

360RWD

Phoenix's 360^{RWD} (Resistivity While Drilling) sub is a spatially compensated, dual frequency, dual spacing device designed for wireline-equivalent Logging While Drilling (LWD) and Measurements After Drilling (MAD) services in all well types. Applications include geosteering, correlation, pore pressure trend analysis, casing point selection, wireline replacement, logging while tripping and logging with and without the flow switch enabled.

- ▶ Symmetrical design, with centrally located antennas, provides real-time compensation, eliminates invasion effects due to measurement delays, and improves accuracy by cancelling variations in receiver channels
- ▶ Operates in all mud types including oil-based and salt-saturated and provides real-time resistivity with flexible transmission formats. High-resolution data is stored in downhole memory which can be retrieved and processed during trips
- ▶ Phoenix provides a complete set of software-enabled borehole corrections and applications, including a dipping bed model for geosteering
- ▶ Integrated with the 360^{RWD} sub, Phoenix uses its robust and reliable P-360 Pulse MWD tool for ease of operation and increased MTBF

OPERATING PARAMETERS

Parameter	Range
Telemetry	Positive Mud Pulse
Collar Sizes	89, 121, 172 mm (3.5, 4.75, 6.75 in)
Operating Flow Rate	Up to 4.2 m ³ /min (1,100 gpm)
Mud Weight	900–2,150 kg/m ³ (7.5–18 ppg)
Sand Content	<2%
Operating Temperature	-18°C–150°C (0°F–302°F)
Operating Pressure	Maximum 135,000 kPa (20,000 psi)
Pressure Drop Across Tool	700 kPa @ 1.5 m ³ /min (100 psi @ 400 gpm)
LCM Tolerance	50 lb per bbl medium nut plug/143 kg/m ³

GENERAL SPECIFICATIONS

Tool Size	Borehole Size	Maximum Dogleg Severity		Connection	Max. Flow Rate, gpm (L/sec)
		Sliding	Rotating		
3.5" (89 mm)	4.625–4.75 in (117–121 mm)	40°/100 ft	16°/100 ft	2 7/8 AOH	120/150 (7.6/9.5) ¹
4.75" (121 mm)	5.625–6.125 in (142–165 mm)	25°/100 ft	13°/100 ft	NC38	280/350 (17.7/22.1) ²
6.75" (172 mm)	8.375–9.875 in (213–2512 mm)	24°/100 ft	10°/100 ft	NC50	700 (44.2) ³

¹ Operation from 120–150 gpm (7.6–9.5 L/sec) will accelerate erosion and will reduce service life

Operation above 150 gpm (9.5 L/sec) will result in severe erosion

² Operation from 280–350 gpm (17.7–22.1 L/sec) will accelerate erosion and will reduce service life

Operation above 350 gpm (22.1 L/sec) will result in severe erosion

³ Operation above 700 gpm (44.2 L/sec) will result in severe erosion

Sand content: <1% by volume recommended

POWER REQUIREMENTS

- ▶ Low operating power for maximum battery life
- ▶ Runs on three 32 Volt 9 cell lithium batteries
- ▶ 32MB internal memory
- ▶ Hatch cover for easy access via an intrinsically safe connection to allow tool programming and memory dump

RESISTIVITY MEASUREMENTS

Frequency	Measurement	Range	Accuracy
2 MHz	Phase Difference	0.1–2,000 ohm-m	± 1% [0.1–50 ohm-m] ± 0.5 mmho/m [above 50 ohm-m]
	Amplitude Ratio	0.1–500 ohm-m	± 2% [0.1–25 ohm-m] ± 1.0 mmho/m [above 25 ohm-m]
400 kHz	Phase Difference	0.1–1,000 ohm-m	± 1% [0.1–25 ohm-m] ± 1.0 mmho/m [above 25 ohm-m]
	Amplitude Ratio	0.1–200 ohm-m	± 5% [0.1–10 ohm-m] ± 5.0 mmho/m [above 10 ohm-m]

TRANSMITTER SPACING

	Measurement Point					
	UH					DH
	T ₁	T ₂	R ₁	R ₂	T ₃ *	T ₄
in	-36.00	-22.50	-4.25	+4.25	+22.50	+36.00
mm	-914.4	-571.5	-107.9	+107.9	+571.5	+914.4

* Not included in 3.5" size

DEPTH OF INVESTIGATION

R _f = 1 ohm-m R _{xo} = 0.5 ohm-m	Depth of Investigation		Vertical Resolution ¹
	Short Spacing Radius	Long Spacing Radius	
2 MHz Phase	21 in (533 mm)	28 in (711 mm)	8 in (203 mm)
2 MHz Phase	26 in (660 mm)	37 in (940 mm)	8 in (203 mm)
400 kHz Phase	30 in (762 mm)	39 in (991 mm)	12 in (305 mm)
400 kHz Phase	36 in (914 mm)	49 in (1,245 mm)	12 in (305 mm)
2 MHz Amplitude	34 in (866 mm)	44 in (1,118 mm)	8 in (203 mm)
2 MHz Amplitude	40 in (1,016 mm)	53 in (1,346 mm)	8 in (203 mm)
400 kHz Amplitude	52 in (1,321 mm)	66 in (1,676 mm)	12 in (305 mm)
400 kHz Amplitude	60 in (1,524 mm)	76 in (1,930 mm)	12 in (305 mm)

¹ 90% response in conductive beds