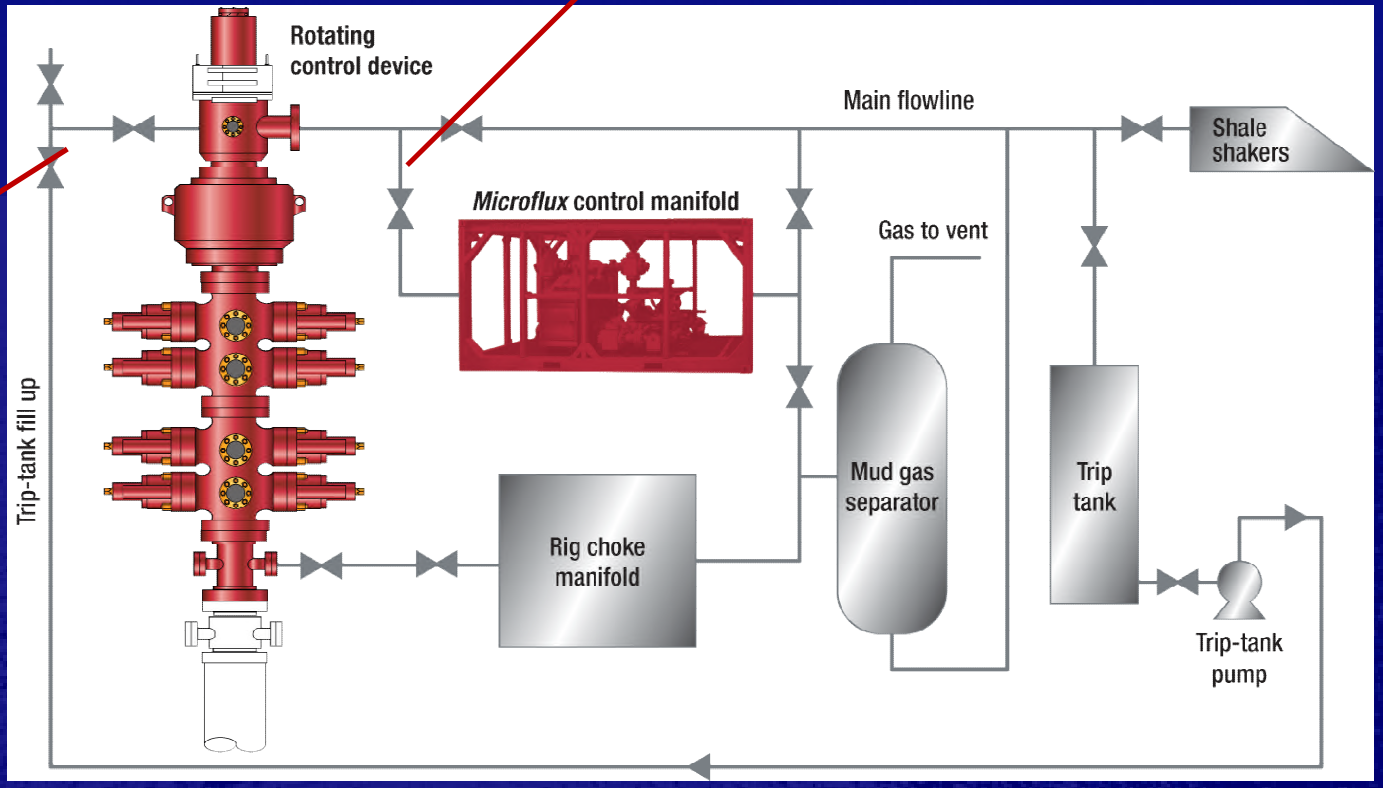
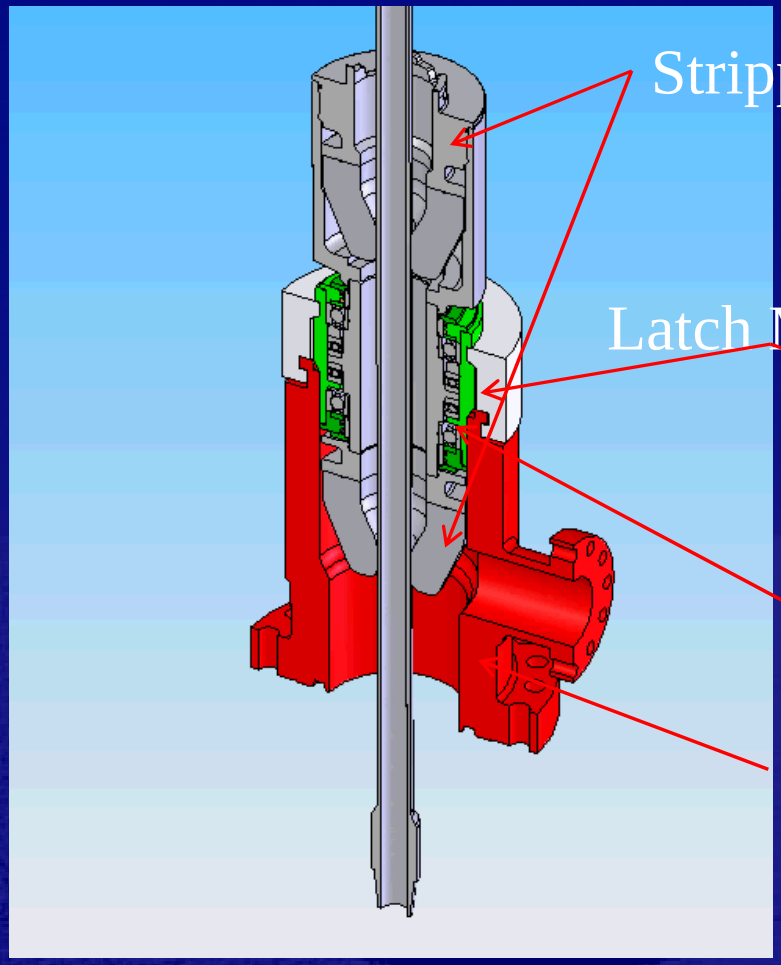
Managed Pressure Drilling

Closing the Loop = Enhanced Control





RCD Function

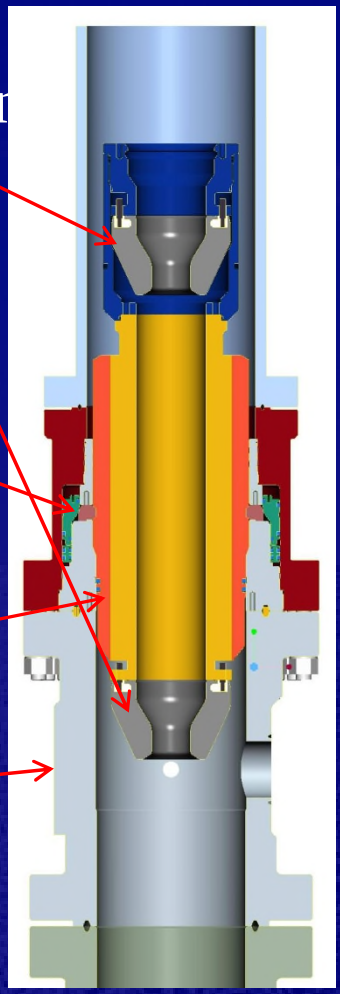


Stripping Elemer

Latch Mechanism

Bearing

Body



Land

Marine

Early Kick/Loss Detection & Control

Application of Coriolis mass flow meters and the principle of Mass Balance to measure and compare the volume and density injected into the well and returned from the well to identify down hole events.

Kick : Input < Output

Loss: Input > Output

The flow meter monitors:

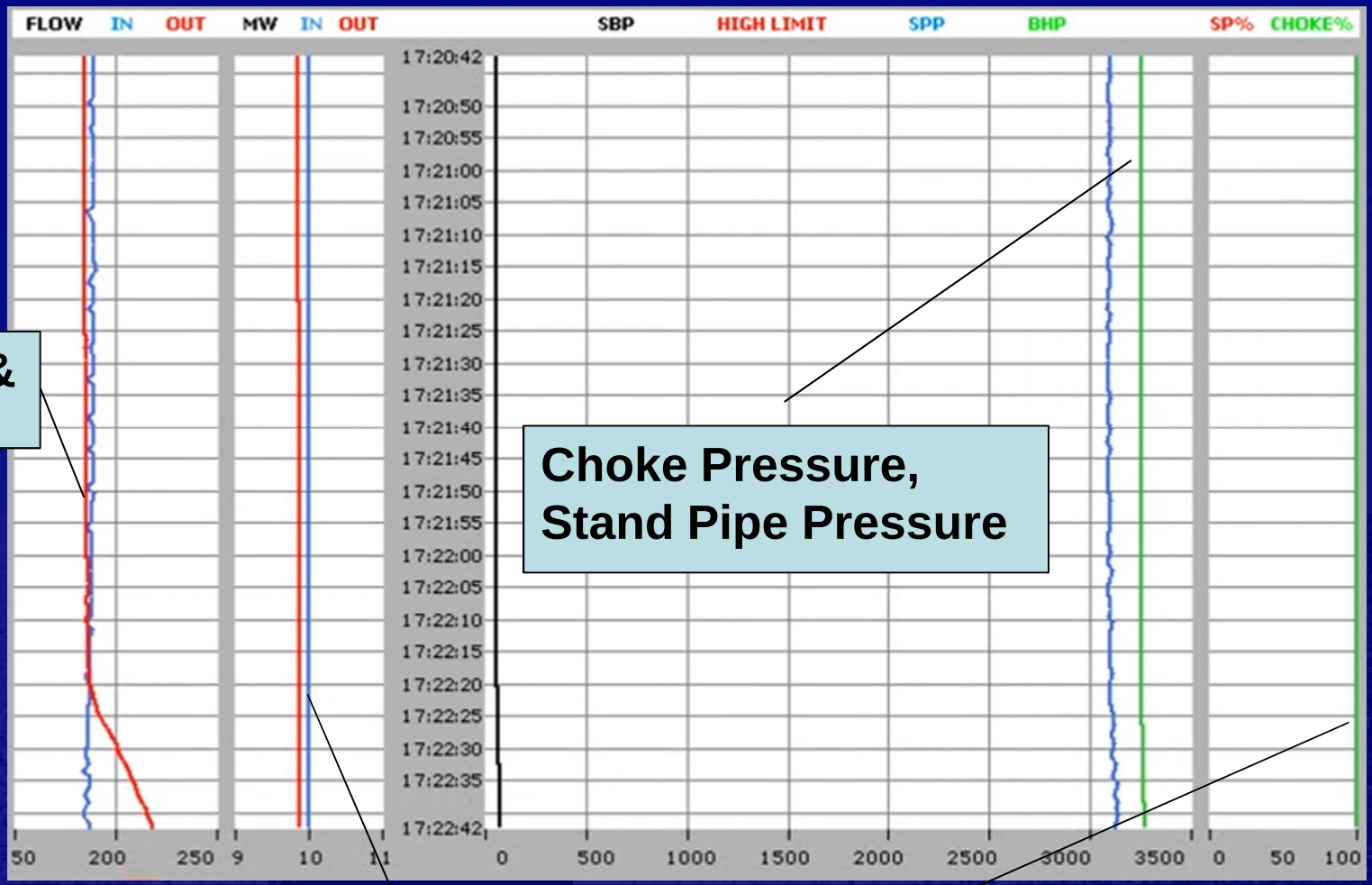
- Mass flow
- Volumetric flow
- Fluid density
- return mud temperature

Nas, S; IADC-SPE 143099 Kick Detection and Well Control in a Closed Wellbore

Visibility to the wellbore = Safety + Efficiency

- Use of advanced flow detection system to ascertain actual pore/frac pressures in real time
  - Reduce uncertainties
- Detect micro-influxes/losses
  - Mass balance with the use of Coriolis meters
  - Differentiate between Ballooning (Breathing) and gas influx
- Kick and Loss Identification and Control
  - Automated processes to identify and control kicks and losses

Monitoring of Critical parameter trends



Flow In & Out

Choke Pressure, Stand Pipe Pressure

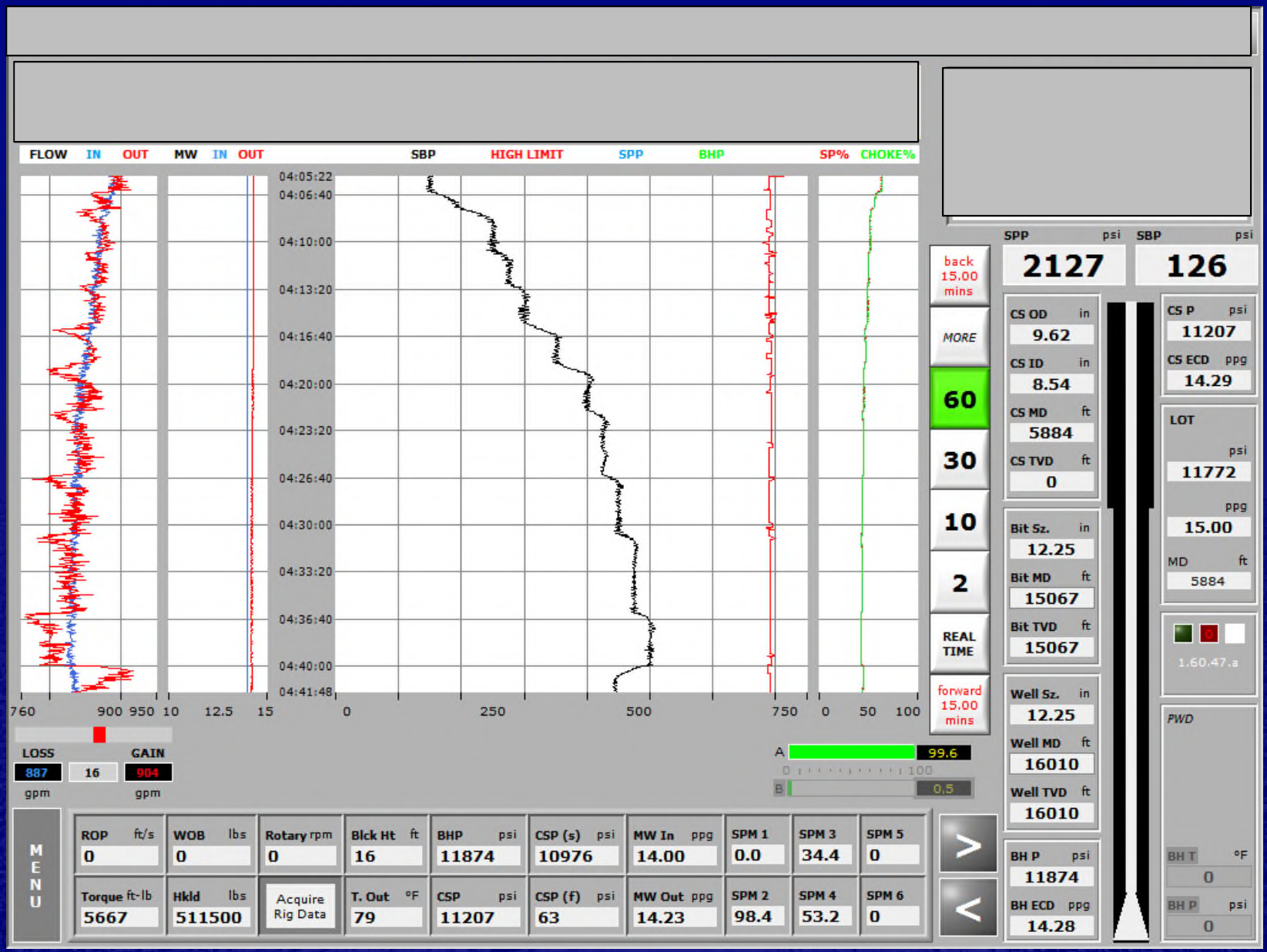
Mud Density In & Out

Choke Position

MPD for loss circulation mitigation

- MPD enables accurate management of annular hydraulic profile to stay between Pore & Fracture gradient limits.
- Loss / influx event can be identified at very early stage hence mitigation can be more effective.
- It allows to perform dynamic LOT / FIT and Pore Pressure test to verify drilling margin as new formation is drilled.
- Wellbore ballooning / breathing can be identified with better accuracy and reliability.

Example: Dynamic Leak off test



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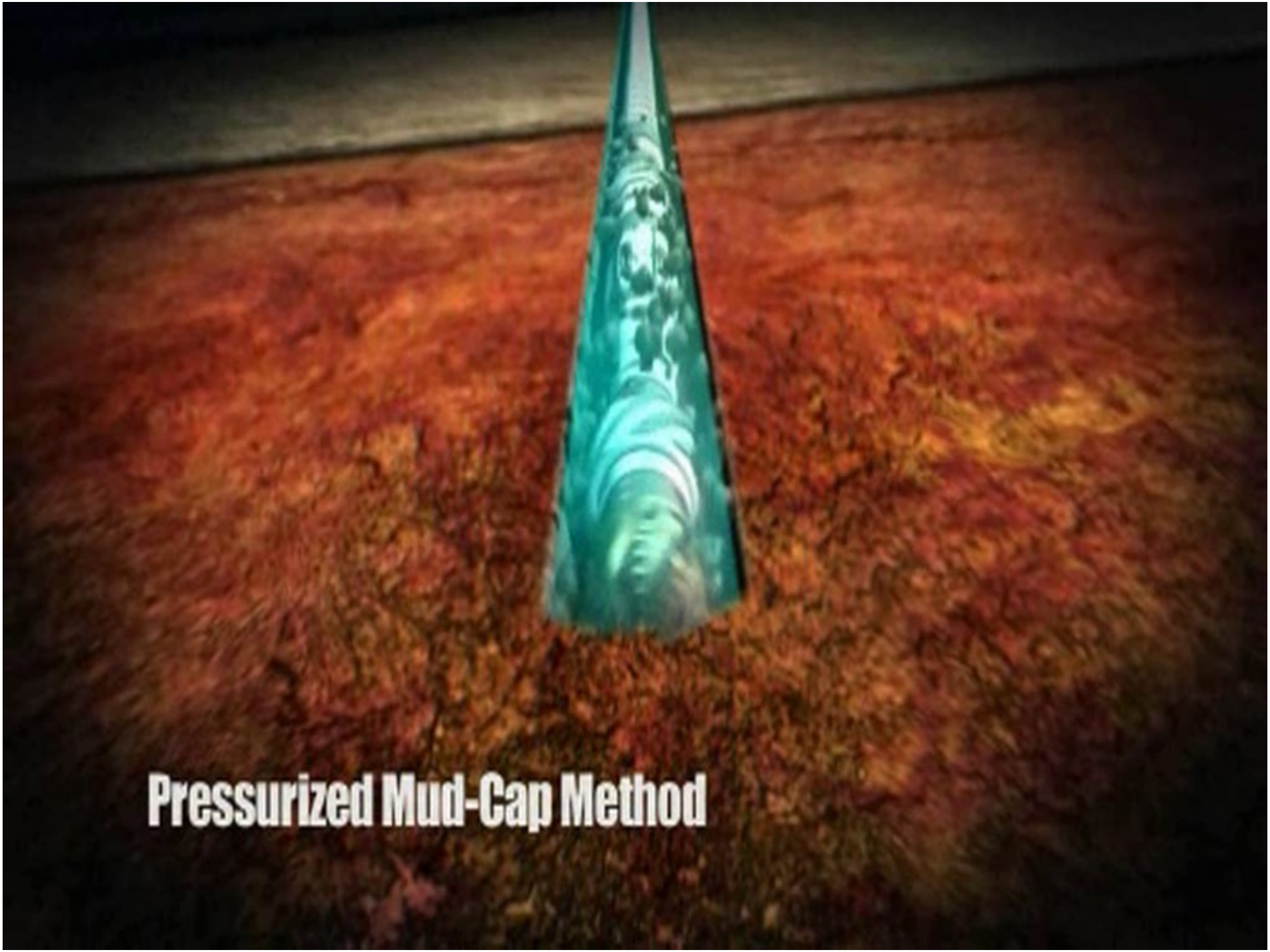
Pressurized Mud Cap Drilling (PMCD)

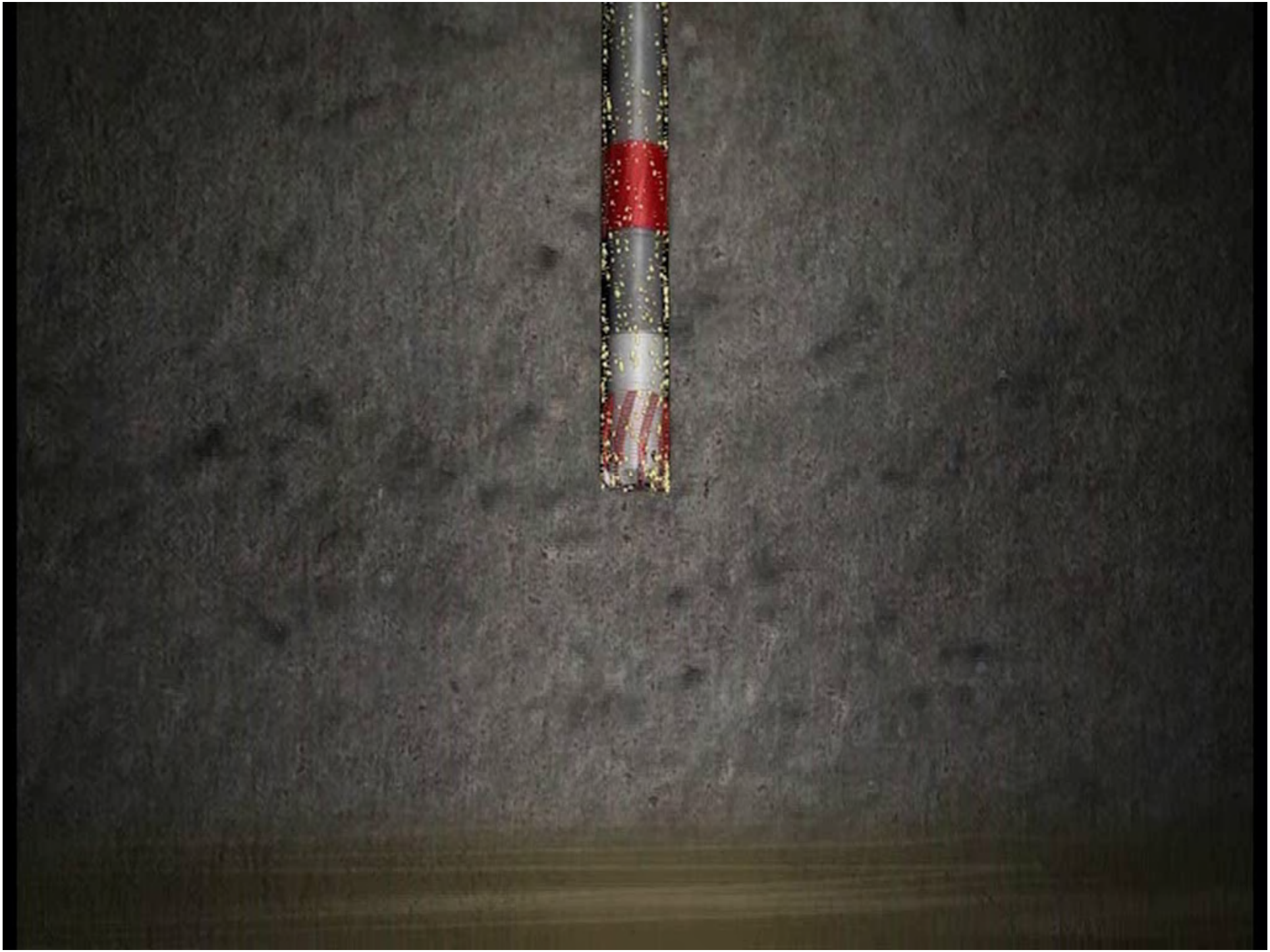
- Suitable for highly fractured reservoirs with total lost circulation scenarios.
- Maintaining Partial column of mud in the annulus to encounter the gas migration.
- Drill ahead while pumping sacrificial fluid (water) into the drill string.
- Maintain required amount of surface back pressure to control mud cap in the annulus.


Pressurized Mud-Cap Method

History of Mechanical Wellbore Strengthening

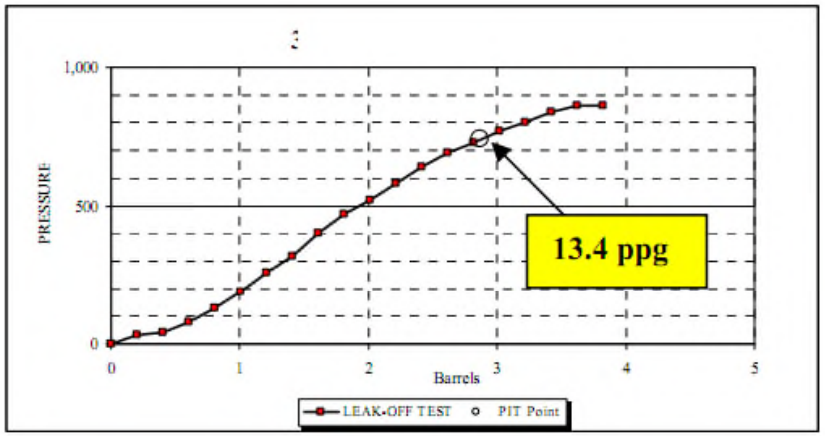
- "Improved wellbore stability has been attributed in part to the "smear effect" achieved when the cuttings and filter cake are pressed into the wall by the combined forces of high annular velocity and pipe rotation. A highly effective seal is formed, helping to minimize losses and increase the tolerance of the well for potentially high equivalent circulating densities (ECD) generated in the restricted annulus."
- WOCWD-0431-04

- Improved Wellbore Stability Achieved with Casing Drilling Operations through Drilling Fluids "Smear Effect"
- Kyle Fontenot and Robert D. Strickler, ConocoPhillips; Pete Molina, Baroid product service line, Halliburton
-



How to Quantify?

- The only real way of measuring the benefits of any wellbore strengthening method is through FIT/LOT.



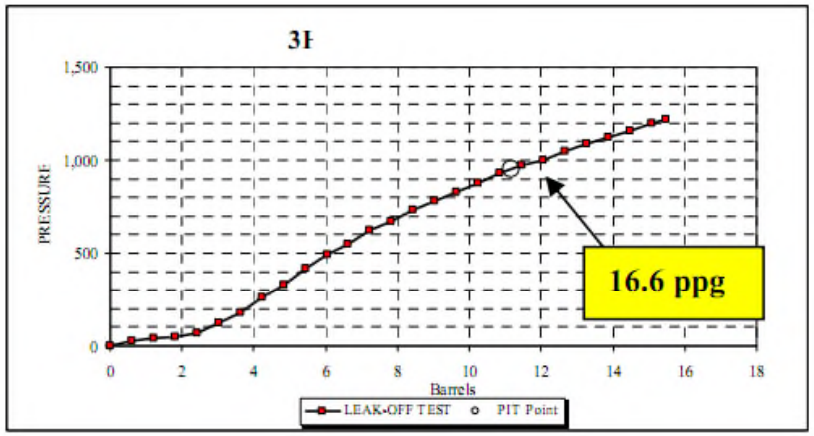


Figure 8: Second well LOT at 7482 feet and then at 7620 feet after CwD to the top of the first reservoir sand

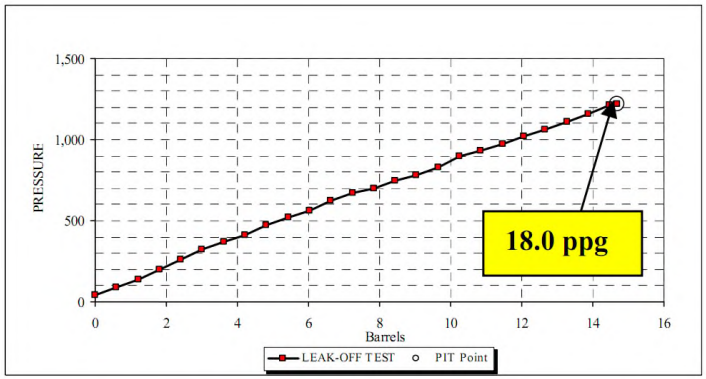


Figure 9: Second well LOT after drilling first reservoir sand

Reference: SPE 128913

How do solid expandable systems work?

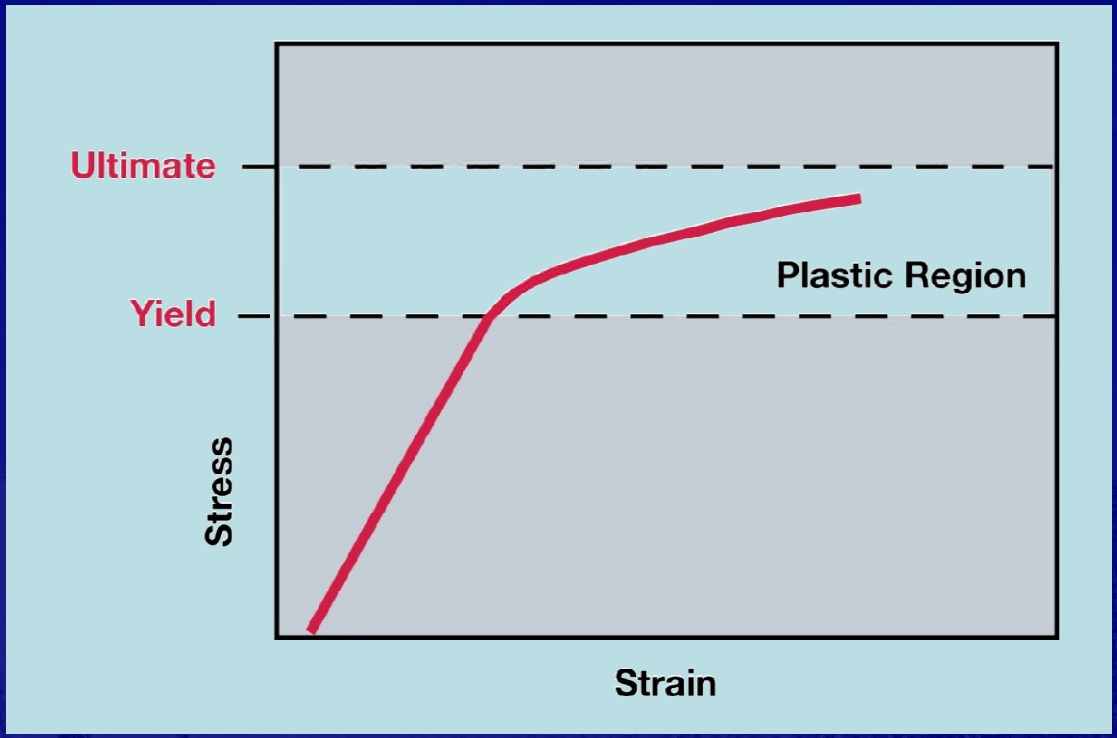
Expandable Technology is based on cold-working or forming tubular products down hole *to…*

eliminate or minimize the telescope effect in well construction (sections of decreasing size with increasing depth) *and…*

maximize pass-through Internal Diameter (ID) during casing remediation.

How do solid expandable systems work?

Solid Cone Expansion



Cone expansion is a swaging process.

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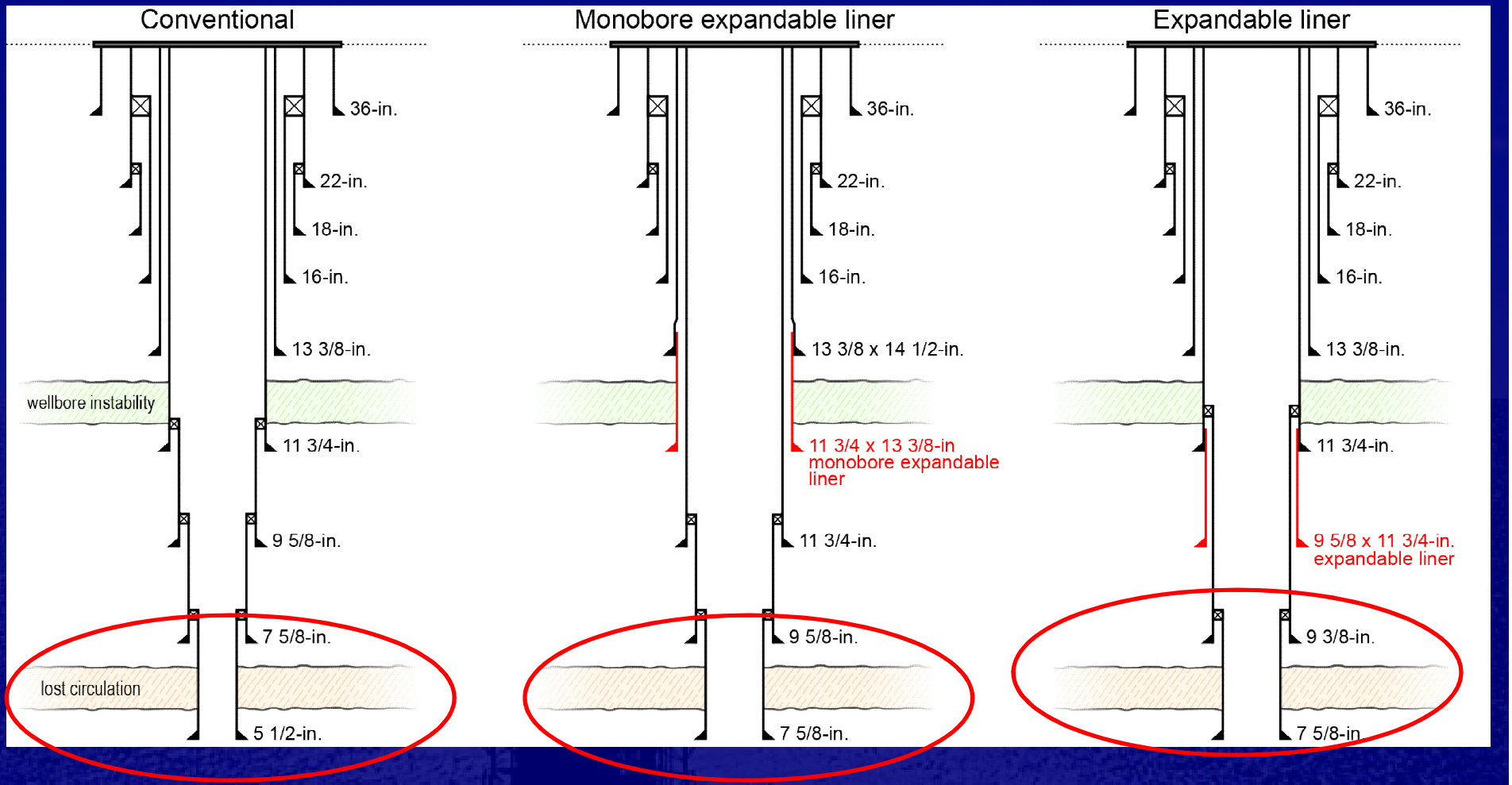
Benefit of Solid Expandable System



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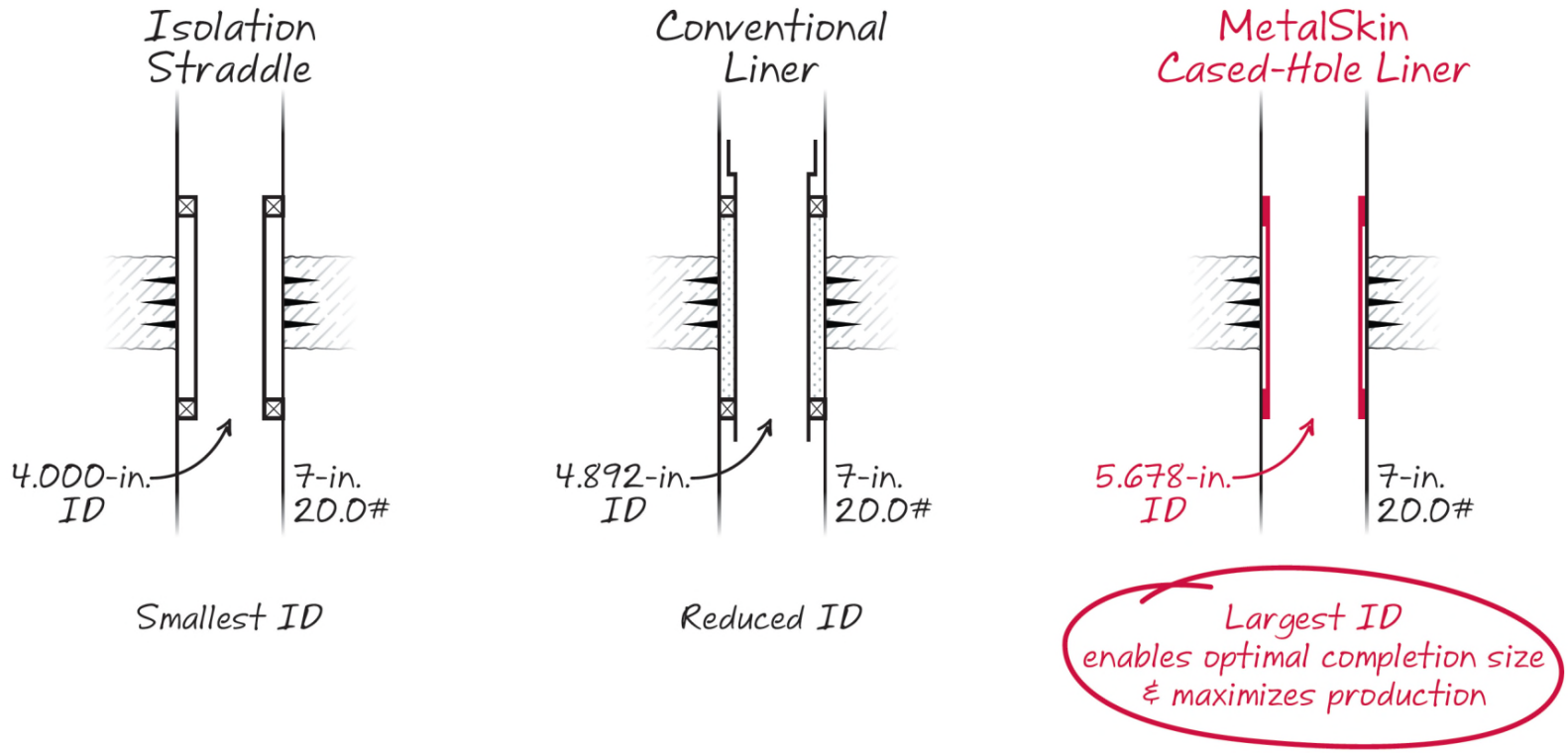
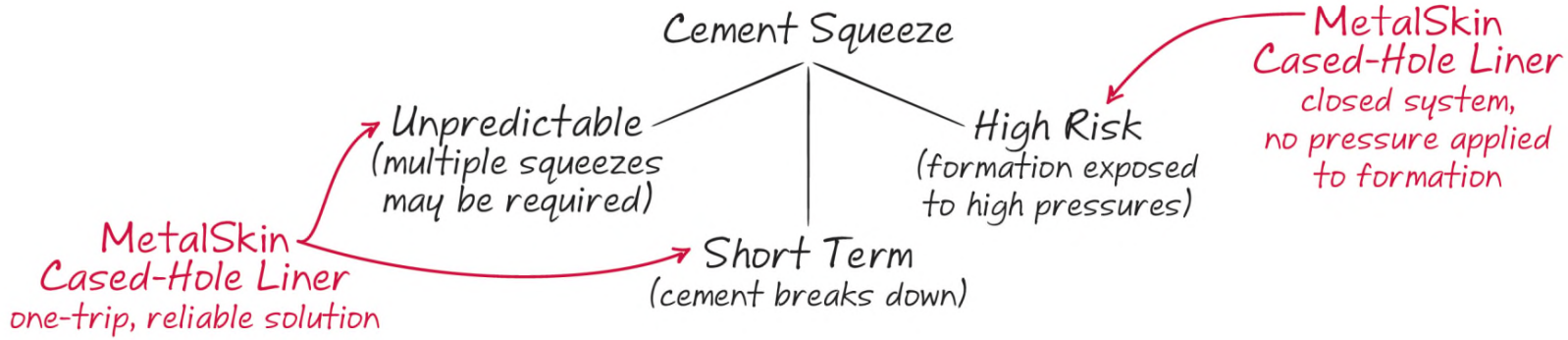
Overcoming Mature Field Challenges





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Conclusions

- MPD technology provides precise control over wellbore hydraulics profile and it can be maintained between Pore & Fracture gradient with greater accuracy and reliability.
- Early kick / loss detection capabilities allows problem to be identified at early stage hence mitigation can be easier.
- Pressurized Mud Cap Drilling (PMCD) method of MPD is applied while drilling through zones with total loss of circulation.

Conclusions - Continued

- Improved Wellbore Stability can be achieved with Drilling with Casing (DwC) Operations through Drilling Fluids “Smear Effect”
- Solid Expandable System can provide effective means to isolate the loss circulation zone without compromising on casing design plan.

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Thank You

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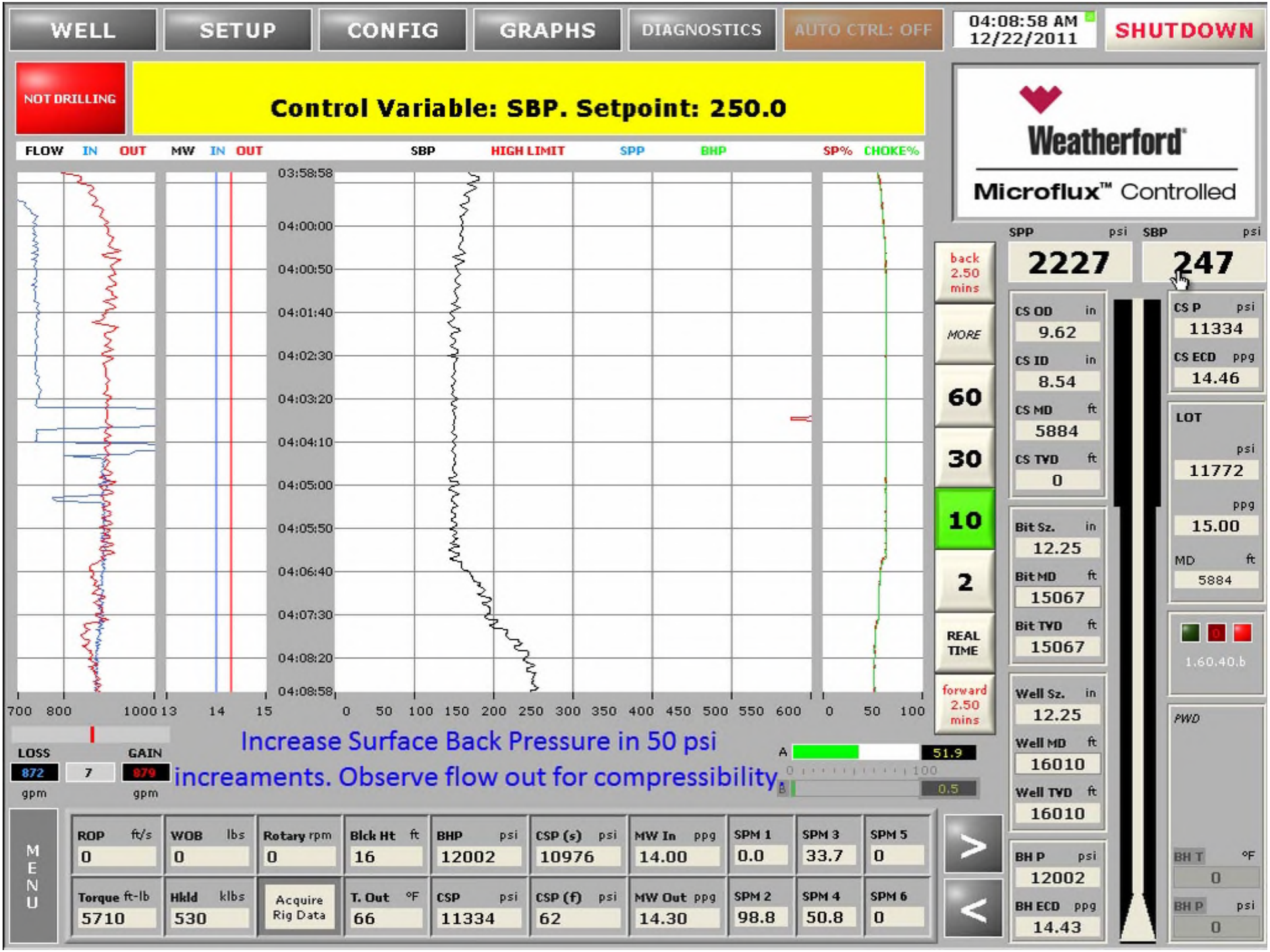
Back up Slides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12/22/2011
SHUTDOWN
NOT DRILLING
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Weatherford
Microflux™ Controlled
FLOW IN OUT
MW IN OUT
SBP
HIGH LIMIT
SPP
BHP
SP%
CHOKE%
03:58:58
04:00:00
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04:02:30
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700 800 1000
13 14 15
0 50 100 150 200 250 300 350 400 450 500 550 600
0 50 100
back 2.50 mins
MORE
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30
10
2
REAL TIME
forward 2.50 mins
SPP psi
2227
SBP psi
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CS OD in
9.62
CS ID in
8.54
CS MD ft
5884
CS TVD ft
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Bit Sz. in
12.25
Bit MD ft
15067
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15067
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12.25
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16010
BH P psi
12002
BH ECD ppg
14.43
CS P psi
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CS ECD ppg
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GAIN
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increaments. Observe flow out for compressibility.
A
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16
BHP psi
12002
CSP (s) psi
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530
Acquire Rig Data
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SPM 4
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