



HEL™ MWD System—High-Temperature Azimuthal Gamma Ray (HAGR™) Sensor

The *HAGR* sensor is an integral part of the hostile environment Logging (*HEL*) MWD system using Geiger Muller tubes to obtain real-time azimuthal gamma ray measurements while drilling. The azimuthal data can be transmitted in quadrant or up/down format for geosteering applications.

The *HAGR* sensor provides real-time azimuthal gamma ray measurements while rotating or sliding at temperatures up to 356°F (180°C) and pressures up to 30,000 psi (207 MPa). This extreme operating requirement requires the use of Geiger Muller tubes rather than scintillation detectors. Five banks of two tubes each are implemented in the 4 3/4-in. sensor, while eight banks are implemented in the 6 3/4- and 8-in. sensors. The number, size and symmetric distribution of tubes were chosen to provide the greatest combination of statistical precision and azimuthal sensitivity.

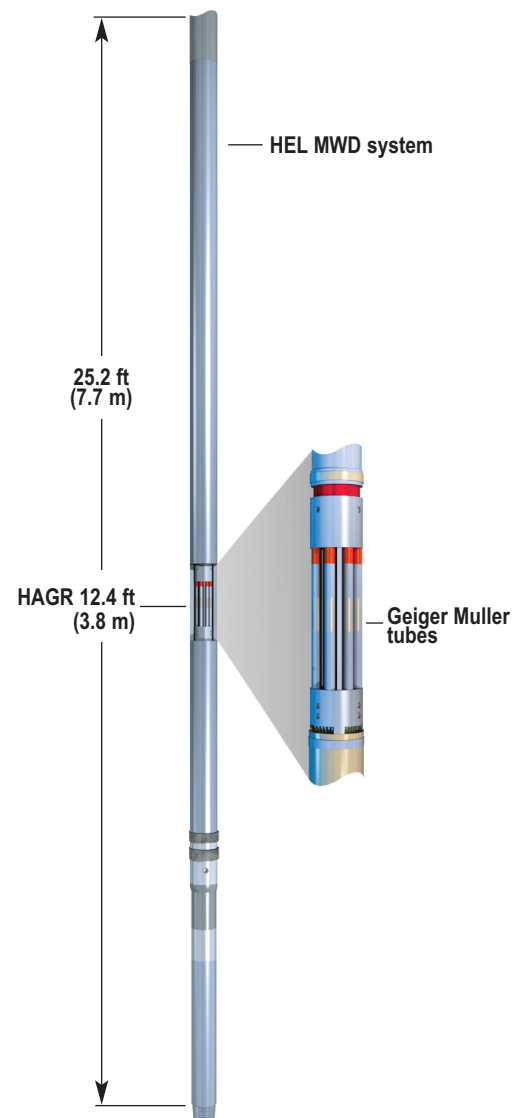
All tools are calibrated to API standards using a combination of measurements made at the University of Houston API gamma ray facility, measurements made in secondary standards and computer modeling. Correction algorithms, developed for mud weight, borehole size and potassium concentration, are in agreement with lab measurements. Field data obtained with the *HAGR* sensor show good correlation with wireline data from the same well.

Applications

- Extreme operating specifications enable accurate, critical formation evaluation data in all challenging environments.

Features, Advantages and Benefits

- Rated up to 30,000 psi (207 MPa) operating pressure, depending on tool size.
- Geiger Muller tubes measure real-time gamma ray to statistically precise ± 5 API at 100 API for 20-s unfiltered samples (± 2.5 API with a five-point non-block filter).
- Rated to 356°F (180°C) operating temperature.
- Data transmitted to surface via the *HEL* MWD system using mud pulse telemetry or EMPulse™ electromagnetic MWD system.





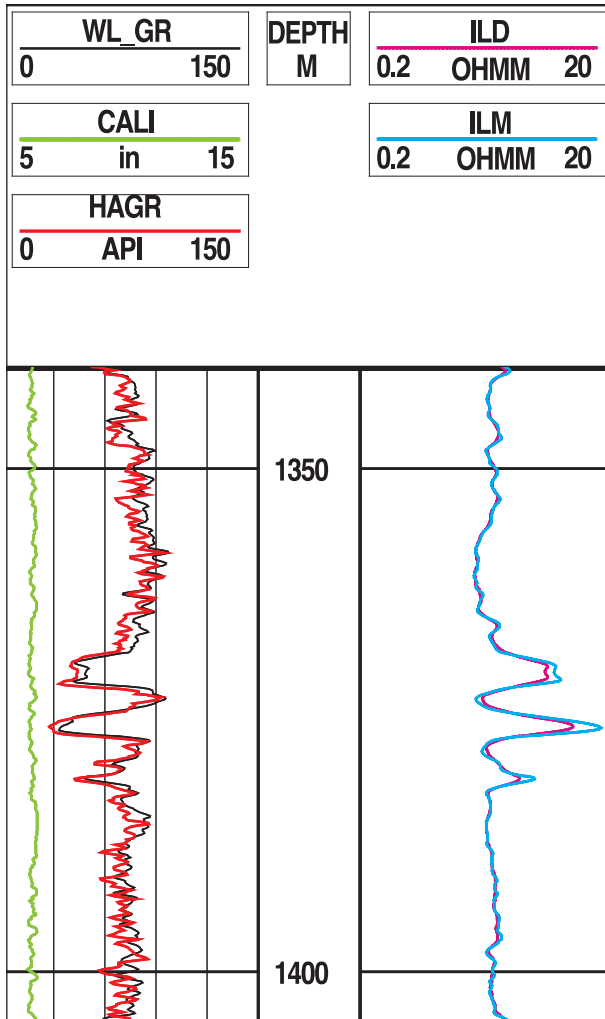
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Specifications

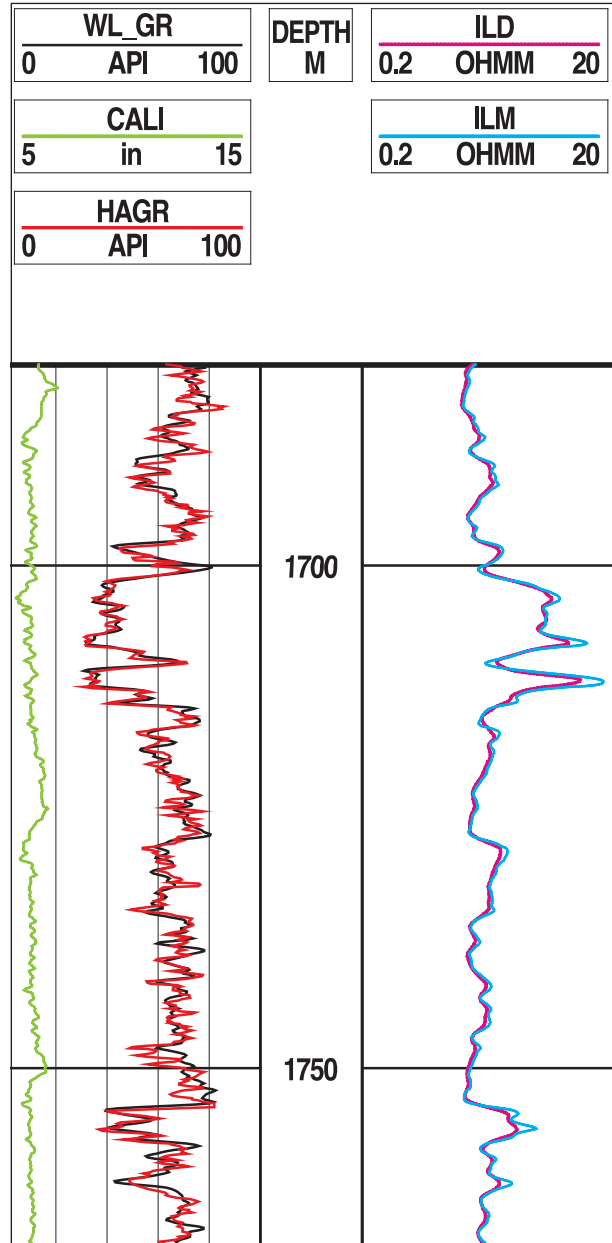
HEL MWD System Mechanical Specifications					
Nominal Sensor OD	4 3/4 in.	6 3/4 in.	8 in.	8 1/4 in.	9 1/2 in.
Maximum OD	5 1/4 in.	7 3/8 in.	8 5/8 in.	8 7/8 in.	9 1/2 in.
Length (HEL system)	25.2 ft	25.3 ft	25.2 ft	25.6 ft	25.8 ft
Weight	1400 lb	2850 lb	4100 lb	4000 lb	5500 lb
Top connection	3 1/2 IF box	4 1/2 IF box	6 5/8 Reg box	5 1/2 IF box	7 5/8 Reg box
Bottom connection	3 1/2 IF pin	4 1/2 IF pin	6 5/8 Reg pin	5 1/2 IF pin	7 5/8 Reg pin
Make-up torque	9900–10,900 ft-lb	28,000–32,000 ft-lb	52,000–56,000 ft-lb	53,000–56,000 ft-lb	75,000–78,000 ft-lb
Maximum torque	16,700 ft-lb	44,700 ft-lb	77,300 ft-lb	80,100 ft-lb	112,000 ft-lb
Maximum tension	528,000 lb	978,000 lb	1,480,000 lb	1,450,000 lb	1,870,000 lb
Bending strength ratio	2:10	2:53	2:70	2:47	3:10
Maximum dogleg severity, rotating	20°/100 ft	11°/100 ft	10°/100 ft	9°/100 ft	8°/100 ft
Maximum dogleg severity, sliding	36°/100 ft	19°/100 ft	16°/100 ft	15°/100 ft	14°/100 ft
Equivalent bending stiffness (OD x ID)	4.75 in. x 3.22 in.	6.75 in. x 4.20 in.	8.0 in. x 4.18 in.	8.25 in. x 5.17 in.	9.5 in. x 5.16 in.
Maximum operating temperature	356°F (180°C)	356°F (180°C)	356°F (180°C)	356°F (180°C)	356°F (180°C)
Maximum operating pressure	30,000 psi (207 MPa)	30,000 psi (207 MPa)	30,000 psi (207 MPa)	25,000 psi (172 MPa)	25,000 psi (172 MPa)
Maximum flow rate	400 gal/min	800 gal/min	800 gal/min	1800 gal/min	1800 gal/min
Maximum sand content	2%	2%	2%	2%	2%
HAGR Sensor Specifications					
Measurement range	0-250 API	0-250 API	0-250 API	0-250 API	0-250 API
Accuracy	± 2 API	± 2 API	± 2 API	± 2 API	± 2 API
Vertical resolution	18 in.	18 in.	18 in.	18 in.	18 in.
Statistical repeatability	± 5 API @ 100 ft/hr	± 5 API @ 100 ft/hr	± 5 API @ 100 ft/hr	± 5 API @ 100 ft/hr	± 5 API @ 100 ft/hr
Measure point from bottom of sensor	12.5 ft	12.3 ft	12.4 ft	12.4 ft	12.4 ft



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Log Example



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