PDD

Pressure During Drilling
Real Time and Memory Bore and Annulus Measurements

Downhole tools, software, analysis, interpretation, control

Surface data and control interfaces
WITS / 4-30mA / RS422 / RS485 / PROFIBUS

Software and Logic

Custom PLC / Software logic engines

Service Benefits

Available in 3-1/2", 4-3/4", 6-3/4", 7-3/4", 8-1/4", 9-1/2" OD tool diameters.
Tolteq, Enteq, Geolink, APS and Benchtree compatible hardware and software
Compatible with Top Mounted or Bottom Mounted pulser assemblies
Physical pressure housing interfaces provided for all above systems with 1.875" OD

PDD Sensor Specifications

PDD Sub Assembly is a standalone sensor and electronics assembly. Battery power is derived from existing system batteries via BattBus connections. Approximately 24" long.

Maximum Operating Temperature:	150°C
Measurement Range:	0 - 15000 psi (1034 Bar)
Accuracy:	+/- 0.25% of full scale
Repeatability:	+/- 3 psi
Transmitted Resolution	3.662 psi / bit
Memory Resolution	+/- 0.25% of full scale
Operating Temperature Range:	-55°C to 150°C
Measurement Type:	Piezo Resistive Silicon Sensor (RMS Custom version)
Corrections:	4th order temperature correction of bias and SF
Averaging Time:	Adjustable from 1sec - 30sec
Realtime update rate:	240 seconds (Estimated)
Realtime update resolution:	0.5' at 50ft / Hour
Memory:	8Mb of non-volatile memory
Memory update rate:	10 seconds bore and annular
Memory update resolution:	0.02' at 50ft / Hour
Power Source:	28V Bus powered 5mA at 28V
Battery Life:	1000 hours
Communications:	QBUS / RS485 / RS232
Shock:	1000G / 0.5mS half sine
Vibration Random:	20G RMS Random
Vibration Sine	30G Peak
Mud type:	Any Oil based or Water based

Internal mounted sleeve rig site changeable to accommodate multiple collar sizes:

Standard Collar Bore sizes: 2-1/2", 2-11/16",3-1/4",3-3/4",4-1/4" (Others sizes available on request)

PDD Processing

•Raw pressure transmitted (Annular and Bore as GENERIC Variables – Units PSI

•Variables Tagged an passed via WITS to RMS offline PC which calculates ECD / and other drilling parameters

• RMS offline computer sends all WITS and corrected data to Digidrill PC for plotting and LAS file generation

• Digidrill PC plots and stores data as function of depth and time.

• PDD memory data processed through Digidrill correlator for depth time correlation and LAS file generation.

REMOTE MEASUREMENT
SYSTEMS LIMITED

PDD Applications

The sleeve below shows the hole through to the body that holds the pressure transducers.

The sleeve with two O rings can be changed at the rig site to accommodate different collar ID'S. The section between the two O rings sees anulus pressure through a hole in the sub wall. A further hole through the sleeve exposes the pressure transducers to annular pressure

PDD Piezo resistive sensor

PIEZORESISTIVE OEM PRESSURE TRANSMITTERS

SERIES 4 LC…9 LC

-40…150 °C, WITH EMBEDDED SIGNAL CONDITIONING

The Series 4 LC…9 LC family of miniature OEM pressure transmitters combines a piezoresistive pressure sensor with -40…150 °C-capable signal conditioning in one compact, easy-to-integrate package.

Technology

The "LC" line of miniature pressure transmitters leverages Keller's extensive background in high-stability piezoresistive pressure sensors and innovative digital signal processing. Now, both pressure sensor and signal processor are integrated into a miniature, hermetically-sealed housing no larger than was once required for the sensor only!

The name given to this new technology is Chip-In-Oil (CIO). CIO means not only that the entire pressure transmitter is embedded within a hermetically-sealed, oil-filled housing, but that this transmitter can then be seamlessly integrated into the OEM product, achieving cost savings and system performance not possible with other, conventional technologies.

Interfaces

The ratiometric analog output simplifies the integrators task by providing a signal output wherein the output is ratiometric to the supply, thereby eliminating the need to incorporate an expensive, absolute reference. Providing an 0,5…4,5 VDC output from a 5 VDC supply, the LC-transmitter is inherently protected against overvoltage and reverse polarity up to ±33 VDC and provides noise immunity by a factor of 10X relative to the latest standards regarding emitted and conducted EMI.

Performance features

- Hermetically protected sensor electronics - extremely resistant to environmental influences
- Operating temperature up to 150 °C
- Ultra-compact, robust housing made from stainless steel (optionally Hastelloy C-276)
- No external electronics for compensation or signal processing
- Extremely accurate, outstanding long-term stability, no hysteresis
- Pressure ranges of 1 bar to 1000 bar
- Extremely easy to integrate in overall systems
- Two-chip solution with pressure sensor and signal processing separation provides a high degree of flexibility.

4 LC

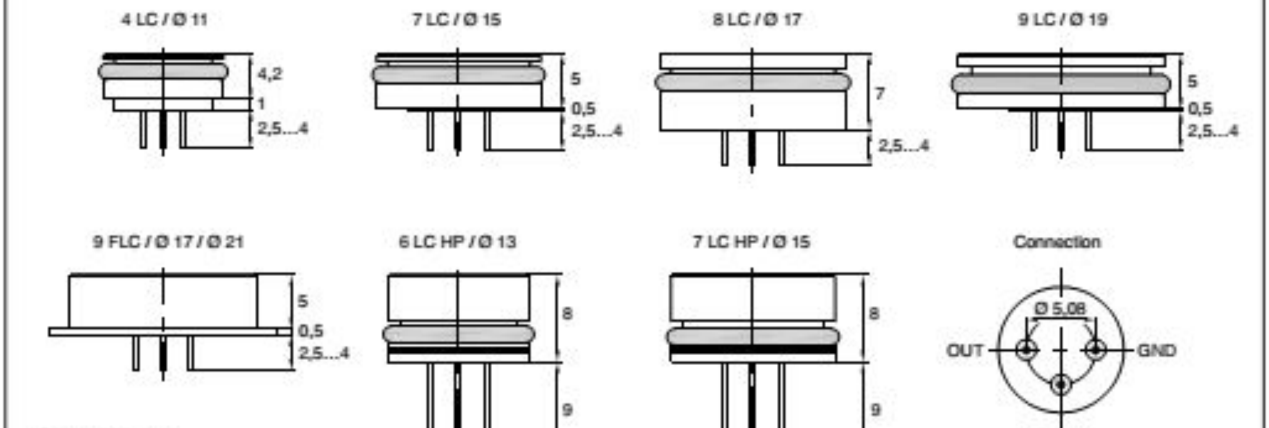
7 LC

8 LC

9 LC

9 FLC

6 LC HP / 7 LC HP (High Pressure)



Generally applies:
No force must be applied to the pins!

PDD Piezo resistive sensor

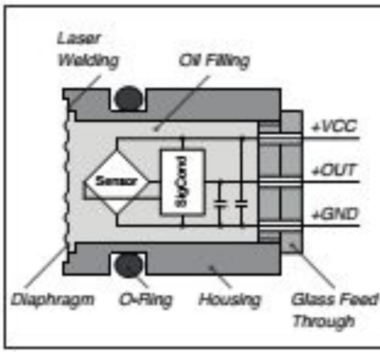
Specifications

Accuracy*	max. +/- 0,25 %FS * Linearity best straight line @ RT, hysteresis, repeatability
Overpressure	2,5 x pressure range, max. 300 bar resp. 1200 bar (6 LC HP, 7 LC HP)
Stability	max. +/- 0,3 %FS

The integration of the transmitter electronics means that even extremely small designs can be properly supported, and there is a considerable amount of freedom for connection variants. Furthermore, there is no need to protect the nonexistent downstream electronics against moisture and condensation.

Type/ Version	Dimensions [mm]	Pressure Range	Storage Temperature	Operating Temperature	TEB [1] [%FS]
4 LC	ø 11 x 4,2	3...200 bar abs.[2]	-10...+80 °C	0...50 °C	± 1,0 %FS
7 LC	ø 15 x 5	2...200 bar abs. 2...30 bar rel.[3]	-40...+125 °C	-10...80 °C -40...+125 °C	± 1,0 %FS ± 2,0 %FS
8 LC	ø 17 x 7	1...200 bar abs. 1...30 bar rel.	-40...+150 °C	-10...80 °C	± 0,8 %FS
9 LC	ø 19 x 5			-40...+125 °C	± 1,5 %FS
9 FLC	ø 17 x 5,5 Flange ø 21	1...50 bar abs. 1...30 bar rel.		-40...+150 °C (only > 3 bar)	± 2,5 %FS
6 LC HP	ø 13 x 8	200...1000 bar	-40...+150 °C	-10...80 °C	± 0,8 %FS
7 LC HP	ø 15 x 8			-40...+150 °C	± 2,0 %FS

[1] TEB (Total Error Band): Maximum deviation within specified pressure and operating temperature range
[2] abs: Absolute Pressure Measurement (PAA: Absolute. Zero at vacuum PA: Sealed Gauge. Zero at 1,0 bar abs.)
[3] rel: Referential version (PR: Vented Gauge. Zero at atmospheric pressure)



Type	3-wire
Signal Output	0,1...0,9 V/V (0,5...4,5 V ratiometric)
Supply	5,0 VDC ± 0,5 V
Reverse Polarity and Overvoltage Protection	± 33 VDC (permanently on all leads)
Power Consumption	max. 8 mA
Load Resistance	> 5 kΩ
Sampling Rate / Bandwidth	2 kHz / 800 Hz
Rise Time T_{90}	1 ms
Response Time (Supply ON)	< 5 ms (0...99%)
Isolation	> 100 MΩ @ 500 VDC
EMC-Industry	EN 61000-6-2 / EN 61000-6-3 / EN 61326-2-3 / BCI 200mA @ 1...250MHz
DO-160F RF Susceptibility (radiated)	Cat. R: 150 V/m @ 400 MHz...8 GHz PM / 30 V/m @ 100 MHz...400 MHz CW & SW,
DO-160F RF Susceptibility (conducted)	Cat.R: 30 mA @ 10 kHz...40 MHz / 3 mA @ 40 MHz...400 MHz
Material in Contact with Media	Stainless Steel AISI 316L (DIN 1.4404 / 1.4435) / optionally Hastelloy C-276 Exception: 6 LC HP / 7 LC HP optionally and @ > 600 bar and > 100 °C: Inconel 718 O-Rings: Viton® 70 Shore A @ 6 LC HP / 7 LC HP: Viton® 90 Shore A Support Ring @ 6 LC HP / 7 LC HP: PTFE
Pressure Endurance	0...100% FS @ 25°C: > 10 mio. pressure cycles with appropriate installation (see install. requirements)
Vibration Endurance	20 g, 5....2000 Hz, X/Y/Z-axis
Shock	75 g sine 11 ms
Oil Filling	Silicone oil, others on request
Electrical Connection	- Glass feed through pins D = 0,45 mm, L = 2,5...4 mm, Positioning: See scale drawing. Attention: It's important not to load forces to the pins! - Silicone wires 0,09 mm² @ the glass feed through pin - Plug JST 1,5 mm, 3-pole. Type: B3B-ZR-SM4-TF. Only for -20...85 °C and not for 4 LC & 6 LC As counterpart: IDC-socket with 1,27 mm flat band. Type: 03ZR-8M-P As counterpart: Crimp-socket with wires AWG 28. Type: ZHR-3, Crimp-contact: SZH-003-P0.5
Options	Other pressure and temperature ranges, other accuracies.

PDD Applications

- Real-time downhole hydraulics monitor
- Real-time ECD monitoring and management
- Annulus cuttings overload detection
- Washout detection
- Kick monitoring and control
- Lost circulation detection
- Mud motor performance and control
- Mud rheology control
- Optimisation of hole cleaning
- Formation fracture / loss limitation
- Air and underbalanced drilling well control
- Nitrogen / Air mix control
- MSE measurement optimisation for Formation Evaluation

Managed Pressure Drilling

- Managing the annular hydraulic pressure profile within the allowed pressure window
- Well control within this window
- Assistance from modelling tools and automated control systems

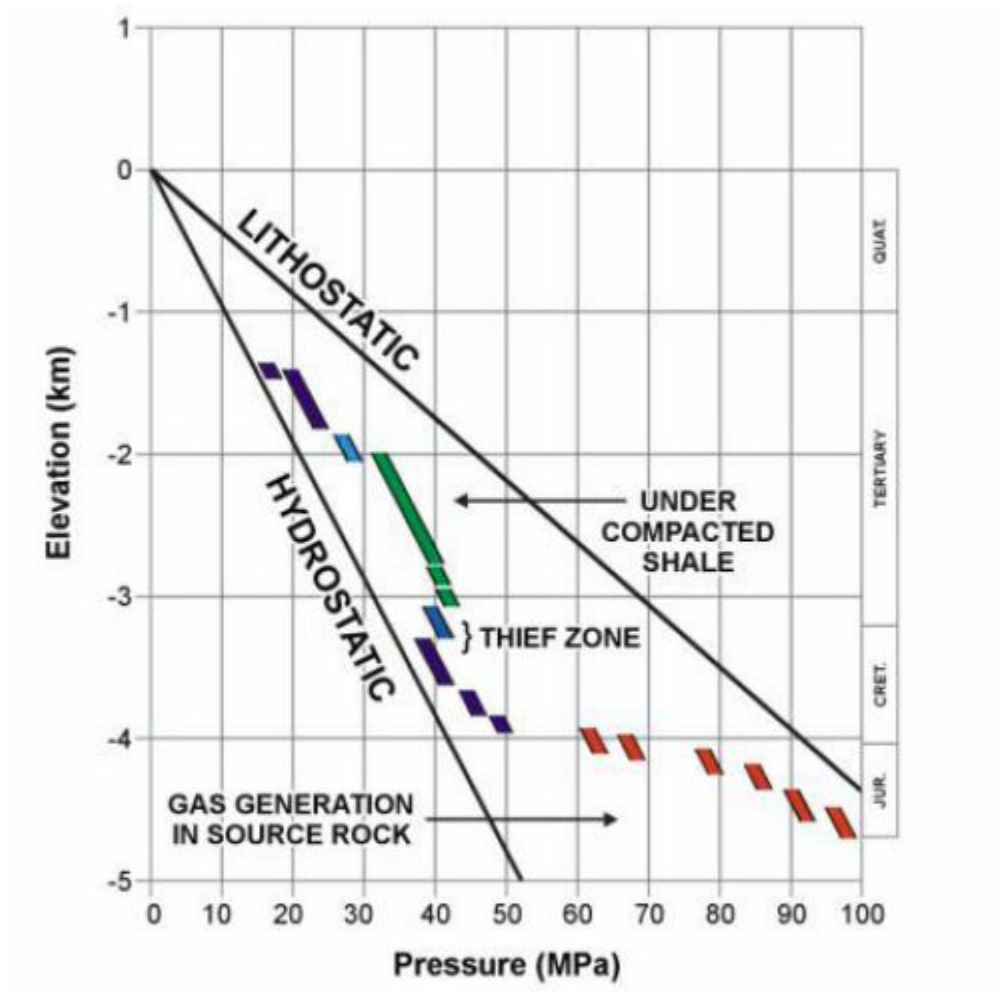
MPD may be accomplished by many means including

- Backpressure
- Variable fluid density
- Fluid rheology
- Circulation friction
- Hole geometry
- Using an active device to manipulate the mud gradient and dynamic pressure

Aims of MPD

- Control Abnormal Pressures
  - Borehole Quality (Sloughing or Collapse)
  - Blow out prevention
- Stay within Fracture Gradient
  - Ensure Casing Shoe Integrity
  - Limit or Stop Lost Circulation
- Restrict or Eliminate Reservoir Damage
  - Prevent Mud / Mud Solids Entering Reservoir Porosity
  - Maximise Production Potential

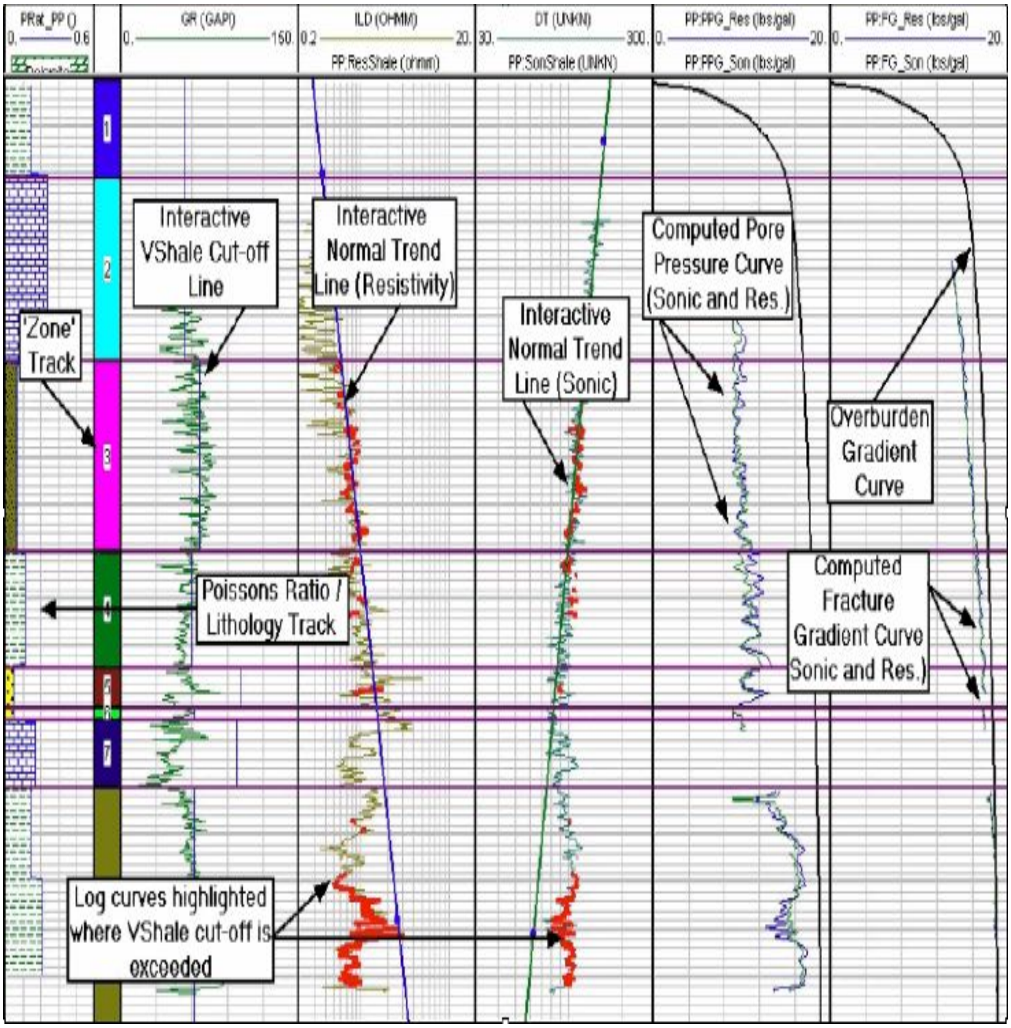
Abnormal Pore Pressure



Pore Pressure Greater or Less than Hydrostatic Pressure

- Rapid Deposition
- Lithology Seal
- Fault Seal
- Depleted Pay Zone

Pore Pressure Prediction

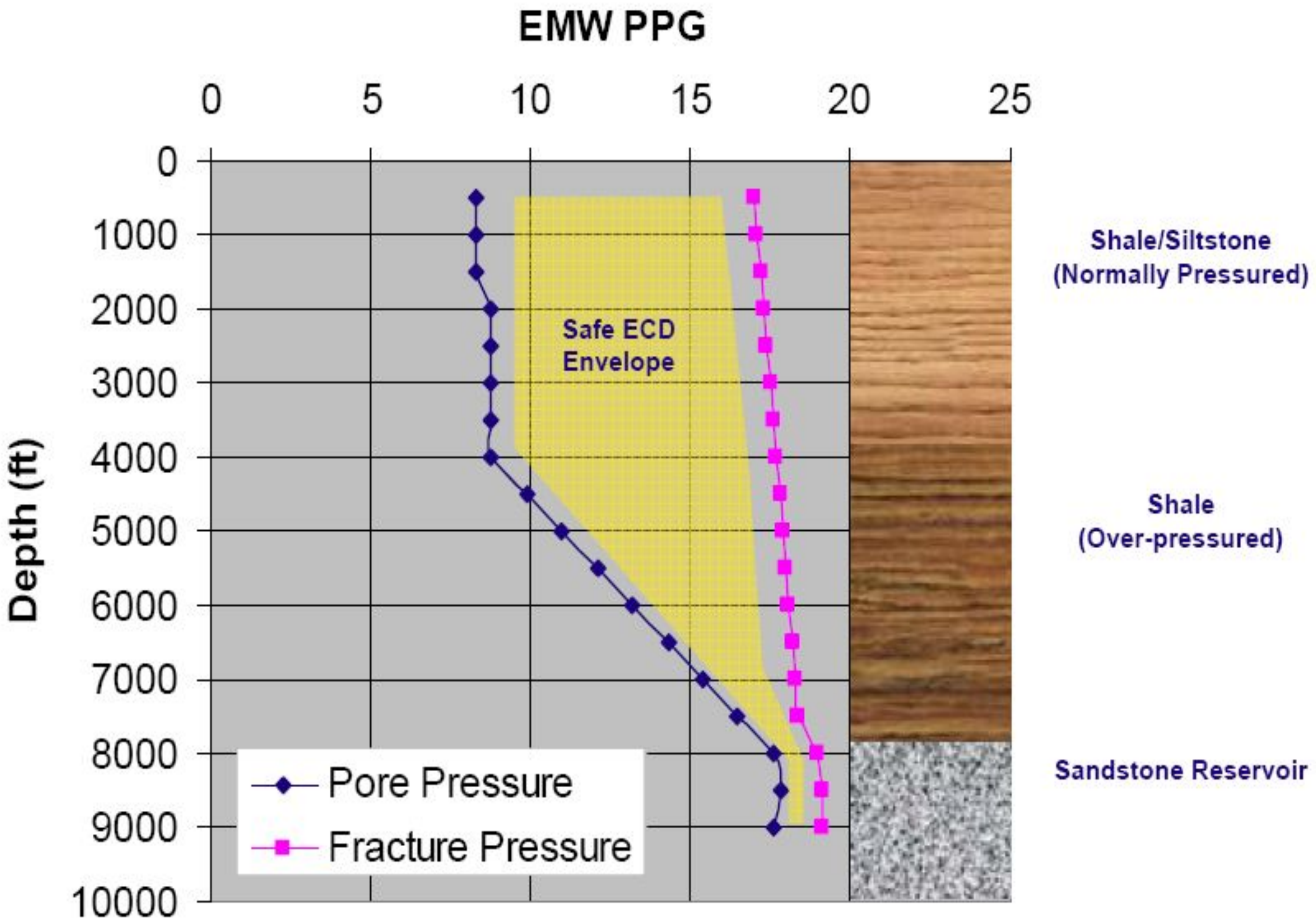


Seismic Data

Log Data

Drilling Data

Mud Weight & ECD Margins



Static Mud Weight and ECD should Control Formation Pressures whilst not approaching Fracture pressure (at last casing shoe)

Failure to Control Pressure

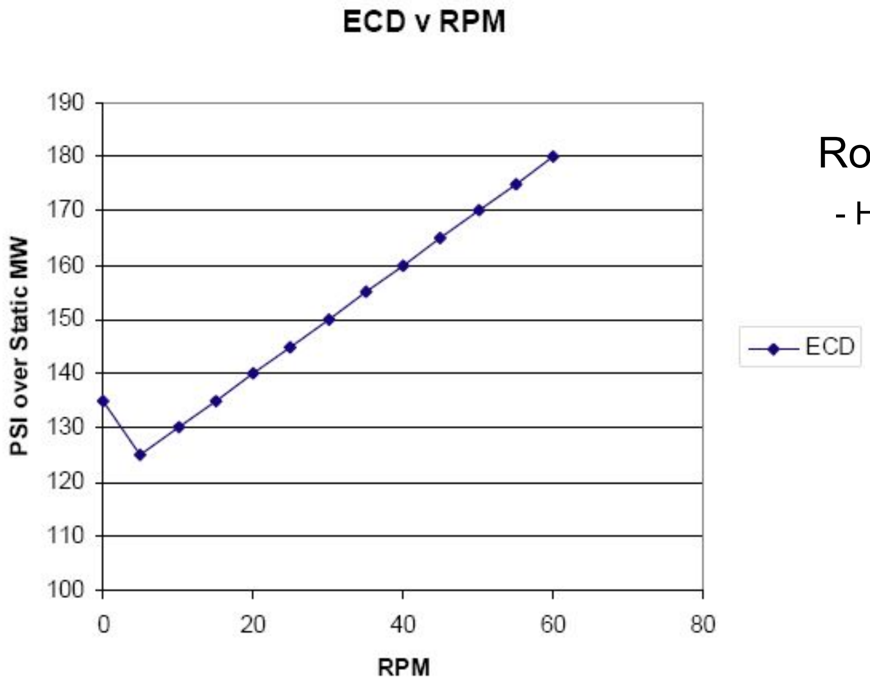
- Shale Caving
- Borehole Rugosity
- Tight Spots
- Well Collapse
- Well Kicks
- Blow Out
- Lost Circulation
- Reservoir Damage

ECD – Effective Circulating Density

$$EMW = \{PDD\ P_{ann}\ (psi) / TVD\ (m) \times 1.421\}$$

- Mud Weight + Annular Friction Losses
- Higher RPM (~>50) increases Annular Friction Losses
- Starting Rotation increases ECD
  - Disturbed cuttings beds
  - Start slowly and circulate clean
- Temperature affects can decrease EMW
- Surge pressures when reaming increase EMW below bit and around BHA
  - Can Cause losses
- Swab pressures when back reaming decrease EMW below bit and around BHA
  - Can cause Kick, connection gas, etc.

RPM Affects ECD



Rotation increases ECD

- Hole size and rhelogy dependant

Temperature Effects on EMW

Temperature / pressure Test in Static Borehole

-Expansion of drilling fluid

-Well weeps fluid to surface

-Reduction of average column density