

### SureLog-AZG



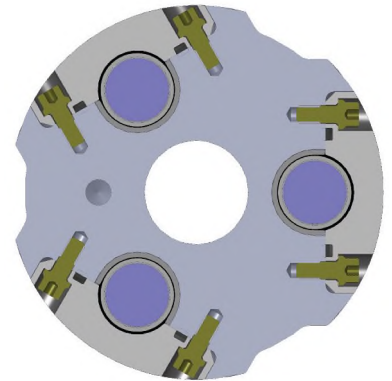
# Azimuthal Gamma Ray Sensor (AZG™)

APS Technology's SureLog™ azimuthal gamma ray (AZG™) sensor enables accurate geosteering by adding imaging capabilities to existing APS Measurement-While-Drilling/Logging-While-Drilling (MWD/LWD) measurements. This sensor employs three ruggedized, shielded gamma ray detectors with photomultiplier tubes along with a directional package, which are mounted in a specially designed collar-based system. This system provides protection against the high levels of shock and vibration experienced during drilling, while also providing maximum measurement sensitivity to the formation. This new sensor is designed specifically for low power consumption and is backward compatible with APS's (MWD) system, including the WPR™ resistivity sensor.



**Gamma Ray Image Log**

APS's azimuthal gamma ray sensor can be programmed to acquire gamma ray data in up to 24 azimuthally sectored bins around the borehole, as well as provide a total gamma ray measurement. Binned data and total gamma data are both recorded in memory and telemetered to the surface for real-time steering decisions. The APS azimuthal gamma sensor is also capable of providing a calibrated API-standard gamma ray response. A well site check source is available to ensure proper pre/post run operational performance, both for use in the field and at the maintenance facility.



The easy-to-use SureLog surface system scales the gamma ray readings to API units, correcting for borehole size, mud weight, collar effects and KCl content of the drilling fluid. The SureLog system is capable of displaying both the total gamma ray log and the gamma image log in real time and as memory log plots. In addition to the log plot displays, the surface system provides user-defined hard copy output logs. Data can be exported in standard log copy formats such as WITS, LAS and ASCII.



Global perspective. Independent thinking.

# Azimuthal Gamma Ray Sensor (AZG™)

## Preliminary Product Specifications

<b>Tool OD</b>	4.75 and 6.75 in. (121 and 171 mm)
<b>Sub Length</b>	88 in. (2235 mm)
<b>Measure Point</b>	~ 30 in. (762 mm) from downhole end
<b>Sensors</b>	3 NaI scintillation detectors with PMTs
<b>Measurement Range API</b>	API-calibrated 0 - 800 API $\pm 3$ API @ 100 API 0.8 cps API per detector
<b>Data Sampling Rate</b>	Programmable, in up to 24 bins
<b>Vertical Resolution</b>	6 in. (152 mm)
<b>Maximum Temperature</b>	302°F (150°C) and 347°F (175°C)
<b>Maximum Pressure</b>	20,000 psi (137.9 MPa)

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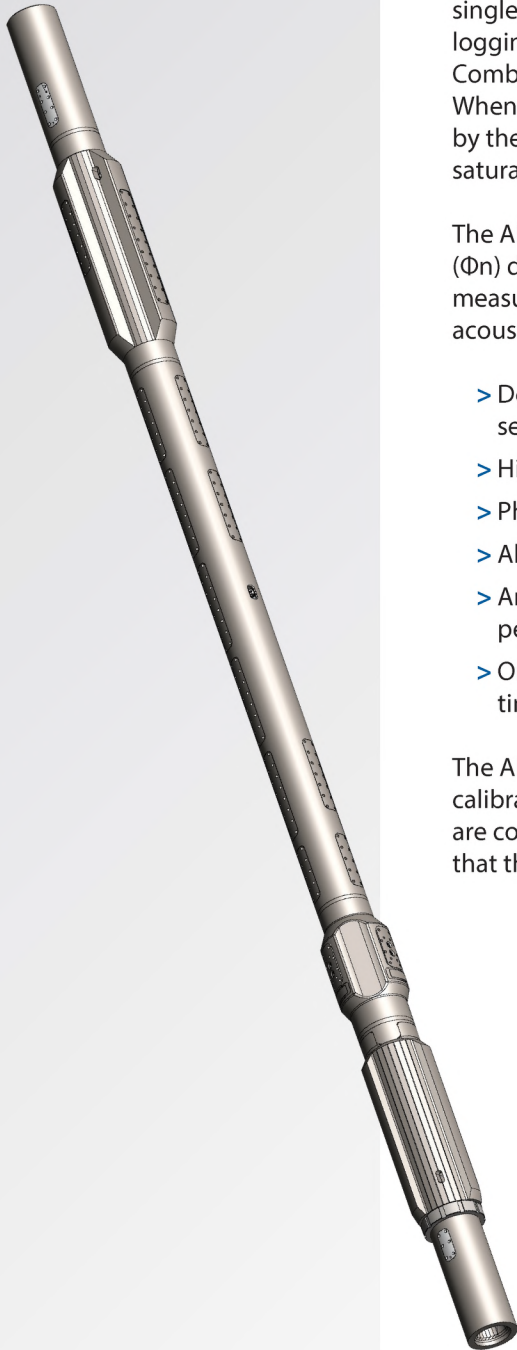
contact@aps-tech.com

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Specifications subject to change without notice.

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### SureLog-iPCD™



# Integrated Porosity, Caliper & Density Sub (iPCD™)

APS Technology's SureLog™ iPCD™ (integrated Porosity, acoustic Caliper & Density) sub adds neutron porosity and litho-density measurements to the SureShot™ MWD / LWD platform. This capability enables extended formation evaluation measurements from a single additional sensor sub. The iPCD is a cost-competitive, reliable formation evaluation logging tool that provides the basic functionality for customers to deliver "Triple Combo" services which, until now, have been restricted to the major service companies. When used in combination with natural gamma and resistivity logs, the logs produced by these new sensors provide a timely and useful estimate of the porosity and water saturation for each reservoir formation, typically before significant invasion.

The APS iPCD provides real-time bulk density ( $\Delta\rho$  or "delta rho") and neutron porosity ( $\Phi_n$ ) data to characterize formation porosity and lithology while drilling. All nuclear measurements are borehole compensated using the standoff data provided by a novel acoustic caliper.

- > Density sensor provides user-configurable formation imaging data with 4 or more sectors in real-time and 24 sectors from memory.
- > High-resolution images allow for structural/stratigraphic dip analysis.
- > Photoelectric factor (Pe) data is stored in memory.
- > All measurements include quality factors and standard log data.
- > An array of rugged acoustic transducers provides a borehole shape/diameter log, permitting borehole breakout analysis.
- > One set of transducers is aligned with the density neutron detectors for accurate real-time standoff measurement.

The APS iPCD tool includes all of the software tools needed for modeling, testing, calibration and borehole correction calculations. In addition, all designs and procedures are consistent with the safe (and licensed) handling of the radioactive sources and ensure that these sources are properly retained while the tools are downhole.

## Nuclear Support

APS will assist customers with the infrastructure planning and procurement of equipment required for safe and compliant handling of nuclear source materials, including establishing requirements and best practices for:

- > Safe storage, handling and transportation of nuclear sources
- > Setting procedures for periodic inspection of nuclear sources
- > Testing, calibration, installation and removal of nuclear sources
- > Design of emergency handling tools and procedures
- > Training of shop and rig site personnel
- > Setting requirements for radiation monitoring and dosimetry

***Establishing and complying with proper procedures is essential to ensure the safety and protection of affected personnel and the environment.***

# Integrated Porosity, Caliper & Density Sub (iPCD™)

## Product Specifications



Dimensions			
Nominal Diameter	4.75 in. (121 mm)	6.75 in. ( 172 mm)	8.0 in. (204 mm)
Length	17.5 ft	19 ft	19 ft
Operational			
Neutron Porosity – Near & Far Li <sup>6</sup> I Crystal / PMT Detectors			
5 Curie AmBe source	1		
Accuracy	±0.5 p.u. < 10 p.u.; ±5% 10-50 p.u.		
Acoustic Caliper			
Transceivers	3		
Azimuth Capable	Yes		
Accuracy	±0.2 in.		
Density – Short & Long NaI Crystal / PMT Scintillation Detectors			
1.7 Curie Cs <sup>137</sup> Source	1		
Azimuthal Capable	Yes		
Operating Range	1.5 g/cc to 3.0 g/cc		
Density Accuracy (30 sec, 1 $\sigma$ )	±0.015 g/cc @ 2.2 g/cc		
Density Repeatability (30 sec, 1 $\sigma$ )	±0.010 g/cc @ 2.2 g/cc		
Pe Accuracy (30 sec, 1 $\sigma$ )	±0.25 B/e <sup>-</sup> (1 - 5 B/e <sup>-</sup> )		
Environmental			
Maximum Temperature	302°F / 150°C (347°F / 175°C option)		
Maximum Pressure	20,000 psi (137.9 MPa)		

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# SureLog-iPZIG

## At-Bit Inclination and Image Gamma Ray Service

### APPLICATIONS

- Real-time geosteering
- Horizontal, ERD, and directional drilling
- Steering within formations with dipping beds
- Casing point selection by detecting formation changes at the bit

### BENEFITS

- Optimal well placement in reservoirs
- Accelerated production
- Reduced well tortuosity and dogleg severity
- Early bed boundary detection

### FEATURES

- Inclination and natural gamma ray measurements situated at the bit
- Azimuthal natural gamma ray image measurements at bit
- Wireless electromagnetic communication between upper and lower subs with data transmitted real-time via Pathfinder MWD system
- Compatible with positive displacement motors and rotary steerable tools
- Stand-alone battery operated electronics
- Compatible with all mud types

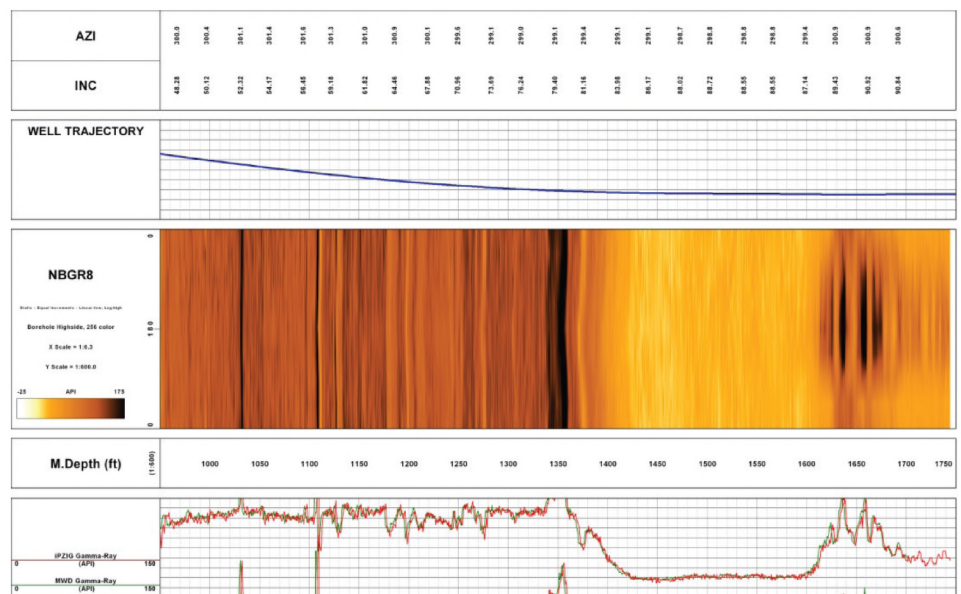
The SureLog™ tool family includes the iPZIG\* system. The iPZIG tool provides at-bit gamma ray images along with traditional natural gamma ray measurements, dynamic inclination, RPM and temperature. The at-bit gamma ray image can be provided in sectors for superior real-time geosteering capabilities that include formation bed dip calculations.

Operating directly behind the drill bit, the iPZIG at-bit inclination and gamma ray service provides real-time measurements that reduce directional drilling risk in critical hole sections. The early indication of changes in lithology, delivered by the gamma ray log, helps to accurately land horizontal wells.

Designed to operate as two separate subs, a lower sub, located directly above the drill bit, acquires data and transmits data to the upper sub, located above the drilling mud motor. The upper sub provides communication to measurement/logging-while-drilling systems.

The iPZIG can accommodate flexible bottomhole assembly (BHA) designs, and is compatible with any drilling mud motor. iPZIG provides the closest to the bit sensor offsets available in the industry and is the only tool to provide both gamma and inclination at the bit. These measurements are used to help determine well path placement and de-termined position in real-time while drilling.

The iPZIG sub is an accurate, cost effective geosteering solution whether drilling for optimum reservoir drainage, setting casing, or just to determine position real-time while drilling.



<b>Tool Specifications</b>			
Nominal OD, in [mm]	4 ¾ [120.7]	6 ¾ [171.5]	8 [203.2]
Maximum OD, in [mm]	5.25 [133.4]	7.25 [184.2]	8.25 [209.6]
UXM tool joint	3 ½ IF Box/Pin	5 ½ FH Box/Pin	5 ½ IF Box/Pin
LXM tool joint	3 ½ Reg Pin/Box	4 ½ Reg Pin/Box	6 ⅝ Reg Pin/Box
UXM length, ft [m]	7.13 [2.17]	5.92 [1.81]	5.92 [1.81]
LXM length, ft [m]	3.33 [1.02]	3.66 [1.12]	3.66 [1.12]
UXM weight, lbm [kg]	375 [170]	620 [282]	756 [344]
LXM weight, lbm [kg]	210 [95]	370 [168]	510 [232]
LXM equivalent stiffness, in [mm]	4.43 [112.5] ID/ 2.25 [57.2]OD	5.99 [152.1] ID/ 2.81 [71.4]OD	6.96 [176.8] OD/ 2.81 [71.4] ID
LXM avg. moment of inertia, in <sup>4</sup> [mm <sup>4</sup> ]	17.6 [722.7]	60 [2,463.7]	112 [4,598.9]
UXM equivalent stiffness, in [mm]	4.52 [114.8] ID/ 2.25 [57.2]OD	6.34 [161.0] ID/ 2.81 [71.4]OD	7.34 [186.4] OD/ 2.81 [71.4] ID
UXM avg. moment of inertia, in <sup>4</sup> [mm <sup>4</sup> ]	19.2 [788.4]	76.2 [3,128.9]	122 [5,099.6]
<b>Tool Joints, 4 ¾ in</b>		<b>Tool Joints, 6 ¾ in</b>	
API 3 ½ IF, field (UXM)		API 5 ½ FH, field (UXM)	
Makeup torque, ft.lbf [N.m]	9,000 [12,202]	Makeup torque, ft.lbf [N.m]	25,000 [33,895]
Bending-strength ratio	2.06	Bending-strength ratio	1.81
API 3 ½, Reg (LXM)		API 4 ½ Reg, (LXM)	
Makeup torque, ft.lbf [N.m]	8,000 [10,847]	Makeup torque, ft.lbf [N.m]	24,000 [32,540]
Bending-strength ratio	4.41	Bending-strength ratio	4.02
<b>Tool Joints, 8 in</b>			
API 5 ½ IF, field (UXM)			
Makeup torque, ft.lbf [N.m]	38,000 [51,520]		
Bending-strength ratio	2.35		
API 6 ⅝ Reg (LXM)			
Makeup torque, ft.lbf [N.m]	38,000 [51,520]		
Bending-strength ratio	3.48		
<b>Operating Limits<sup>†</sup></b>			
Max. dogleg, rotating, deg/ft	17/100	10/100	10/100
Max. dogleg, sliding, deg/ft	31/100	16/100	16/100
Max. tension, lbf [kg]	263,000 [119,295]	400,000 [181,437]	450,000 [204,117]
Max. torque, ft.lbf [N.m]	9,000 [12,203]	23,000 [31,184]	35,000 [47,453]
Max. operating temp., degF [degC] <sup>††</sup>	302 [150], 350 [175]	302 [150], 350 [175]	302 [150], 350 [175]
<b>Measurement Specifications</b>			
Gamma ray sensor offset, in [mm]	16.69 [423.9]	21.00 [533.4]	21.29 [540.8]
Inclination sensor offset, in [mm]	34.1 [866.1]	38.55 [979.2]	39.14 [994.2]
Inclination range, deg	5 to 180	Inclination accuracy, deg	0.3
At bit rpm	30 to 450	Total gamma range, API	0 to 1,200

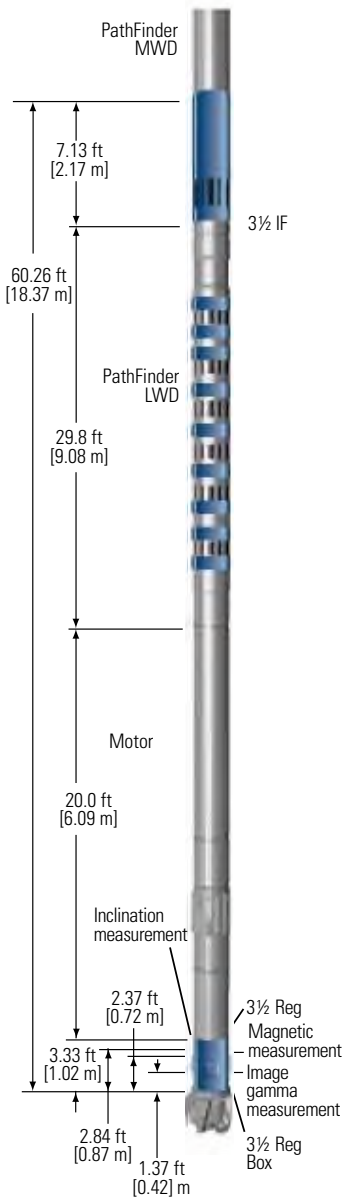
<sup>†</sup>Contact APS Technology for limitations in specific applications.

<sup>††</sup>Standard tool configuration 32 to 302 degF [0 to 150 degC], optional Survivor Series rating 32 to 350 degF [0 to 175 degC].

# iPZIG 475

## At-Bit Inclination and Image Gamma Ray Service

## Mechanical Specifications



### Tool Specifications

Nominal OD, in [mm]	4 3/4 [120.7]	Max. OD, in [mm]	5.25 [133.4]
Internal diameters, in [mm]		Internal diameters, in [mm]	
UXM	3.50 [88.9], 2.80 [71.1], 2.50 [63.5]	LXM	3.80 [96.5], 1.10 in [27.9]
Length, ft [m]		Length, ft [m]	
UXM	7.13 [2.17]	LXM	3.33 [1.02]
Tool joints, box/pin		Tool joints, box/pin	
UXM	3 1/2 IF	LXM	3 1/2 Reg
Weight, lbm [kg]		Weight, lbm [kg]	
UXM	375 [170]	LXM	210 [95]
UXM Equivalent stiffness, in [mm]	4.52 [114.8] OD/2.25 [57.2] ID	UXM Avg. moment of inertia, in <sup>4</sup> [cm <sup>4</sup> ]	19.2 [788.4]
LXM Equivalent stiffness, in [mm]	4.43 [112.5] OD/2.25 [57.2] ID	LXM Avg. moment of inertia, in <sup>4</sup> [cm <sup>4</sup> ]	17.6 [722.7]

### Tool Joint Specifications

API 3 1/2 IF, field (UXM)	
Makeup torque, lbf.ft [N.m]	9,000 [12,202]
Bending-strength ratio	2.35
API 3 1/2 Reg, (LXM)	
Makeup torque, lbf.ft [N.m]	8,000 [10,847]
Bending-strength ratio	4.41

### Sensor Measurement Points

Image gamma measurement, ft [m]	1.37 [0.42]
Magnetic measurement, ft [m]	2.37 [0.72]
Inclination measurement, ft [m]	2.84 [0.87]

### Operating Specifications

Max. dogleg, rotating, °/100 ft	17	Max. dogleg, sliding, °/100 ft	31
Max. tension, lb [kg]	263,000 [119,295]	Maximum torque, lbf.ft [N.m]	9,000 [12,203]
Max. temp., degF [degC]	302 [150], 350 [175] <sup>†</sup>	Flow rates, galUS/min [m <sup>3</sup> /min]	125 to 375 [0.473 to 1.420]

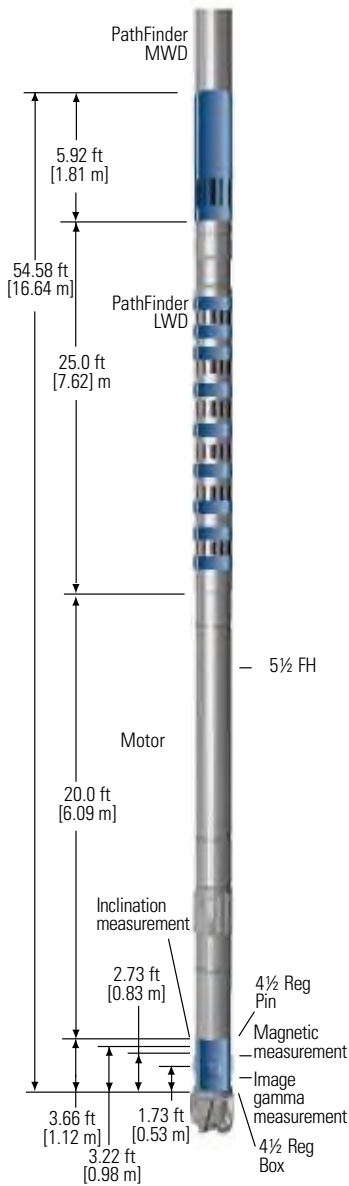
Note: All dimensions are nominal. Configuration options are available. Tool drawing is not to scale.

<sup>†</sup>Standard tool configuration 32 to 302 degF [0 to 150 degC], optional Survivor Series rating 32 to 350 degF [0 to 175 degC].

# ipZIG 675

## At-Bit Inclination and Image Gamma Ray Service

# Mechanical Specifications



### Tool Specifications

Nominal OD, in [mm]	6¾ [171.5]	Max. OD, in [mm]	7.25 [184.2]
Internal diameters, in [mm]		Internal diameters, in [mm]	
UXM	5.10 [129.5], 4.00 [101.6], 3.50 [88.9]	LXM	5.30 [134.6], 2.00 [27.9]
Length, ft [m]		Length, ft [m]	
UXM	5.92 [1.81]	LXM	3.66 [1.12]
Tool joints, box/pin		Tool joints, box/pin	
UXM	5½ FH	LXM	4½ Reg
Weight, lbm [kg]		Weight, lbm [kg]	
UXM	620 [282.0]	LXM	370 [168.0]
UXM equivalent stiffness, in [mm]	6.34 [161.0] OD/2.81 [71.4] ID	UXM avg. moment of inertia, in <sup>4</sup> [cm <sup>4</sup> ]	76.2 [3,128.9]
LXM equivalent stiffness, in [mm]	5.99 [152.1] OD/2.81 [71.4]	LXM avg. moment of inertia, in <sup>4</sup> [cm <sup>4</sup> ]	60.0 [2,463.7]

### Sensor Measurement Points

Image gamma measurement, ft [m]	1.73 [0.53]
Magnetic measurement, ft [m]	2.73 [0.83]
Inclination measurement, ft [m]	3.22 [0.98]

### Tool Joint Specifications

API 5½ FH, field (UXM)	
Makeup torque, lbf.ft [N.m]	25,000 [33,895]
Bending-strength ratio	1.81
API 4½ Reg, (LXM)	
Makeup torque, lbf.ft [N.m]	24,000 [32,540]
Bending-strength ratio	4.02

### Operating Specifications

Max. dogleg, rotating, °/100 ft	10	Max. dogleg, sliding, °/100 ft	16
Max. tension, lb [kg]	400,000 [181,437]	Maximum torque, lbf.ft [N.m]	38,000 [51,520]
Max. temp., degF [degC]	302 [150], 350 [175] <sup>†</sup>	Flow rates, galUS/min [m <sup>3</sup> /min]	250 to 750 [0.946 to 2.839]

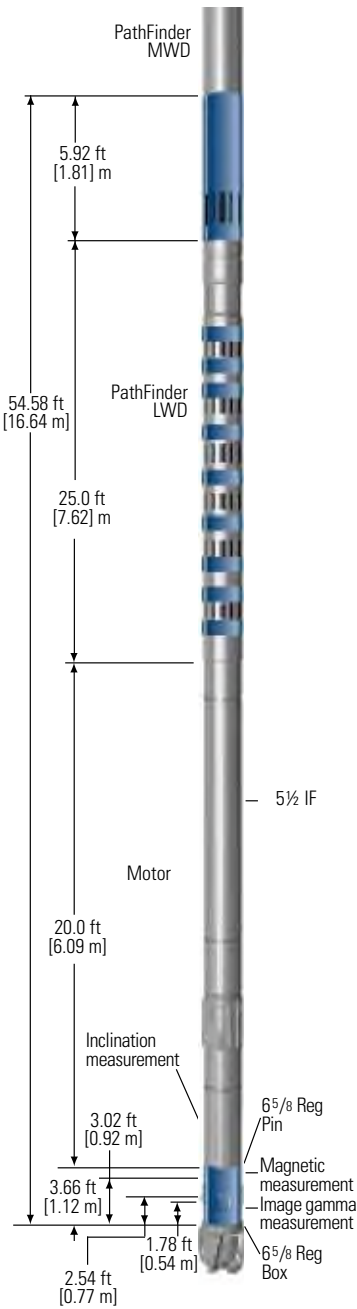
Note: All dimensions are nominal. Configuration options are available. Tool drawing is not to scale.

<sup>†</sup>Standard tool configuration 32 to 302 degF [0 to 150 degC], optional Survivor Series rating 32 to 350 degF [0 to 175 degC].

# iPZIG 800

## At-Bit Inclination and Image Gamma Ray Service

# Mechanical Specifications



### Tool Specifications

Nominal OD, in [mm]	8 [171.5]	Max. OD, in [mm]	8.25 [209.6]
Internal diameters, in [mm]		Internal diameters, in [mm]	
UXM	5.10 [129.5], 4.00 [101.6], 3.50 [88.9]	LXM	5.30 [134.6], 2.00 [27.9]
Length, ft [m]		Length, ft [m]	
UXM	5.92 [1.81]	LXM	3.66 [1.12]
Tool joints, box/pin		Tool joints, pin/box	
UXM	5½ IF	LXM	6⅝ Reg
Weight, lbm [kg]		Weight, lbm [kg]	
UXM	756 [344]	LXM	510 [232]
UXM equivalent stiffness, in [mm]	7.34 [186.4] OD/2.81 [71.4] ID	UXM avg. moment of inertia, in <sup>4</sup> [cm <sup>4</sup> ]	122.0 [5,099.6]
LXM equivalent stiffness, in [mm]	6.99 [176.8] OD/2.81 [71.4]	LXM avg. moment of inertia, in <sup>4</sup> [cm <sup>4</sup> ]	112 [4,598.9]

### Sensor Measurement Points

Image gamma measurement, ft [m]	1.78 [0.54]
Magnetic measurement, ft [m]	2.54 [0.77]
Inclination measurement, ft [m]	3.02 [0.92]

### Tool Joint Specifications

API 5½ IF, field (UXM)	
Makeup torque, lbf.ft [N.m]	38,000 [51,520]
Bending-strength ratio	2.35
API 6⅝ Reg, (LXM)	
Makeup torque, lbf.ft [N.m]	38,000 [51,520]
Bending-strength ratio	4.38

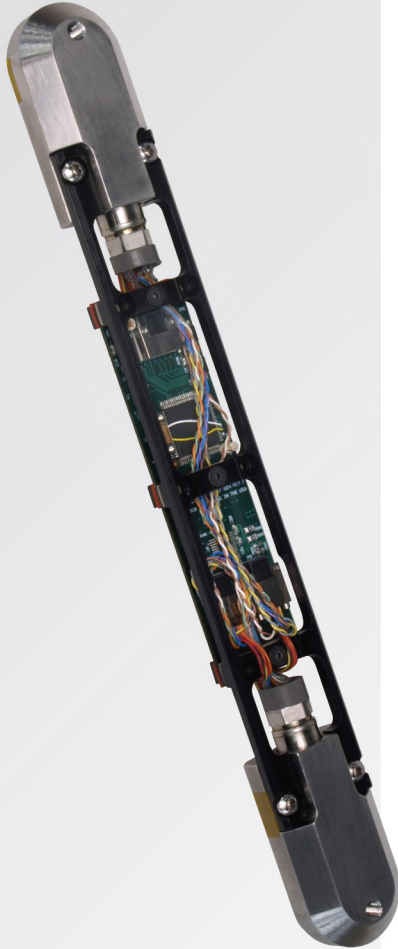
### Operating Specifications

Max. dogleg, rotating, °/100 ft	10	Max. dogleg, sliding, °/100 ft	16
Max. tension, lb [kg]	450,000 [204,117]	Maximum torque, lbf.ft [N.m]	35,000 [47,453]
Max. temp., degF [degC]	302 [150], 350 [175] <sup>††</sup>	Flow rates, galUS/min [m <sup>3</sup> /min]	250 to 750 [0.946 to 2.839]

Note: All dimensions are nominal. Configuration options are available. Tool drawing is not to scale.

<sup>††</sup>Standard tool configuration 32 to 302 degF [0 to 150 degC], optional Survivor Series rating 32 to 350 degF [0 to 175 degC].

**SureLog-WPR-PWD**



# WPR™ Pressure While Drilling Sensor

APS's SureLog™ Pressure While Drilling (PWD) sensor for WPR™ measures annular and drill pipe pressures in 4.75, 6.75 and 8.0 in. (121, 172 and 204 mm) WPRs. Captured data may be transmitted in real time via APS's SureShot™ MWD/LWD system, or stored in downhole memory for later download and analysis. Real-time data or pressure alarms may be transmitted via SureShot MWD.

## Applications include:

### Managing Downhole Pressures

Measurement and real-time monitoring of hydrostatic and dynamic circulating fluid pressures for balanced, managed pressure drilling (MPD), and underbalanced drilling (UBD).

### Maintaining Formation and Borehole Integrity

Real-time annular and bore pressure measurements help assess the optimum pressures required within narrow fracture and pore pressure windows.

### Managing Hydraulics Programs

Real-time determination of equivalent circulating density (ECD) for hole cleaning, swab and surge pressures for borehole stability, and BHA pressure loss.

### Supporting Early Detection Programs

Timely annular, bore, and differential pressure readings facilitate early detection of fluid influx and lost circulation.

## Product Preliminary Specifications

	Measurement	
	Range	Accuracy
<b>Annular Pressure</b>	0 - 20 kpsi (137.9 MPa)	±0.1% of FSR
<b>Drill Pipe Pressure</b>	0 - 20 kpsi (137.9 MPa)	±0.1% of FSR
<b>Resolution</b>	1.0 psi (6,895 Pa)	
<b>Local Temperature Compensation</b>	Yes	
<b>Data Sampling Rate</b>	5 seconds total (annular + drill pipe)	
<b>Data Storage</b>	Raw and compensated data are time-stamped and stored in SureShot memory.	
Environmental		
<b>Operating Temperature</b>	-13° to 347°F (-25° to 175°C)	
<b>Maximum Pressure</b>	20 kpsi (137.9 MPa)	

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# Wave Propagation Resistivity Sub (WPR™)

## SureLog-WPR™



4.75 in.  
(121 mm)  
WPR

APS's SureLog™ WPR™ sub is a spatially compensated, dual frequency (400 kHz & 2 MHz), 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 (for air- and foam-drilled wells).

WPR's symmetrical design, with centrally located receive antennas, provides real-time compensation, eliminates invasion effects due to measurement delays, and improves accuracy by canceling variations in receiver channels.

WPR 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.

APS provides a complete set of software-enabled borehole corrections and applications with WPR, including a dipping bed model for geosteering.

APS offers a Pressure-While-Drilling (PWD) option for 4.75 in., 6.75 in. and 8.0 in. WPR.

## WPR General Specifications – Operational

"Tool Size"	Borehole Size	Maximum Dogleg Severity		Connection	Max. Flow Rate, gpm (L/sec)
		Sliding	Rotating		
3.5 in. (89 mm)	4.625 - 4.75 in. (117 - 121 mm)	40°/100 ft	16°/100 ft	2 7/8 AOH	120/150 <sup>[1, 6]</sup> (7.6/9.5)
3.75 in. (95.25 mm)	4.75 - 5.63 in. (121 - 143 mm)	38°/100 ft	15°/100 ft	2 7/8 AOH	200 <sup>[2, 6]</sup> (12.61)
4.75 in. (121 mm)	5.625 - 6.125 in. (142 - 165 mm)	25°/100 ft	13°/100 ft	NC38	280/350 <sup>[3, 6]</sup> (17.7/22.1)
6.75 in. (172 mm)	8.375 - 9.875 in. (213 - 251 mm)	24°/100 ft	10°/100 ft	NC50	700 <sup>[4, 6]</sup> (44.2)
8.0 in. (204 mm)	12.125 - 14.75 in. (308 - 375 mm)	15°/100 ft	8°/100 ft	6 5/8 Reg.	900/1,200 <sup>[5, 6]</sup> (63.1/75.7)

- 120 gpm (7.6 L/sec) for Non-extended Flow Guide and 150 gpm (9.5 L/sec) for Extended Flow Guide. 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.
- Operating above 200 gpm (12.61 L/sec) will accelerate erosion and will reduce service life.
- Operation from 280 - 350 gpm (17.7 - 22.1 L/sec) will accelerate erosion and will reduce service life. Operating above 350 gpm (22.1 L/sec) will result in severe erosion.
- Operating above 700 gpm (44.2 L/sec) will result in severe erosion.
- Operation from 900 - 1,200 gpm (63.1 - 75.7 L/sec) will accelerate erosion and will reduce service life. Operating above 1,200 gpm will result in severe erosion.
- Sand Content: < 1% by volume recommended.

### Mechanical and electrical connections and interface to APS SureShot™ MWD

- > Resistivity sub is a node on the SureShot RS-485 bus

### Power requirements

- > Low operating power for maximum battery life
- > Designed to run with turbine alternator and 0x/1x/2x/3x battery (10 cell DD), or 3x/4x batteries

### Tool Programming and Data Dump Port

- > Hatch cover for easy access via cable connection to allow tool programming and memory dump. Memory data dumps and tool programming can also be performed when the tool string is disconnected from the resistivity via the tool string lower end.
- > 32 MB integrated FLASH memory

# Wave Propagation Resistivity Sub (WPR™)

## Product Specifications

### Environmental

<b>Operating Temperature</b>	0° to 302°F; 347°F option (-18° to 150°C; 175°C option)
<b>Pressure</b>	20,000 psi (138 MPa)

### Compensated Resistivity Measurements

Frequency	Measurement	Range	Accuracy
2 MHz	Phase Difference All Spacings	0.1 – 4,000 ohm-m	± 2% [0.1 – 25 ohm-m] ± 0.5 mmho/m [above 25 ohm-m]
	Attenuation Near Spacing	0.1 – 300 ohm-m	± 2% [0.1 – 25 ohm-m] ± 1.0 mmho/m [above 25 ohm-m]
	Attenuation Far Spacing	0.1 – 500 ohm-m	± 2% [0.1 – 25 ohm-m] ± 1.0 mmho/m [above 25 ohm-m]
400 kHz	Phase Difference All Spacings	0.1 – 4,000 ohm-m	± 1% [0.1 – 25 ohm-m] ± 1.0 mmho/m [above 25 ohm-m]
	Attenuation Near Spacing	0.1 – 300 ohm-m	± 1% [0.1 – 25 ohm-m] ± 2.0 mmho/m [above 25 ohm-m]
	Attenuation Far Spacing	0.1 – 500 ohm-m	± 1% [0.1 – 25 ohm-m] ± 2.0 mmho/m [above 25 ohm-m]

3.5 in.  
(89 mm)  
WPR

### Transmitter / Receiver Spacings

	Measure Point						
	UH	T <sub>1</sub>	T <sub>2</sub> *	R <sub>1</sub>	R <sub>2</sub>	T <sub>3</sub> *	DH
<b>in.</b>		-36.00	-22.50	-4.25	+4.25	+22.50	+36.00
<b>mm</b>		-914.4	-571.5	-107.9	+107.9	+571.5	+914.4

### Depth of Investigation, Vertical Resolution

R <sub>f</sub> = 1 ohm-m R <sub>xo</sub> = 0.5 ohm-m	Depth of Investigation		Vertical Resolution**
	Short Spacing Radius	Long Spacing Radius	
2 MHz Phase Difference	21 in. (533 mm)	28 in. (711 mm)	8 in. (203 mm)
400 kHz Phase Difference	30 in. (762 mm)	39 in. (991 mm)	12 in. (305 mm)
2 MHz Attenuation	34 in. (866 mm)	44 in. (1,118 mm)	8 in. (203 mm)
400 kHz Attenuation	52 in. (1,321 mm)	66 in. (1,676 mm)	12 in. (305 mm)
R <sub>f</sub> = 10 ohm-m R <sub>xo</sub> = 0.5 ohm-m	Depth of Investigation		Vertical Resolution**
	Short Spacing Radius	Long Spacing Radius	
2 MHz Phase Difference	26 in. (660 mm)	37 in. (940 mm)	8 in. (203 mm)
400 kHz Phase Difference	36 in. (914 mm)	49 in. (1,245 mm)	12 in. (305 mm)
2 MHz Attenuation	40 in. (1,016 mm)	53 in. (1,346 mm)	8 in. (203 mm)
400 kHz Attenuation	60 in. (1,524 mm)	76 in. (1,930 mm)	12 in. (305 mm)

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\* Not included in 3.5 in. and 3.75 in. size. \*\* 90% response in conductive beds.