2PEA-1000 & 2PEA-1000/F

PolyElectric Probes

Overview

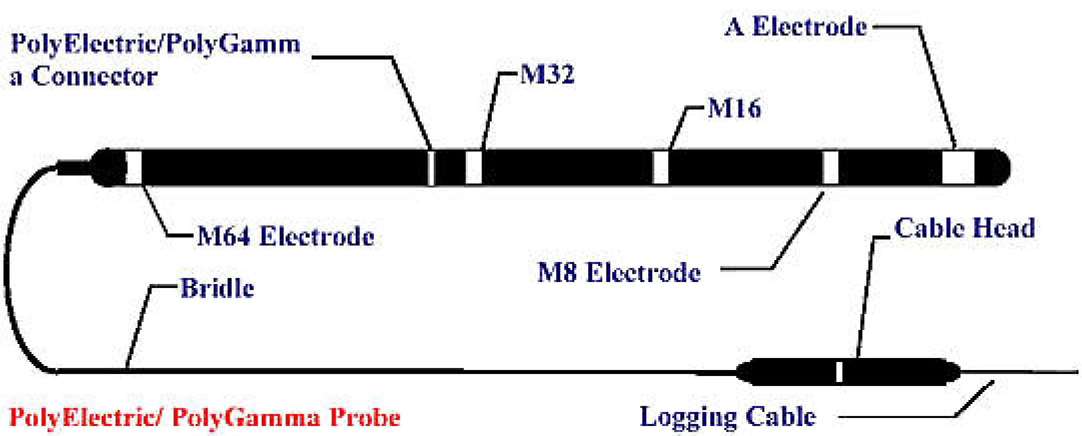
The 2PEA-1000 PolyElectric probe and the 2PGA-1000 PolyGamma probe combine to make a multiparameter probe. The totally digital probe combination measures 8, 16, 32, and 64inch (0.2, 0.4, 0.8, 1.6 meter) normal resistivity, single point resistance, self potential, and natural gamma. When the 2PEA-1000/F PolyElectric probe is used with the 2PGA-1000 PolyGamma probe, fluid resistivity and fluid temperature are also measured. These probe combinations operate with the MGX II series portable digital logger or the Series V digital logger. The normal resistivity measurements, single point resistance, and self potential measurements are designed for surveying open (uncased) fluid filled boreholes.The 8" (20 cm) normal resistivity spaced response, and the single point resistance, are similar to a ***focused*** resistivity log as they define thin beds.

Connectors and Layout

The function of each electrode is listed below, starting with the bottom electrode and proceeding towards the top of the probe. For more information on the function of these electrodes, consult the Theory of Operation section of this document. Connectors for the tool are as follows. The PolyGamma probe top described below is a standard single conductor probe top. Other variations of probe tops and wiring can be ordered from the factory. The connector between the PolyElectric and PolyGamma probes is a ring style connector. The numbering of the rings begins from the inner most ring (ring 1) and proceeds to the outer ring (ring 6).

PolyElectric Bridle

The bridle must be connected between the cable head and the top of the PolyElectric -PolyGamma Probe combination as illustrated. The bridle provides electrical isolation from the logging cable armor for normal resistivity logging. The 2PEA-1000/F has fluid temperature and fluid resistivity sensors located on the bottom of the probe. Please call for more information.



Electrodes:

Electrode	***Functional Name***
Bottom electrode	'A' electrode or Current Electrode, and 'R': single point resistance electrode
Second from bottom	'M8' electrode: 8inch normal resistivity measure electrode
Third from bottom	'M16' electrode: 16inch normal resistivity measure electrode
Fourth from bottom	'M32' electrode: 32inch normal resistivity measure electrode
Top electrode	'M64' electrode: 64inch normal resistivity measure electrode; and 'SP': self potential electrode
Cable Armor	'N' electrode: measure reference electrode
Surface Electrode	'B' electrode: current return electrode (Mudplug)

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PolyGamma Probe Top Connector:

Pin	Signal	Origin
Probe top housing	Probe power ground	Armor
Center pin in probe top	Probe power positive	Center conductor

PolyElectric Probe Top and PolyGamma Probe Bottom Connectors:

Ring	Signal	Origin
1	SP, R or 64" Normal	Electrode below probe top
2	Center conductor	Center pin on probe top
3	Pulse return	Returns Gamma pulse to center conductor
4	Pulse	Output from Gamma circuit
5	Armor	Armor of probe top
6	P. S. Control	PolyElectric Probe

Theory of Operation

Normal Resistivity Measurements

The normal resistivity and single point resistance measurements are accomplished by measuring the amount of survey current that the logger and probe produce between the ‘A’ electrode and the mudplug (or armor during the ‘normal resistivity using armor’ operational mode). A voltage is measured for each resistance or resistivity channel. All voltage measurements are made with respect to the armor. The quotient between the voltage and current for each channel is used to calculate the reported value.

For the normal resistivity measurements, Ohm’s law can be written

$$\frac{V}{I} = R = \frac{\rho \cdot l}{A} \quad \text{or} \quad \rho = \frac{A \cdot V}{l \cdot I} \quad \text{or} \quad \rho = G \cdot \frac{V}{I}$$

where r is resistivity (ohm-meters), R is resistance (ohms), l is the distance the survey current travels (meters), A is the cross sectional area that the current travels through (meters 2), V is voltage (volts), and I is current (amps). The quantity (A/l) is called the geometric factor G (meters). The geometric factor is approximately 12.5 times the ‘AM’ spacing, in meters. The survey current leaves the ‘A’ electrode in all directions, diverging as it does so. In a homogenous medium, concentric spheres centered around the ‘A’ electrode, and with radius ‘AM’, delineate the volume of investigation for the normal resistivity measurement. ‘AM’ refers to the distance between the ‘A’ and ‘M’ electrodes. The volume of investigation (in a homogenous medium) for the 8 inch normal resistivity measurement is a sphere with an 8 inch radius; the volume of investigation for the 64 inch normal resistivity measurement is a sphere with a 64 inch radius. These spheres are called equipotential surfaces. The voltage is measured between an equipotential surface (sphere surrounding the volume of investigation) and the reference (armor). This voltage is divided by the measured value of the survey current, and the result multiplied by the geometric factor to obtain resistivity.

The normal resistivity circuits report the average resistivity of the material in the volume of investigation and the volume of investigation may vary for heterogeneous mediums. Therefore, the measured resistivity is called the apparent resistivity. Many computer programs are available to convert apparent resistivity to true resistivity. These programs usually require a geologic model and the apparent resistivity data to calculate true resistivity. Some programs calculate synthetic logs such as invasion profile, synthetic focused resistivity logs, and porosity logs.

Single Point Resistance Measurement

Refer to Ohm’s law from above for the explanation of the single point resistance measurement. As the survey current leaves the ‘A’ electrode, the current diverges, and the cross sectional area A through which it travels becomes very large compared to l. The quantity (l/A) in the first equation approaches zero as the distance from the ‘A’ electrode increases. Therefore most of the measured resistance is a result of the survey current near the ‘A’ electrode and also at the mudplug where the current converges. The resistance indicated by the single point resistance circuit, is the sum if the resistance near the mudplug, and the resistance near the ‘A’ electrode. Since the resistance near the mudplug does not change, any excursion indicated in the single point resistance log is a result of the change in resistance near the ‘A’ electrode.

When the PolyElectric - PolyGamma probe combination is operated in ‘R-SP’ mode, the current generator and all measure circuits are contained in the logger at the surface. The mudplug is used as the current return (‘B’) and reference (‘N’) electrodes. The top electrode on the probe functions as the current (‘A’) and measure (‘M’) electrodes. In this mode, the top electrode on the probe is connected to the cable line center conductor. Since the probe requires no power, this mode of operation is sometimes referred to as the ‘passive’ mode.

SP measurement

The SP (self potential) circuits measure the DC (direct current) voltage between the top electrode on the probe and the armor. The resistivity circuits utilize an AC (alternating current) survey current so that the SP circuits are not affected. When the PolyElectric - PolyGamma probe combination is operated in 'R-SP' mode, the current generator and all measure circuits are contained in the logger at the surface. The mudplug is used as the current return ('B') and reference ('N') electrodes. The top electrode on the probe functions as the current ('A') and measure ('M') electrodes. In this mode, the top electrode on the probe is connected to the cable line center conductor. Since the probe requires no power, this mode of operation is sometimes referred to as the 'passive' mode. This mode may give better SP log results near the water level in the borehole.

Fluid Resistivity Measurement

The fluid resistivity measurement generates a survey current between small current ('A' and 'B') electrodes located inside the survey tube. Small measure ('M' and 'N') electrodes, located between the current electrodes, are used to measure the potential difference generated in the fluid by the current electrodes. The process is identical to that of the normal resistivity measurements, except that the volume of investigation is entirely contained in the survey tube.

Fluid Temperature Measurement

The fluid temperature measurement uses a solid-state temperature-sensing device. The electrical output of this device is proportional to the temperature of the fluid. The thermal mass of the temperature sensor is kept as low as practical so that the time required for the sensor to respond to a change in temperature is minimal.

Derived Measurements

Measurements from the PolyElectric probe can be combined to make derived quantities. Lateral resistivity logs and synthetic LL7 logs can be obtained from normal resistivity logs. Mud invasion profiles can be determined with multiple spaced resistivity logs. These profiles illustrate rock permeability. Mud resistivity can be calculated from the fluid resistivity. Mud resistivity can then be used to calculate porosity. Many of these calculated measurements can be made in real time while logging the data. For more information about these and other derived measurements, consult Terraplus.

Length 2PEA-1000	74 inches (188 cm)
Length 2PEA-1000/F	87 inches (221 cm)
Diameter	1.55 inches (40 mm)
Weight 2PEA-1000	16 lbs. (7.3 Kg)
Weight 2PEA-1000/F	22 lbs. (10 Kg)
Operating Temperature	0 to 70 degrees C
Storage Temperature	-40 to 125 degrees C
Maximum Pressure	2000 psi (13.8 Pa)
Low Range Normal Resistivity Measurement	0 to 250 ohm-meters
High Range Normal Resistivity Measurement	0 to 2500 ohm-meters
Normal Resistivity Accuracy	1 %
Normal Resistivity Resolution	0.02 %
Low Range Single Point Resistance Measurement	0 to 500 ohms
High Range Single Point Resistance Measurement	0 to 5000 ohms
Single Point Resistance Accuracy	1 %
Single Point Resistance Resolution	0.02 %
Self Potential Measurement Range	-1.5 to 1.5 VDC
Self Potential Measurement Accuracy	1 %
Self Potential Measurement Resolution	0.04 %
Fluid Resistivity Measurement Range	0-100 ohm-meters
Fluid Resistivity Accuracy	1 %
Fluid Resistivity Resolution	0.02 %
Fluid Temperature Measurement Range	-20 to 70 degrees C
Fluid Temperature Accuracy	0.5 %
Fluid Temperature Resolution	0.05 %